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Lunds Tekniska Högskola

Sales and Operations Planning - Identifying and creating product families

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SIGNED: ..... DATE: .....
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Abstract

Background: Sales and Operations Planning (S&OP) is a framework used in order to balance supply and demand. It seeks to address the complexity of planning through a cross-functional process, involving key representatives from departments of interest. In order to conduct S&OP efficiently, planning has to be done on the right level. If it is done on a too detailed level, overview becomes too complex and time-consuming. If it on the other hand is done on a too aggregated level, the process will lack sufficient data to base decisions on. None of these scenarios are desirable, as the purpose of the S&OP process is informed and efficient decision-making. The appropriate level of analysis is conducted on product families, which is the grouping of products based on certain characteristics. Alfa Laval has recently started to implement S&OP and now seeks to find the right level of aggregation and appropriate product families for their S&OP process.

Purpose: The purpose of this Master Thesis is to develop a general process with guiding principles for identifying and creating product families.

Research question: What should the general process for identifying and creating product families be?

Method: Theoretical studies were combined with an empirical investigation of the S&OP practice at six companies. The investigation consisted primarily of interviews with key representatives at the organizations. An in-depth examination was conducted at Alfa Laval, which included a proposal of product families for the company to use. Based on the research and the experience from creating product families, a product family process was developed.

Findings: The Product Family Process consists of the following six steps:

Keywords: Sales and Operations Planning, S&OP, Product families, Product Family Process (PFP)

Sammanfattning

Bakgrund: Sälj och verksamhetsplanering (SVP) är ett ramverk för att balansera utbud och efterfrågan. Processens huvudsakliga syfte är att adressera komplexitet vid planering genom tvärfunktionellt samarbete, vilket involverar nyckelpersoner från relevanta avdelningar. För att effektivt bedriva SVP måste planeringen ske på rätt nivå. Om den görs på en för detaljerad nivå blir den översiktliga bilden för komplicerad och tidskrävande. Om den istället görs på en för aggregerad nivå kommer processen sakna den nödvändiga data som krävs för att fatta beslut. Inget av dessa alternativ är önskvärda eftersom ett viktigt syfte med SVP är att göra välinformerade och effektiva beslut. Den lämpliga analysnivån görs på produktfamiljer, vilket är gruppering av produkter baserat på deras specifika egenskaper. Alfa Laval har nyligen börjat implementera SVP och undersöker nu aggregeringsnivå samt lämpliga produktfamiljer för deras SVP process.

Syfte: Syftet med examensarbetet är att utveckla en allmän process med riktlinjer för att identifiera och utveckla produktfamiljer.

Forskningsfråga: Hur bör en generell process för att identifiera och skapa produkterfamiljer se ut?

Metod: Teoretiska studier kombinerades med empirisk undersökning av tillämpningen av SVP hos sex företag. Undersökningen bestod primärt av intervjuer med nyckelpersoner från organisationerna. En djupare undersökning av Alfa Laval utfördes, vilket innefattade ett förslag på de produktfamiljer som företaget borde använda sig av. Baserat på studierna och forskningen samt erfarenheten från att skapandet av produktfamiljer utvecklades en produktfamiljsprocess.

Slutsatser: Produktfamiljsprocessen består av följande sex steg:

Nyckelord: Sälj och verksamhetsplanering, SVP, Produktfamiljer, Produktfamiljsprocessen (PFP)

Table of abbreviations

S&OP *Sales and Operations Planning*

GPHE *Gasketed Plate Heat Exchangers*

BU *Business Unit*

PFA *Production Flow Analysis*

LTH *Lunds Tekniska Högskola*

KAM *Key Account Manager*

STECO *Steering Committee*

R&D *Research and Development*

L12M *Last Twelve Months*

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Chapter 1

Introduction

This chapter addresses the background and purpose of the Master Thesis. It also describes the problem, the company Alfa Laval and the research question for this project. Finally, the focus and delimitations are presented.

1.1 Background

Sales and Operations Planning (S&OP) is a framework used in order to balance supply and demand. Even though this framework has existed for more than 35 years, it is still a concept that gives many companies a competitive advantage today. S&OP is part of tactical planning, which is interstage between long term strategic planning and short term operational planning. A key part of S&OP is facilitating the planning process by bridging the gap between these two planning levels, which is partly done through the mapping and sorting of products into suitable product families (Grimson & Pyke, 2007).

S&OP seeks to address the complexity of planning through integrating a cross-functional, company-wide plan and as previously mentioned, closing the gap between strategic and operational planning. It also provides a decision-making process for senior management in order to make sure tactical plans in all business functions are aligned and support the business plan. Successful implementation of S&OP will lead to the company enjoying benefits such as high service

levels, low manufacturing costs and low level of capital tied up in inventories (Grimson & Pyke, 2007).

In order to successfully implement S&OP, product families have to be defined. If the planning process is done a level consisting of too much detail, overview of the process becomes complex and time-consuming. If it on the other hand is done on a too aggregated level, the process will lack sufficient data to base decisions on. None of these scenarios are desirable, as the purpose of the S&OP process is informed and efficient decision-making. It is therefore essential to define the right level of categorization in order to make overview possible, while simultaneously also having enough information to make informed decisions about the planning process. Depending on the type of product, product range and complexity, some companies can relatively easily create product families while others have it more difficult (Wallace & Stahl, 2008). Due to having a great variation of products as well as a high degree of customization, Alfa Laval belongs to the latter.

1.2 Company description

Alfa Laval was founded in 1883 by Gustaf de Laval. Today Alfa Laval is a world leader within the areas of *heat transfer*, *separation* and *fluid handling* and has customers in more than 100 countries. Heat transfer refers to the process of heating and cooling which is needed in most industrial processes. This is the largest product segment for Alfa Laval. Separation addresses the technology of separating solid gases and particles. Fluid handling is the transportation and regulation of fluids in both a safe and efficient manner. The market share for the three technologies can be seen below in table 1.1 (Alfa Lavala, 2018).

Table 1.1: *Market share by technology for Alfa Laval (Alfa Lavalc, 2018).*

Technology	**Market share**
Heat transfer	> 30 %
Separation	25-30 %
Fluid handling	10-12 %

Alfa Laval supplies a diverse market within for example nuclear power, the engineering sector, refinery sector, mining industry, and food industry and has a yearly revenue of 35 billion SEK. The company employs 17 000 employees, primarily in Denmark, Sweden, India, China, France, and the US. The headquarters is located in Lund, Sweden but there are 42 major production units worldwide. Alfa Laval focuses a substantial amount of resources towards new technology and invests approximately 2,5 % of the revenue in *Research and Development* (R&D) and also holds more than 2500 patents. Every year between 35 to 40 new products are launched (Alfa Lavala, 2018).

Alfa Laval's vision is to "*help create better everyday conditions for people by offering efficient and environmentally responsible products and solutions in the areas of heat transfer, separation and fluid handling*". Alfa Laval believes that they are in a unique position for facilitating a better environment as they provide solutions that improve the energy efficiency of industrial processes (Alfa Lavalc, 2018).

The Heat Exchanger

The Master Thesis project focuses on Alfa Laval Lund GPHE which creates Gasketed Plate Heat Exchangers. A Gasketed Plate Heat Exchanger provides efficient heat transfer in compact equipment, see figure 1.1. It is the corrugated plates in the Heat Exchangers that makes it possible to draw heat from gas or liquid to another source. The product range is wide and the Heat Exchanger can be used for heating, cooling, heat recovery, evaporation and condensation in industries ranging from HVAC, refrigeration, engine cooling, dairy and food to heavier processes like chemical processing, oil production and power generation (Alfa Lavalb, 2018).

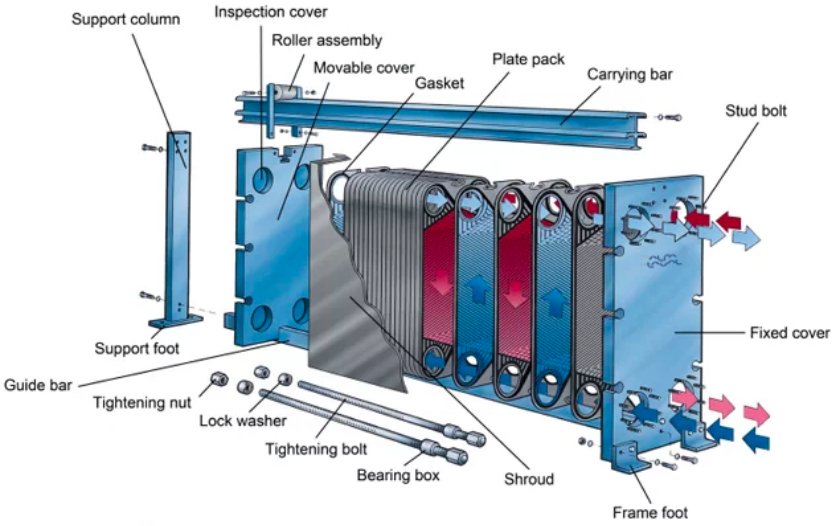

Figure 1.1: *The components in a Gasketed Plate Heat exchanger (Alfa Lavalb, 2018).*

1.3 Purpose

The purpose of this Master Thesis is to develop a general process with guiding principles for identifying and creating product families.

1.4 Problem description

The department Plan at Alfa Laval Lund is responsible for the planning of *Gasketed Plate Heat Exchangers* (GPHE). Alfa Laval is in the early stages of implementing S&OP, which means that there are internal processes and frameworks that need to be implemented before they can gain the full benefits of the process. The product families are currently not at the appropriate level of aggregation, which complicates the S&OP process. The amount of information regarding the creation of product families is currently limited, especially in comparison to other S&OP processes. Companies in need of creating product families may therefore find this process difficult as no clear model or method has been formulated (Ånell, 2019).

1.5 Research question

Research question: What should the general process for identifying and creating product families be?

1.6 Focus and delimitations

The focus of this Master Thesis is to suggest a general process for how to create product families. The Master Thesis students will focus on comprehending the theory behind product families and compare it with how other companies have created their product families. Based on the developed process, product families will be created for Alfa Laval. However, the solution for Alfa Laval will be confidential. The developed process will be based on academic literature and empirical analysis of six companies.

1.7 Guidance during the Master Thesis project

The team received guidance and advice from both LTH and Alfa Laval during the Master Thesis project. The people and teams that provided this support are listed below:

Faculty of Engineering, LTH - Supervisor
People: Jan Olhager, Professor of Engineering Logistics at LTH.
Jan Olhager was the supervisor for our project and very knowledgeable within both S&OP and the Master Thesis process. His advice was particularly helpful when it came to structuring the project, how to approach different issues and where to get theoretical data.

Alfa Laval - Supervisor
People: Hanna Ånell, Supply Planner at Alfa Laval.
The team worked closely with Hanna Ånell who is very experienced within S&OP as well as Alfa Laval. Ånell served as the primary advisor regarding ideas and planning throughout the project.

Alfa Laval - Guiding Team

People: Alexandra Kristensson, Hanna Ånell, Karin Cederlund, Daniel Edman, Shrikrishna Tiwari

The purpose of the Guiding team was to follow up the team's work, to provide support for decisions and to provide advice for issues the team had encountered with the project.

Alfa Laval - Steering Committee

People: Anna Wieslander, Johan Blom

Steering Committee (STECO) is a group consisting of main representatives from the production. The team attended the meetings where the team updated the STECO of how the thesis was progressing and the team also received updates on how the business was operating at the moment.

Alfa Laval - Sponsor

People: Conny Lindberg, Manager of Operations Planning

Conny Lindberg was the owner and sponsor of the Master Thesis project at Alfa Laval. He supervised and made sure that the team had all the material needed to proceed with the necessary processes.

Chapter 2

Methodology

The purpose of this chapter is to describe how the Master Thesis project was conducted. It also seeks to explain different methodological approaches and motivate the chosen methods. The chapter is concluded with a discussion about the credibility of the project.

2.1 Research methods

There are several ways to conduct a study. Which kind of approach to use depends on factors such as purpose, field, scope, focus, level of analysis, etc. In order to know how a study is to be conducted it is therefore vital to define what kind of study that is to be performed. The following sections will describe these different approaches, as well as motivating which methods this project will choose and why.

2.1.1 Exploratory, descriptive, explanatory and normative studies

Choosing the appropriate type of study is dependent on the present knowledge within the area of investigation. There are usually four types of studies (Björklund & Paulsson, 2012):

- Explorative studies are done when the existing knowledge is limited, and the purpose is to gain basic understanding within the field.

- Descriptive studies are preferred when basic knowledge already exists within the field and the goal is to describe and not to explain relations.

- Explanatory studies can be used when seeking a deeper knowledge and understanding and when the goal is to both describe and explain the investigated phenomenon.

- Normative studies are appropriate when some knowledge within the area exists and the goal is to suggest actions and provide guidance on how to proceed.

Chosen study
The purpose of the Thesis Project is to develop a generic process for identifying and creating product families. It also seeks to provide a solution for how Alfa Laval Lund GPHE should sort their products into product families in order to facilitate the S&OP process. The Master Thesis project will therefore be a normative study.

2.1.2 Quantitative and qualitative studies

Depending on the purpose of the study, a qualitative study or a quantitative study can be performed. The results from a quantitative study are easier to generalize, but a qualitative study is better suited when the purpose is to gain a deeper understanding of a specific problem. These two types of studies can therefore be summarized in the following way (Björklund & Paulsson, 2012):

- Qualitative studies are to be performed if one seeks to gain a deeper understanding regarding a certain problem, event or situation.

- Quantitative studies are appropriate when the investigated problem can be measured or estimated in numerical terms.

Chosen study
As the project seeks to gain a deeper understanding regarding the S&OP pro-

cess and how to create product families the study will be qualitative. Quantitative data will be used if needed, but will not be the focus of the project.

2.1.3 Case design

In order to properly conduct case studies, it is important to understand that there are different designs depending on what and how something is to be investigated. The different scenarios can be summarized as being holistic or embedded and single or multiple. A study can, therefore, be a combination of the different types, for example, a single holistic study. However, it is important to define each category (Yin, 2006):

- Holistic case study is the systematic approach of a phenomenon and is used when the underlying theory is holistic and no sub-units can be defined.

- Embedded case study is the investigation of different sub-units of a phenomenon. It is useful for confronting rival interpretations and to strengthen internal validity.

- Single case design should be used if the case is either longitudinal, is to test a specific theory, represents a specific situation or reveals a situation.

- Multi-case design is to be performed if the purpose is to compare different studies, avoid unnecessary variation, test conclusions or to provide the bigger picture.

Combining the above described typologies leads to a total of four case study designs. These are holistic single case design, holistic multi-case design, embedded single case design, and embedded multi-case design.

Chosen case design
Since the project seeks to study several companies this study will be a multiple case study. The study also seeks to develop one generic process for creating product families, meaning that the study is also holistic. The chosen design is therefore a multiple holistic case design.

2.2 Conducting the project

Apart from the structure and type of project, a strategy for how to collect data is needed. There are many potential sources of data and it is important to specify which and why the chosen sources are used (Höst, Regnell, & Runeson, 2006).

2.2.1 Primary and secondary data

When conducting a study it is important to decide if one is to use primary or secondary data. Primary data is data that the researchers have collected or produced while secondary data is data that has been collected or produced by others. Primary data is also collected with the aim to develop a solution for the current problem, while secondary data is an interpretation of data which was often collected for other purposes (Surbhi, 2016).

Chosen data collection approach
There are several ways to collect primary data (Surbhi, 2016). As the project strives to gain an in-depth understanding of the S&OP process in practice, the main way of collecting primary data is through various types of interviews. The Master Thesis project will not use any secondary data.

2.2.2 Project structure and strategy

In order to solve the thesis problem, a clear structure is needed. The project can be divided into four main categories, and even though the process is often iterative the primary order is as follows:

1. Theoretical review
2. Empirical review
3. Analysis
4. Project recommendation

2.2.3 Theoretical review

Before investigating the thesis problem and the possible solutions, a comprehensive understanding of the academic field is needed. The team has basic insight into the S&OP process prior to this project, but in order to gain a firm theoretical foundation, the first phase of the project will be spent on researching the subject matter, primarily through studying literature, academic journals, and papers. Initially, the field will be researched in broad terms in order to gain a general understanding. Conveniently, the team supervisor Jan Olhager has expertise in the area, which includes having written a book which partially covers the subject. His books and lectures on this topic will be one of the starting points for the information gathering. Subsequently, the scope of the sought material will be narrowed to concern how to define and structure product families within a company in regards to S&OP.

Information will be gathered both through internet searches as well as through academic journals and books. In the case of internet searches, the team will primarily use Lund University's online database LUBsearch but the search engine Google will also be used as a means to gain general information. Simple search terms such as "S&OP", "product family grouping" and "operations planning" will be used and the results ranked after the most citations.

2.2.4 Empirical structure and process

Interview structure

There are primarily three ways to structure an interview. The first is a structured interview. This is is in principle a verbal questionnaire. The benefits

compared to a regular questionnaire is the possibility to clear up any questions that the interviewee might have regarding for example formulations. However, it is much less time efficient for the interviewer compared to letting the interviewee answer the questionnaire independently (Höst et al., 2006).

The second is the semi-structured interview, which mixes having open and leading questions with questions that have a clear set of possible answers. It is important to formulate the questions with clear possible answers in the same way in different interviews in order to compare answers (Höst et al., 2006).

The third, the unstructured interview, has areas of interest which the interviewer asks questions about. These questions do not have to be formulated the same for different interviews. However, it is important to make sure that different areas of interest are explored and possibly time regulated in order to prevent the interviewee from avoiding certain subjects or lingering on an area which is not of interest for the study (Höst et al., 2006).

Chosen structure

The team will choose to conduct semi-structured interviews, as flexibility is needed when interviewing employees from different departments. However, having an unstructured interview would lead to a too wide scope as the team has a specific area of interest which is to be explored (Höst et al., 2006).

Interview process

The interview process can be divided into four parts: *context*, *introductory questions*, *main questions*, and *conclusion*. The interview starts by defining the context of the interview. During this part, the interviewer should describe what the purpose of the interview is and why the interviewee was chosen. If the interview is to be recorded, consent from the interviewee must be given. In order to further establish context and also to get the conversation flowing naturally, introductory questions are asked. These questions are neutral and address the interviewees education, position within the company, previous experience, etc. The main questions should be asked in an order that seems logical for the interviewee in order to facilitate the flow and answers. The interview is finally concluded by the interviewer and the interviewee gets the possibility to add, object to and/or clarify any positions or formulations (Höst et al., 2006).

This framework was very helpful in order to make sure the interviews were structured properly and had a good flow. This format was applied during all interviews.

The interviewer's skills

In order to facilitate the interview, it is advantageous if the interviewer has a set of skills in order to properly conduct the interview. These skills are difficult to quantify, but can be generally summarized into *asking good questions*, *being a good listener*, *being flexible and adaptive, having a clear understanding of the issues* and *not being skewed by faulty or biased perceptions* (Yin, 2006).

As interviews are dynamic and the information gained is reliant on what the interviewee reports, asking good questions is vital in order to make sure that the relevant data is obtained. It is also important to be able to put information in the right context and to properly understand what the interviewee is trying to communicate. The dynamic element also means that unexpected events may occur or that the interviewee is not on the same page as the interviewer regarding what the purpose of the interview is. Being flexible and adaptive during the interview but at the same time able to stay on the purpose of the interview is therefore a useful skill. In order to make judgments regarding what information that is important, having a clear understanding of the issues is required, meaning a firm theoretical foundation is needed. It is important to not be skewed by faulty or biased perceptions against any information gained during the interview. While exploring a problem, or trying to find solutions one has to be open minded in order not to risk missing a vital insight. This is especially true if the findings run contrary to current beliefs. Being aware of bias, and open for new ideas is, therefore, a very important quality for the person/persons who are conducting the case (Yin, 2006).

These aspects were important to the team and were reflected over before each interview.

Cross-case analysis

When comparing commonalities and differences between several processes, events or activities a cross-case analysis is a useful approach. The method seeks to synthesize findings from several cases within a multi-case setting. By doing this overarching conclusions can be drawn based on the findings (Höst, Runesson, Dybå, & Cruzes, 2014).

The Master Thesis project will be investigating several companies through benchmarking (see section 2.2.5). Each company will first be analyzed individually, also known as a within-case analysis. By conducting a cross-case analysis commonalities and differences between these within-case analyses can be identified in order to further explore how to create product families.

2.2.5 Empirical review

It is important that data is gathered from a multitude of sources in order to get an in-depth understanding of S&OP. The empirical investigation can be sorted into three different categories:

- Individual interviews
- Benchmarking
- Workshop

Individual interviews
Individual interviews refer to interviews held with employees of interest at Alfa Laval. The interviews will primarily be conducted during the earlier phases of the project in order to get a better understanding of the processes at Alfa Laval. These interviews will as previously mentioned be semi-structured, as the purpose is explorative but simultaneously has a scope within S&OP and also sought to answer specific questions. A detailed interview protocol can be found in Appendix A.1.

Benchmarking
The purpose of benchmarking is to describe a certain phenomenon which is difficult to separate from its environment (Höst et al., 2006). Benchmarking will be conducted with employees from in total six companies. The primary goal is to get industry examples of how to implement S&OP, to investigate how S&OP in practice differs from S&OP in theory, and especially to investigate how and with what logic other companies choose to categorize their product families. The benchmarking will be designed as semi-structured interviews, as there are clear goals for what information will be retrieved and which specific questions will be asked, but the interview also provides leeway for the intervie-

wees to expand on certain topics which he/she feels are of interest. A detailed benchmarking protocol can be found in Appendix A.2.

After describing the practice at the benchmarked organizations a within-case analysis is conducted, which means that each company is analyzed in regards to the aspects which that company believed to be most important for the S&OP process and especially for product families. The purpose of the analysis is therefore to investigate which factors the interviewee believes to be the most important and to summarize what the key take aways and learnings from each individual benchmarking are.

In order to draw conclusions of the within-case analysis a cross-case analysis is conducted where investigation is done into how generalizable the findings are. Furthermore, the findings are also compared to the theory in order to analyze if there is support from academic literature. The logic is that a frequently reported factor is more important than factors that are reported less frequently. If the factor also has theoretical support, this further strengthens its importance. The findings of both commonalities as well as differences are thereafter discussed in order to further investigate which factors that are generalizable.

In order to make sure that the Master Thesis students had correctly understood what the interviewee had suggested a copy of the summarized interview was sent for verification.

Workshop
The workshop will be prepared group discussions with employees of interest at Alfa Laval. The purpose is to let the group discuss both how to create product families at Alfa Laval as well as various solutions proposed by the Master Thesis students. These group Workshop will be attended by representatives from different departments in order to get a wide range of viewpoints and expertise. A detailed Workshop description can be found in Chapter 5.

2.2.6 Analysis and project recommendation

The analysis is based on academic literature and information retrieved from the interviews and benchmarked companies. The interviews are conducted in

order to take into account as many viewpoints and aspects as possible. In order to make sure that the right conclusions are drawn from the interviews, several factors are considered when evaluating the answers. The primary basis of analysis should be made on the existence and frequency of words as well as descriptions and answers and proposed solutions (Höst et al., 2006). In addition, the employee's position, knowledge within the field and experience is taken into account. It is also noted how well the answer corresponds to the literature. The findings are discussed iteratively during the project in order to continuously develop theories for how to solve the Master Thesis problem. When all interviews are completed, a final analysis is conducted, from which general process for identifying and creating product families is developed and a recommendation for how Alfa Laval is to sort their products into product families is given.

2.3 Research credibility

In order to assess the validity of research four factors are taken into account: reliability, construct validity, external validity, and internal validity.

2.3.1 Reliability

When conducting any kind of experiment it is important that it can be reproduced in the same way and produce similar results. If a study produces the same outcome while having consistent conditions, the study has high reliability. Any random variables which can affect the study must therefore be eliminated in order to achieve high reliability (Laerd Statistics, 2012d). The primary method of collecting data is through interviews which means that in order to have high reliability, the interviews are to be structured and performed in a methodical and consistent way. This is partly done by carefully creating a protocol, which is discussed and reviewed several times by the team before initiating the interviews.

2.3.2 Internal validity

Internal validity is about decreasing the possibility of confound. This means that the number of independent variables is narrowed in order to with confidence clarify which variable that explains cause and effect (Laerd Statistics, 2012c). This is done by investigating how many sources that confirmed the findings, as well as comparing the empirical findings with the academic literature.

2.3.3 External validity

External validity is the degree to which the results of the study can be generalized to other contexts outside the study (Laerd Statistics, 2012b). The main purpose of the project is to develop a Product Family Process based on the investigation of six different companies. The findings from the organization are then analyzed and discussed in order to create a generalizable process. The hope is to create a process which can be applied to all relevant manufacturing industries. The recommendation to Alfa Laval will be based on this process.

2.3.4 Construct validity

Construct validity describes how well a study measures what it claims to be measuring. It is especially valuable if the study is dealing with subjective concepts (Laerd Statistics, 2012a). In order to make sure that bias and other factors do not affect the project, it is made sure that a proper protocol is created as well as choosing to interview employees from different departments with different viewpoints. In addition, the team will also perform benchmarking against other companies to get their point of view.

Chapter 3

Theoretical framework

This chapter describes the theoretical framework of Sales & Operations Planning. A deeper investigation is done into product families and the processes of interest for the Master Thesis project.

3.1 Sales and Operation Planning

Before elaborating on how S&OP functions and what processes that are involved, one has to answer the question of why implementing S&OP is a good idea in the first place. It is not uncommon for companies to have issues with customer service, inventories, lead times, production rates, etc. S&OP is a process which seeks to remedy these problems by providing a framework in which organizations cooperate cross-functionally and thereby gain valuable insights from different viewpoints. It also gives top management a real overview and control over the business. The first step is to recognize the main drivers for these problems. Fundamentally the issues stem from a failure to balance the following aspects (Wallace & Stahl, 2008):

- Demand and Supply
- Volume and Mix

3.1.1 Demand and supply

Not being able to balance demand and supply has negative results regardless of which way the imbalance tilts. If demand exceeds supply aspects such as quality, cost and service suffer. If the situation is reversed and supply exceeds demand margins will be lowered, costs will increase, available capital will be limited and the probability of layoffs increases. It is therefore vital to have a process which makes it possible to be in control of the balancing of supply and demand (Wallace & Stahl, 2008).

3.1.2 Volume and Mix

A first important step is to be able to separate the two categories conceptually, with volume representing the big picture and mix representing detail. It is important to point out that if the volume is handled properly, the problems associated with the mix are significantly alleviated. At the same time, if the volume is not properly planned the opposite is true. Despite this, it is not uncommon that companies focus most of their time on the mix and not on volume. The reason is that mix are the individual products which the customers communicate about with the company (Wallace & Stahl, 2008).

Volume	Mix
The big picture	*The details*
• How much?	• Which products?
• Rates	• Sequence
• Product families	• Individual products or customer orders

3.1.3 Planning horizon

S&OP is part of the tactical planning, see Figure 3.1, which is interstage between long term strategic planning and short term operational planning (Olhager, 2018). A key part of S&OP is facilitating the planning process

by integrating these two planning levels through the mapping and sorting of products into proper and suitable product families (Grimson & Pyke, 2007).

"S&OP is a business process that links the corporate strategic plan to daily operations plans and enables companies to balance demand and supply for their products." - (Grimson & Pyke, 2007, p. 323)

Figure 3.1: *A visualization of the planning pyramid (Roos & O'Meara, inspired by: (D'Alessandro, 2018)).*

3.2 Sales and Operations Planning process

In order to fulfill the mentioned goals of S&OP, it is vital to have a cross-functionally integrated process, meaning that it includes representatives from sales, marketing, development, manufacturing, sourcing, and finance (Grimson & Pyke, 2007). The S&OP process therefore takes the different stakeholder viewpoints into consideration, which results in a well-informed overview (Olhager, 2018). In order to make the S&OP process agile and up-to-date, it is recommended that the process has a total cycle time of one month, and is also continuously repeated every month (Vereecke, Vanderheyden, Baecke, & Steendam, 2018); (Tuomikangas & Kaipia, 2014). This process consists of five different stages which are visualized below (Wallace & Stahl, 2008):

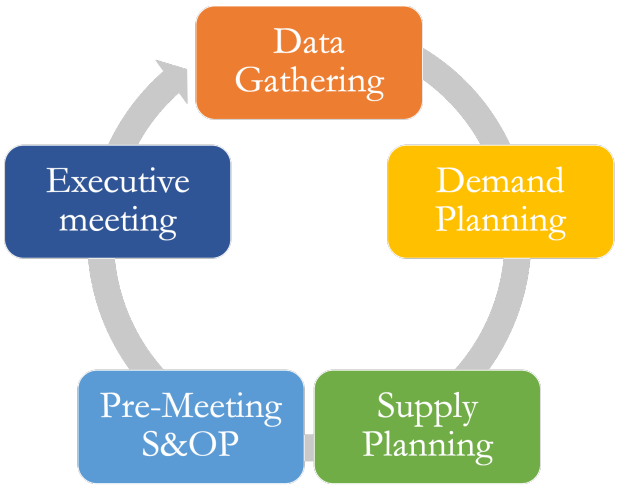

Figure 3.2: *The Sales and Operations Planning process (Roos & O'Meara, inspired by: (Wallace & Stahl, 2008)).*

3.2.1 Data Gathering

The S&OP process begins with the sales department gathering data to create a forecast based on predicted customer demand. At this stage, there are no constraints in regards to what capability the organization has in terms of volume. The planning horizon for the forecast depends on which industry that it is applied to, but it is typically 3 to 18 months at S&OP level. While the Sales department gathers information about the forecast, the operational team collects information about inventory strategy, supply chain capacity, and internal capacity (Grimson & Pyke, 2007).

3.2.2 Demand Planning

The second step of the S&OP process is Demand Planning. In this phase, the information from the Data Gathering stage is used in order to make a further estimation of demand for the different products throughout the supply chain. The goal is to provide useful information for the S&OP process in order to make sure that planning is done properly. Both qualitative and quantitative information is needed, and it is important that the data is accurate, timely and usable (Wallace & Stahl, 2008).

It is important to note that there is a variation of possible demand such as independent demand, dependent demand, and intra-dependent demand. The most common way of planning is for independent demand, but this does not take into account the chain reactions that can be produced throughout the supply chain, thereby negatively impacting the planning and flow of products. It is vital to note that the more that is known about the product demand, the better the Demand Planning, and therefore also the S&OP process, will be (Pentz, 2016).

Effective Demand Planning

There are several ways to make Demand Planning effective. The exact strategy may differ depending on the company, however, there are some aspects that always should be taken into consideration (Wallace & Stahl, 2008).

If the company is a Make-to stock business it is beneficial to use historical sales data in order to create a statistical forecast. By taking into account historical fluctuations and patterns more informed decisions can be made. As organizations often experience trends and seasonalities, an overview of previous demand changes can eliminate some of the otherwise unexpected fluctuations. If the company is a Make-to order business it is more effective to work with customers to establish at what volume and when they anticipate an increase in demand. Partners such as distributors and manufacturers often have valuable information about future trends which help organizations plan future demand (Wallace & Stahl, 2008).

It is important to reassess the forecast by investigating if there are future trends that are not captured by the historical analysis. This reassessment results in what is called a ”Management Forecast” and should be done by managers from Sales and Marketing. As historical data by definition only takes past trends into consideration it is vital that this is combined with an analysis of future events (Wallace & Stahl, 2008).

A final valuable action is to document and review assumptions and data. This makes it possible to motivate decisions and to make future changes in order to improve the S&OP process (Wallace & Stahl, 2008).

3.2.3 Supply Planning

The third step of the S&OP process is Supply Planning. The goal is to investigate what the capacity and capabilities the organization has in order to ensure that the demand needs can be met. (Pentz, 2016);(Wallace & Stahl, 2008).

In the Supply Planning process, all the involved functions meet in order to establish a final operating plan for the next phase. This meeting is usually held once a month, however, there is literature that indicates that organizations are moving against a more frequent timetable (e.g. daily meetings). The process involves activities such as capacity planning, procurement, demand prioritization, inventory optimization, order scheduling, and supplier management (Wallace & Stahl, 2008).

3.2.4 Pre-meeting

The pre-meeting's primary purpose is decision making. Almost all decisions regarding the monthly S&OP process are made in this stage, especially in regards to the executive aspects, which means that it is important that key representatives from the departments of interest attend. The framework that the meeting should work with is "if this were our business, what decisions would we choose to make?". The outcome from this phase should be a final and agreed upon recommendation for the final phase, the Executive Meeting (Wallace & Stahl, 2008).

3.2.5 The Executive meeting

The goal of this phase is to review the decisions made in the previous phase and to decide whether to accept or modify these decisions. It is important that this meeting has a clear agenda that has been set beforehand and that all the participants are familiar with it. The result should be an overall game plan and it is important that the decisions and actions become available for stakeholders shortly after the meeting (Wallace & Stahl, 2008).

3.3 Product families

It is very difficult to plan the production to the smallest detail at the highest level of the planning hierarchy, see Figure 3.3. Doing so would most likely lead to a too slow and uncertain planning process. Instead, it is vital to find products and resources with similar characteristics and group them together in so-called product families and production departments, respectively (Olhager, 2000).

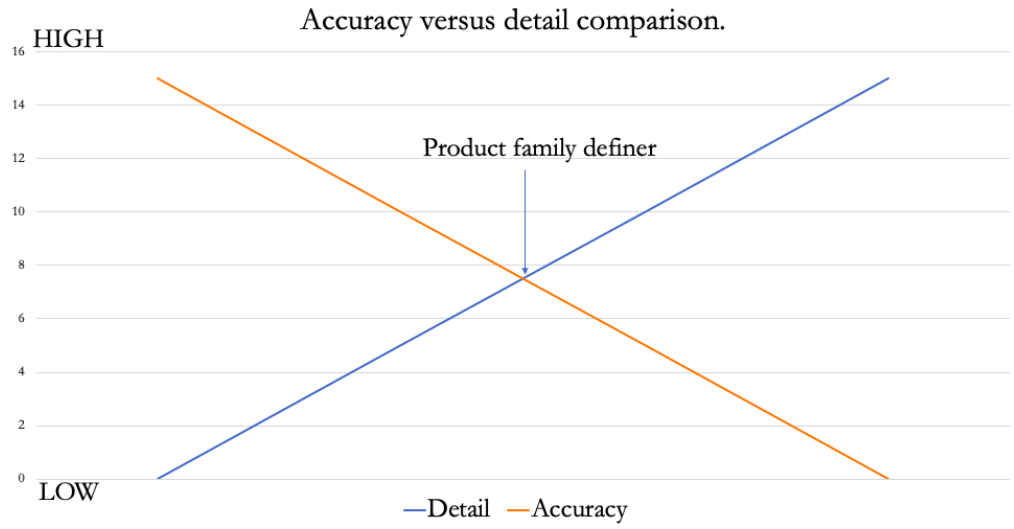

Figure 3.3: *Accuracy versus detail comparison (Roos & O'Meara, inspired by: (Sheldon, 2006)).*

By using an example the concept of product family becomes easier to grasp. Take for example an organization that produces different types of tables. The tables are made of different materials and have different kinds of finishes. From a sales and marketing perspective, these tables may be seen as different types of products. However, from a S&OP perspective, the products might belong to the same product family if they are using the same resources when manufactured, for example, employees or equipment (Chapman, 2006).

The benefits of aggregating data into product families are that the amount of data necessary for planning is reduced and the variability in demand data is reduced. When creating product families it is often based on similar sales and

manufacturing equipment, and it needs to be meaningful in terms of values and sales generated. It is highly important that the logical grouping of product families makes sense for both departments Sales and Operations (Olhager, 2018). The optimal amount of product families is 6-12 per *Business Unit* (BU) and approximately 25 sub-product families for each product family. The reason for these amounts is that top management is generally not interested in details unless it is absolutely necessary and constraining the number of product families simplifies overview and therefore also decision making. The end result will be a more effective process (Wallace & Stahl, 2008); (Olhager, Rudberg, & Wikner, 2001).

In a high-performance S&OP process the business planning, demand planning, and operation planning, needs to be designated and measured in precisely the same way as the product families are designed (Sheldon, 2006).

3.3.1 Selecting the product families

There are many organizations that argue that they have a too complex business to define even a few product families. It is however important that organizations ask themselves what the purpose of their product families are. If the company prioritizes filling customer orders and making shipments, product families are too aggregated to use because there is a need to retrieve information on order level. However, if the organization is going to implement an S&OP process, product families are needed. The question is what the right level of aggregation is. At the top of the pyramid, see Figure 3.4, the level of aggregations is too high and at the bottom of the pyramid there is too much detail to take into consideration (Wallace & Stahl, 2008).

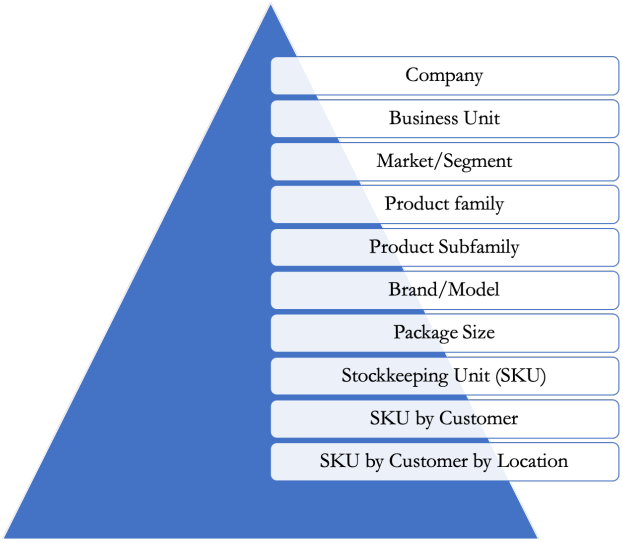

Figure 3.4: *Forecasting pyramid (Roos & O'Meara, inspired by:(Wallace & Stahl, 2008)).*

It is essential that the product families make sense from both a financial and operational perspective. There are several ways to structure the product families (Wallace & Stahl, 2008):

- by product type (e.g. scotch, bourbon, gin)
- by product characteristics (e.g. high performance, deluxe, or standard)
- by product size (e.g. large, medium, or small)
- by brand (e.g. Impala, Malibu, Trailblazer, Tahoe, or Corvette)
- by market segment (e.g. industrial or consumer)
- by distribution channel (e.g. mass merchandisers, original equipment manufactures, or aftermarket)
- by customer

The key question the organizations should ask themselves is "how do you go to the marketplace?". An example is Acme Widget that decided to focus on market segment and product size. First their products have both industry and consumer as a market segment and then Acme Widget decided to divide the

production lines into product families small, medium, and large (Wallace & Stahl, 2008). Another example is regarding organizations with Make-to-Order products, it is common to divide their product families by customers and to use the 20/80 rule. This means that 20% of the customers stand for 80% of the business and these are divided into individual product families while the remaining (i.e. 80%) are grouped as one product family(Wallace & Stahl, 2008).

From the examples above the product, families are based on how Sales view the situation. The question is, does it make sense to base the product families from the Operations point of view? The answer is yes, but only if it simultaneously makes sense for Sales. There are additionally two questions that should be considered (Wallace & Stahl, 2008):

- Will it be more difficult for Sales to forecast succesfully?
- Will it be more difficult for Sales to relate the Executive S&OP process to how they go to the market and how they work with customers?

If the answer to these questions is yes, then the best strategy is not to use that categorization (Wallace & Stahl, 2008).

3.3.2 Measuring performance

Measuring the performance in operations is a relatively straight forward process, see Table 3.1. The performance is only evaluated by product family. Most organizations tend to look at the total volume but doing so are not in line with the S&OP thinking. In order to take advantage of performance accuracy, it is vital that the product families are used throughout the planning process (Sheldon, 2006).

From the example in Table 3.1 the *S&OP Commitment (units)* stands for the number of units that is going to be produced. The column with *Actual (units)* represent the amount of products that was sold (Sheldon, 2006).

Table 3.1: *Operations Planning Metric (Roos & O'Meara, inspired by:(Sheldon, 2006)).*

Product family	**S&OP Commitment (units)**	**Actual (units)**	**Performance**
Product family A	14120	12930	92%
Product family B	7001	6704	96%
Product family C	1670	1300	78%
Product family D	2300	2290	99%
Product family E	5155	5020	97%
Total performance			**92%**

The measurements should be done at the average accuracy per product family and there is no point to make a more detailed evaluation. The performance points out where the deviation(s) have occurred and it is then the organization's task to find the root cause of this problem. When the metrics point out that there is a mismatch in the planning the organization can learn from this and improve the process (Sheldon, 2006).

3.3.3 Subfamilies

Going back to the previously mentioned example, Acme Widget has two production lines, industrial and consumer, that were divided into three product families (i.e. small, medium, and large), see Figure 3.5. Furthermore, the employees that worked with the consumer production line noticed that seasonality affected the products, which lead to the product subfamilies *seasonal* and *everyday*. The seasonal subfamilies usually had extensive production prior to meeting peak demand (e.g. during Christmas) while the everyday subfamilies were more stable. This affects the production differently and is vital for top management to know in case the inventory changes (Wallace & Stahl, 2008).

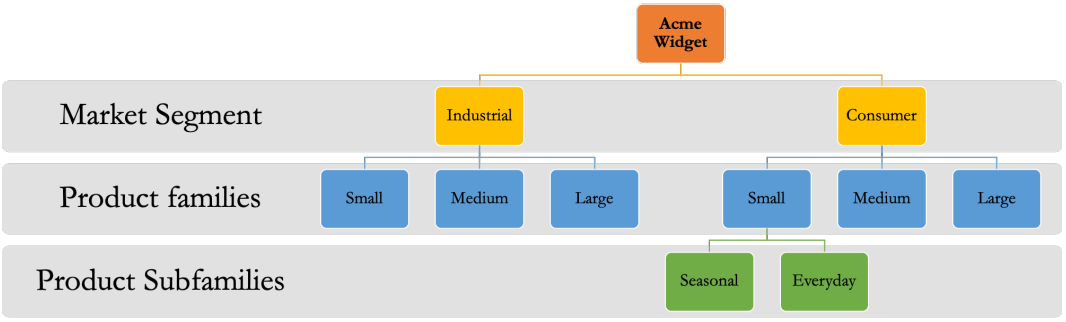

Figure 3.5: *A visualization of Acme Widget's product families (Roos & O'Meara, inspired by: (Wallace & Stahl, 2008)).*

3.3.4 Issues regarding aggregation

The most common problem regarding product families is the level of detail (i.e. level of aggregation) and that organizations are often using monetary terms. Regarding the first problem, the rule of thumb is to aggregate whatever products or services that are using the same category of resources into one product family. For example, if there are products that are using the same resources (e.g. equipment or set of people) they can be aggregated to a product family (Chapman, 2006). The next problem is that companies are typically using monetary terms when forecasting and then failing to convert this to terms that are valuable for Operations, for example, lead time, resources, etc. If it is not converted to operational terms the information is not applicable and therefore cannot be used (Olhager, 2000).

3.4 Production flow analysis

Another tool that could help with the grouping of equipment is called *Production Flow Analysis* (PFA), see Figure 3.6. This method can assist in order to comprehend the best way to group either product to product group or resources to the resource group. The purpose of PFA is to find the pattern between the products and the equipment in the production (Olhager, 2000).

There are primarily two ways to handle this problem (Olhager, 2000):

- Start creating product families by comprehending similarities in resources
- Start creating resource families by comprehending the similarities in the processing of products

PRODUCT	PRODUCTION LINE				
		LINE 1	LINE 2	LINE 3	LINE 4
	PRODUCT 1	X	X		
	PRODUCT 2	X	X		
	PRODUCT 3			X	X
	PRODUCT 4			X	X
	PRODUCT 5			X	
	PRODUCT 6	X	X		

Figure 3.6: *Production flow analysis. (Roos & O'Meara, inspired by:(Olhager, 2000))*

By analyzing Figure 3.6 it becomes clear that Product 1, 2 and 6 can be sorted into the same product group. Similarly, product 3, 4 and 5 can also be sorted into one product group. Furthermore, Production Line 1 and 2 and Production Line 3 and 4 can be sorted into two respective resource groups. This is displayed in Figure 3.7.

PRODUCT	PRODUCTION LINE				
		LINE 1	LINE 2	LINE 3	LINE 4
	PRODUCT 1	X	X		
	PRODUCT 2	X	X		
	PRODUCT 6	X	X		
	PRODUCT 3			X	X
	PRODUCT 4			X	X
	PRODUCT 5			X	

Figure 3.7: *A visualization of how product groups and resource groups can be created with the help of PFA (Roos & O'Meara, inspired by:(Olhager, 2000)).*

Chapter 4

Empirical investigation

This chapter presents the information gathered through the benchmarking of six companies that are working with S&OP. The interviews focus on the S&OP process and specifically how the organizations chose product families and how they are working with them today. After each company interview, a within-case analysis is performed and the chapter is finalized with a cross-case analysis. Note: in order to preserve company secretes specific details are kept confidential.

4.1 Introduction

In order to create an in-depth analysis, the Master Thesis project seeks to investigate several companies in regards to the S&OP process. Each investigation is summarized in a within-case analysis and in order to find similarities a cross-case analysis is conducted. The interview questions can be found in Appendix A.2.

4.2 Reference Company A

This interview was conducted with the Planning Manager at Company A which is a large agricultural company.

Company A has a data system that enables them to create a forecast on a detailed level. The most crucial part of the S&OP process is to make conscious and evidence-based decisions and that there is trust in the process. By knowing how the decision will affect the company and what impact it will have on the production decisions become easier to make. This also makes it possible to trace the decision and use it as a historical framework for future decisions.

4.2.1 The Sales and Operation Planning Process

Company A rolled out their S&OP process approximately three years ago and had from the beginning a central team with Demand and Supply planners. The organization has realized that centralization might not be the best option, which has now instead led to decentralization and are therefore moving the operational decisions and responsibility back to the sites in order to be closer to the decision-making process.

The S&OP process at Company A has five steps, see Figure 4.1. The S&OP process is in total one month, starting week one with a product review, week two with demand review and week three with supply review. During week four both the pre-meeting S&OP and S&OP execution meeting is held.

Figure 4.1: *A visualization of Company A's S&OP process (Roos & O'Meara, inspired by: Company A (2019)).*

Product review

The attendees at the product review meetings are Demand planners for the specific product families, master data manager, and the Sales team. At the meetings, they discuss abnormalities in the production and the market or if there are any products that have lost profitability. This meeting starts at the category level and is broken down to article level for those products that have deviated from the normal.

When Company A started their S&OP process three years ago they focused on retail which had the highest margin. However, retail did not have the highest turnover. This led to that during the fourth step in the S&OP process retail only stood for 10 percent of the volume which leads to that the involved people that managed the rest (i.e. 90 percent) felt left out and uninterested.

Demand review

At the demand review meetings, the Sales manager and Demand planners typically discuss if the company is following the budget which is discussed at the product family level. If there is a product that has differed significantly it is also discussed at the article level. During these meetings the *Key Account Manager* (KAM) only discusses the largest two to three customers.

In Company A's industry, there are a lot of products that are sold through promotions, which makes it extremely important to discuss the campaigns and have control of the production volumes.

Supply review

At the supply review meetings Company A breaks down all the changes to product type, as each product has a specific production line where it is produced. This means that it is not necessary to discuss the site's total volume since the bottlenecks are not shown at this level but instead on the production line level. The Supply review meetings are divided into two parts. During the first part, they discuss the products Company A are to produce themselves and during the second part they discuss the products that are to be purchased.

4.2.2 Current product family structure

The grouping of products into product families was not a complex process as they are categorized the same way the products are grouped in the organizations in general, which is aligned with how the company reports its financial results. Any other kind of grouping would only have created problems and other complications within the company. In general it is important to have a congruent structure and use the same terms to describe different processes within the company.

Company A's current product hierarchy can be seen in Figure 4.2. At the highest level Company A has four product families. These product families are then broken down into approximately 20 sub-product families per product family. However, in general these product families are directly broken down to the article level, described as product type in Figure 4.2. This is partly due to that the sub-categories are more abstract, making them harder to relate to, but mainly because the discussions during the S&OP process only deals with articles that deviate from the normal in regards to capacity and demand.

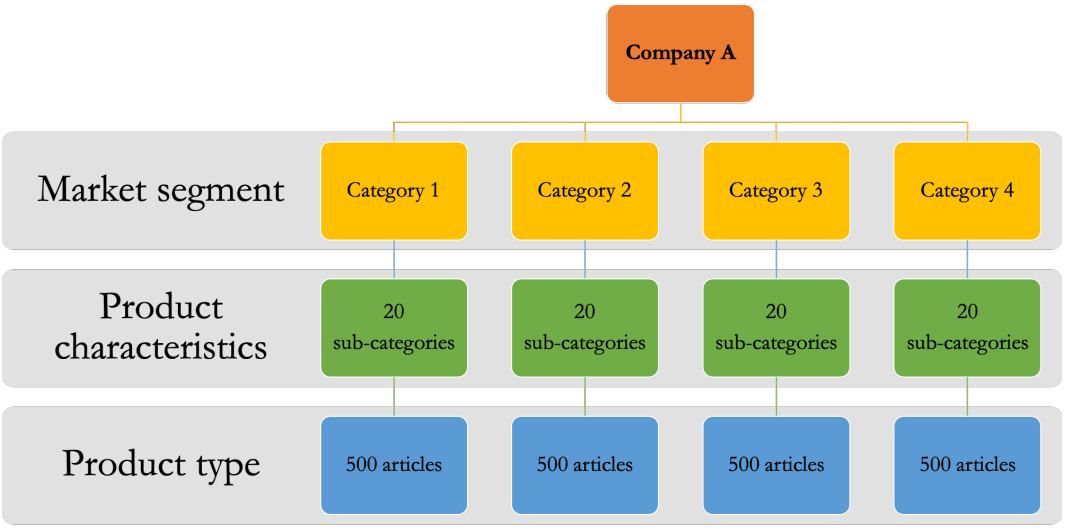

Figure 4.2: *A visualization of Company A's product hierarchy structure (Roos & O'Meara, inspired by: Company A (2019)).*

4.2.3 Future product family structure

Company A has recently changed the way the financial result is reported which is now done by country. This has led to a need to change the product families in order to match the organizational structure. This is necessary due to that if the S&OP team wants to promote a change that affects the organization, that change needs to be communicated in terms that top management easily can comprehend and relate to. This has led to that the product family level will be based on the countries that Company A has production in. The sub-product family level will be based on production sites. In other words, Company A's S&OP process must be aligned with the overall organizational structure. These changes also make it easier to evaluate the process continuously from a financial perspective.

4.2.4 Within-case analysis

The Master Thesis students have analyzed the interview with Company A in order to identify key learnings and other findings of interest.

These are summarized below:

- It is vital to make conscious decisions during the S&OP meetings.
- The S&OP process is reliant on trust.
- Figure out what is important for the company, for example being able to handle promotions.
- Everyone should speak the same organizational language. The supply chain cannot speak in terms of volume while finance talks in monetary terms.
- It is important that the S&OP process is cross-functional.
- The product families must be linked to the financial results and overall organizational structure.
- The product families needs to be understandable for top management in order to get support.
- Discuss deviations during the S&OP meetings.
- The number of product families do not correspond with the academic literature.
- Product families need to be connected to the production in order to comprehend capacity.

4.3 Reference Company B

This interview was conducted with the Demand planner at Company B which is a large fertilizing company.

The most crucial part of Company B's planning process is to have good communication, especially with the Sales department. It is important that Sales comprehends the benefits of the S&OP process. Another important aspect is

to understand which parameters that are important for the company such as lead time, cost, or components and if these parameters change depending on the market segment. With this information, it becomes easier to understand how planning should be conducted.

4.3.1 The Sales and Operation Planning Process

Company B has no stated S&OP process but still follows the logic behind it. The current planning process started in 2014 and consists of three steps, see Figure 4.3. The S&OP process is in total one month and starts week one with the demand review. Company B has a planning system to support the Demand planners and Supply planners work.

Figure 4.3: *A visualization of Company B's S&OP process (Roos & O'Meara, inspired by: Company B (2019)).*

Demand review

The attendees at the Demand review meetings are the Demand planning manager, Sales manager, Country manager, KAM, and Operations planning manager. The purpose of the product review meeting is to follow up on the sales plan, discuss new products, discuss the inventory, uncertainty, eventual problems and shortcomings. The goal is to discuss the areas that could affect sales and are held on a country level. With the help of the planning system, it is possible for the Demand planners to create a forecast on product level and then aggregate to total volume.

Supply planning
The attendees at the Supply planning meeting are the Demand planning manager, Operational planning manager, and each country's Terminal manager. The purpose of the meeting is to balance demand and supply and to create a plan for how to succeed with this. For Company B it is vital to utilize the maximum capacity, in their case inventory at their terminals. It is the Supply planners responsibility is to make sure that the terminals are used to 100 %. Their main market is season dependent which means that there will be a high demand during a few months.

Another challenge for the Supply planner is that Company B has two production lines with different production rates, which makes it crucial for the production to know exactly which product that is going to be produced in order to allocate capacity in the right production line. The Supply planners have the planning system which supports the work and enables a plan for how to balance the demand and supply.

Global meeting
At the Global meetings the main purpose is to decide which market segment to prioritize in order to balance the global demand and supply.

4.3.2 Product families

Company B is easily divided into distinct and separate industries and types of products. This made the categorization of the product planning levels a relatively straightforward process as the organization already was structured by the different markets and product types, which is displayed in Figure 4.4. The Main market stands for the majority of the sales volume and is dependent on seasonality. In addition to product type, the product families are also differentiated by sales price. This categorization facilitates a flexible production through capacity-sharing and the financial aspect simplifies the connection to the organization as a whole. The product subfamilies are based on the variation and similarities of the product components.

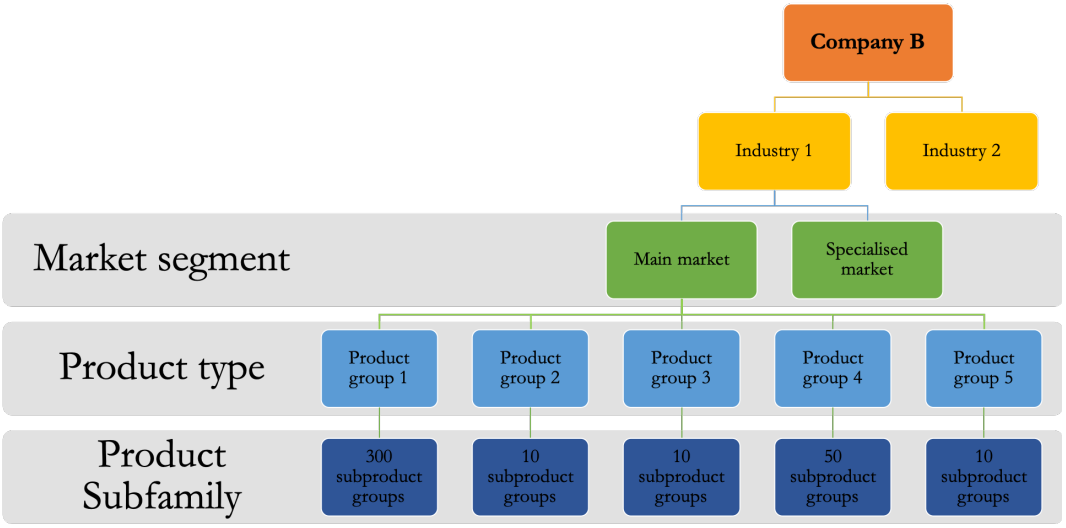

Figure 4.4: *A visualization of Company B's product hierarchy structure (Roos & O'Meara, inspired by: Company B (2019)).*

4.3.3 Within-case analysis

The Master Thesis students have analyzed the interview with Company B in order to identify key learnings and other findings of interest. These are summarized below:

- Good communication is vital for the S&OP process.
- The S&OP process should involve both the Sales and Operations department.
- Product families and the S&OP process is strongly tied to the organizational structure.
- It is important to discuss problems and deviations that have occurred.
- Comprehend what is important for the company, for example seasonality.
- It is important that there is trust in the process and that it is cross-functional.

4.4 Reference Company C

This interview was conducted with the Global S&OP manager at Company C which is a medium-sized chemical company.

Company C has an advanced system to support their S&OP process, which enables them both to create a forecast on a detailed level and scenario analysis for the production. The most crucial part of the S&OP process for Company C is to have management support, meaning that top management needs to prioritize and believe in the S&OP process. Furthermore, it is important that the data is correct, clean and validated and that decisions are made during the meetings. The S&OP process is not a logistics plan but instead a business plan. For example, this can be what market Company C should enter, which needs to be connected to the budget and strategy.

4.4.1 The Sales and Operation Planning Process

Company C started their S&OP process five years ago. The process is controlled centrally and has four steps following the structure in Figure 4.5 and cycles on a monthly basis. Company C has three different business areas, resulting in three S&OP processes, where Master region 1 stands for the majority of the sales volume, see Figure 4.6.

Figure 4.5: *A visualization of Company C's S&OP process (Roos & O'Meara, inspired by: Company C (2019)).*

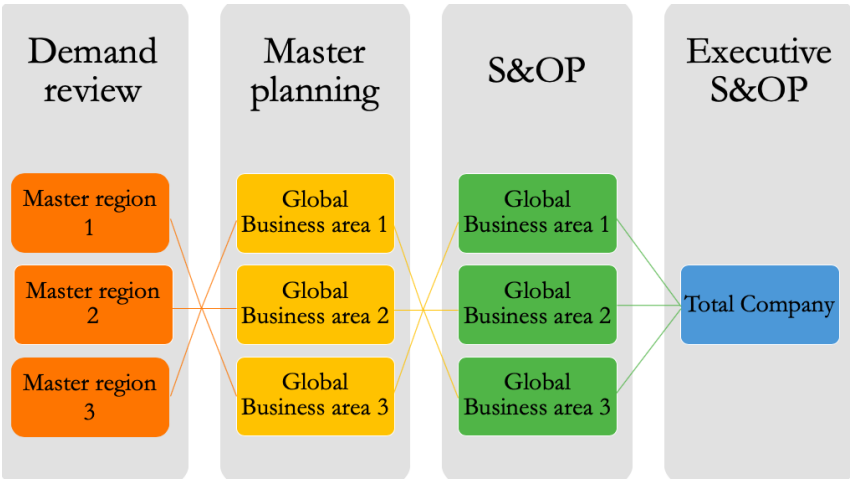

Figure 4.6: *A visualization of Company C's three S&OP processes (Roos & O'Meara, inspired by: Company C (2019)).*

Demand review

The Demand review starts with all the Global Sales managers estimating and filling out what is called the unconstrained forecast, where the total demand from the different markets is taken into account without taking capacity limits into consideration. When all the information is gathered the company's data system compiles it and creates a total forecast. The Demand manager then sets up meetings for each region, where the Sales manager and BU manager discuss the forecast.

Master Planning

The Demand manager and the Operations manager send the forecast and the capacity plan to Master planning manager. The Master planning manager then balances demand and supply with support from a supply planning system. This system simulates different scenarios based on both volume and margin while taking into consideration parameters such as inventory, capacity, demand, and other constraints.

S&OP

The main goal of the S&OP meetings is to make decisions in regards to deviations that have occurred. Managers from all the affected departments attend the S&OP meeting, including for example Production managers, Products managers, Supply chain managers, and etc.

Executive S&OP
Some decisions often have a too comprehensive scope for the S&OP phase to address. The primary purpose of the Executive S&OP meeting is to handle these issues and come to a conclusion of what actions need to be taken. In order to make these decisions, this meeting is primarily attended by Global planners and Group management.

4.4.2 Product families

Company C's product families are linked to the overall organizational structure, displayed in Figure 4.7. The company is divided into three business areas (i.e. main markets) which are then divided up in three BUs. Each business unit has one to four product families, that are based on the industry in order to allocate capacity in the production. These can then be broken down to the product level which includes more detailed information such as industry specification and application area. The final level is SKU which includes all components. With just a few components Company C has the possibility to create an extensive variation of products.

When conducting the S&OP process data is collected on the SKU level. This information is then compiled by the data system which aggregates this to the BU level. This way all information is available while simultaneously enabling planning. It also becomes possible to evaluate previous decisions by facilitating historical overview. The aggregation mirrors how the organization is structured from a financial point of view, which is essential as discussions must be held using the same terms. If two different kinds of categorization existed the communication and therefore also decisions would become much more difficult. The meetings are discussed at the BU or product family level since more details are unnecessary.

When planning Company C starts from SKU level (i.e. customer, material, and resources) and then aggregates it up to the BU. This makes it possible to track all the decisions back to its origin. Most importantly it is aggregated the same way as finance, which means that everyone talks the same language. During the meetings the discussions are held at product family or business unit level, since explaining it deeper will become too detailed.

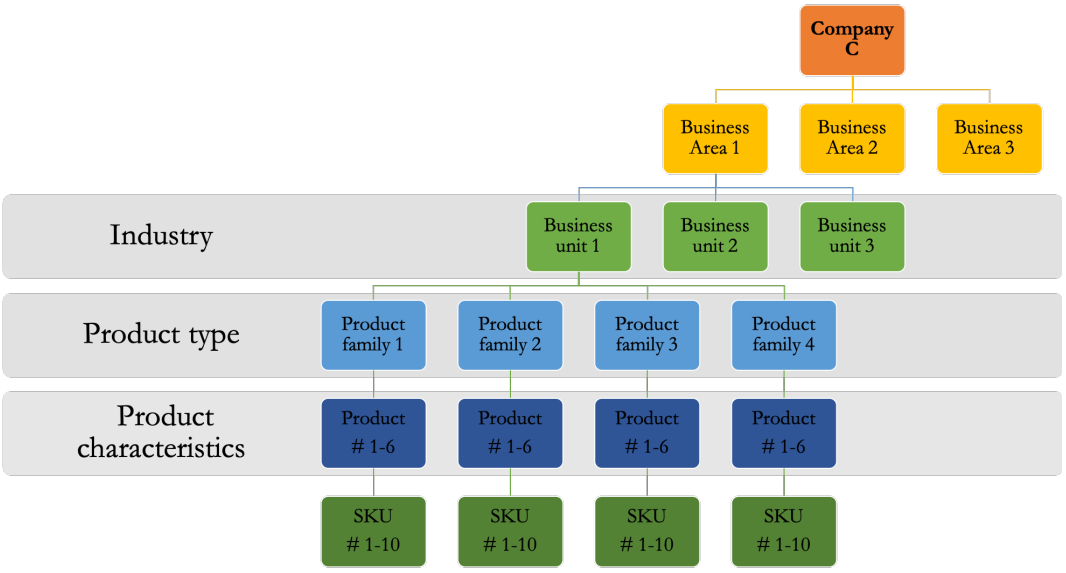

Figure 4.7: *A visualization of Company C's product hierarchy structure (Roos & O'Meara, inspired by: Company C (2019)).*

4.4.3 Within-case analysis

The Master Thesis students have analyzed the interview with Company C in order to identify key learnings and other findings of interest. These are summarized below:

- The product families should be easily defined and make sense for the company as a whole.
- The S&OP process and product families need to be linked to sales and the financial structure.
- Important to not have the S&OP meetings on a too detailed level, instead discuss on BU or product family level.
- Understand what is important for the organization, for example what type of industry and application the product is going to be used in.
- Depending on what industry the product is going to it will allocate different capacity in production.

- Have a bottom-up approach when planning.
- A good data system is vital for the S&OP process.
- Top management support is required.
- It is important that the data is correct, clean and validated.
- It is important that decisions are taken during meetings.
- The S&OP process is a business plan, needs to be connected to the budget and strategy.
- Important that the S&OP process is cross-functional.
- Everyone must use the same terms when discussing processes

4.5 Reference Company D

This interview was conducted with the Sales & Operations planner and Demand planning manager at Company D which is a medium sized technology company.

The most crucial part of the S&OP process for Company D is that everyone believes in the process. In order for S&OP to have a successful impact on the company, it needs to be recognized as an important process in the organization. For example, when an agreement has been made in regards to how to balance supply and demand it is vital that everyone works in alignment towards these goals.

4.5.1 The Sales and Operation Planning Process

Company D has recently started to implement its S&OP process which has led to that the process is currently structured in a slightly different way, as displayed in Figure 4.8. The plan, however, is to have a fully implemented

process soon, which will follow a more classic approach, see Figure 4.9. The current process has a cycle time of one month and is driven primarily by Demand planning. This means that Demand planning pulls information from the Product planning and Supply planning processes. The organization does not currently have a process of balancing supply and demand but is instead using an unconstrained forecast.

The main challenge of implementing the complete S&OP process will probably be to move from ”silo-thinking” (i.e. as separate functions) to re-conceptualizing the process as one whole cross-functional system. Furthermore, it might also be difficult to find the right level of aggregation.

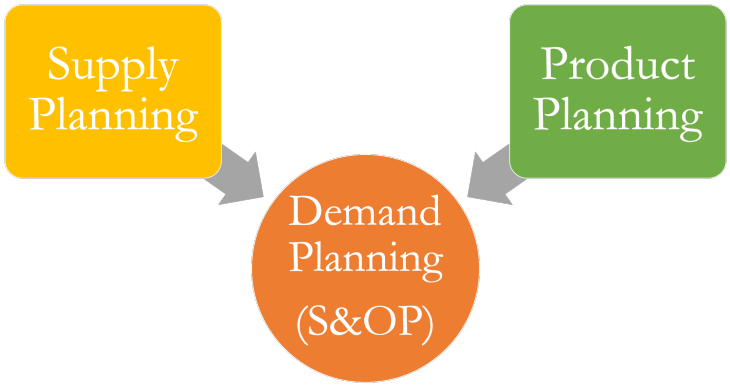

Figure 4.8: *A visualization of Company D's current ”S&OP” process (Roos & O'Meara, inspired by: Company D (2019)).*

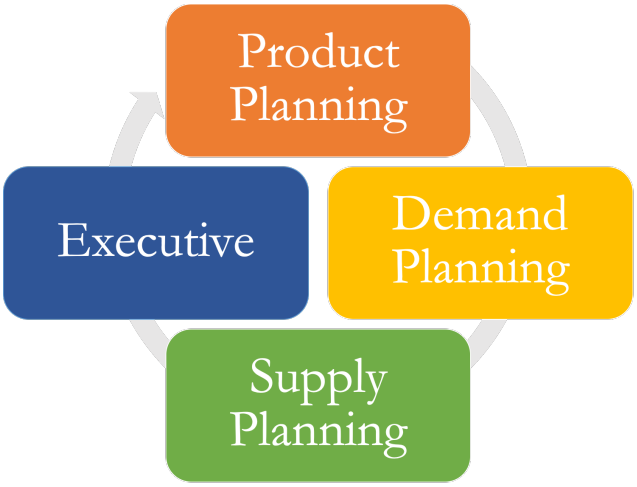

Figure 4.9: *A visualization of Company D's future S&OP process (Roos & O'Meara, inspired by: Company D (2019)).*

Product Planning
Company D introduces new products every month. This has led to a close collaboration with the Demand planners in order to estimate what the effects will be. Important aspects to consider could for example be how the new product will affect the sales of the current products, how the new product is going to be introduced, if any old product should be removed from the market, how the pattern of sales looks for similar products, or what the price should be for the new product.

Demand Planning
The Demand planners at Company D create the forecast and it is their responsibility to retrieve the relevant data from the Product planners, Supply planners and sales regions. The Demand planners have a close collaboration with the sales regions in order to notice for example markets trends or signals about larger customer projects. As Company D works with an unconstrained forecast, it is the Supply planners who make sure that the demand is fulfilled.

Supply Planning
The Supply planners do not at the moment have a clear S&OP process for balancing the supply with demand. They do however have great knowledge about Company D's suppliers, which is vital in order to work with the unconstrained forecast. The next step for Company D is to implement a more sophisticated process.

4.5.2 Product family

Company D focuses on innovation and as previously mentioned introduces new products every month. This means that *Research and Development* (R&D) has a strong influence on the organization. A visualization of the product hierarchy in Figure 4.10 shows that the majority of products are under Product code 1, which is also the biggest market for Company D in terms of volumes and financial value.

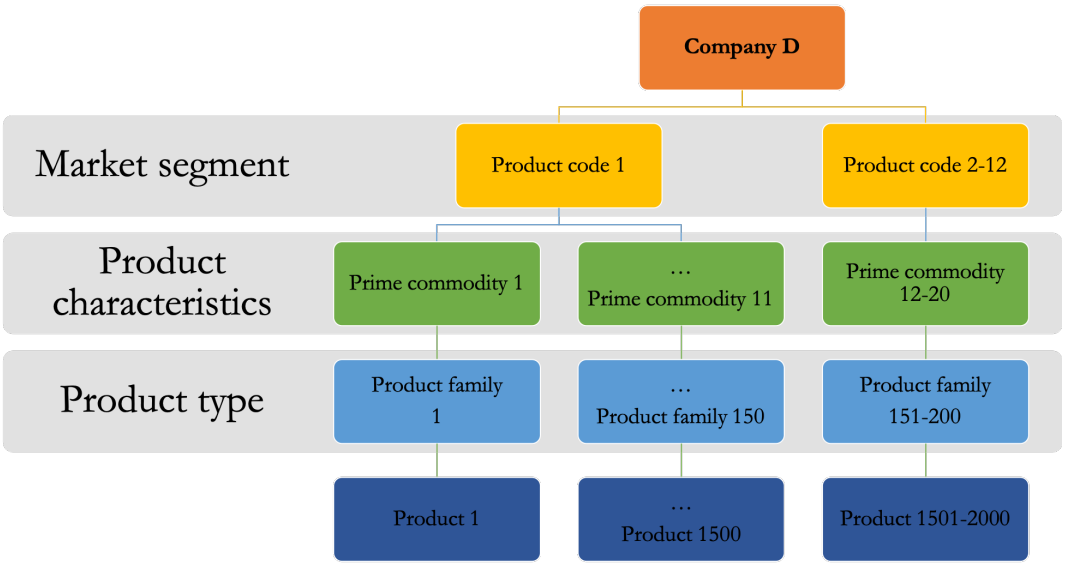

Figure 4.10: *A visualization of Company D's product hierarchy structure (Roos & O'Meara, inspired by: Company D (2019)).*

The product code level is the different market segments and the prime commodities level is primarily based on R&D. The Demand Planners, in general, have a specific Prime commodity which they are responsible for as well as the whole product portfolio that is associated with that Prime commodity. At the next level, product families are divided into inexpensive products, standard products, expensive products, and the shape of the product. At the last level, the products are typically divided into kind of usage, for example indoors or outdoors.

Company D's organizational structure is to a large degree structured after R&D, which is the driving department. This has led to the S&OP process following a similar structure. It would be difficult to change the categorization in the S&OP process as it would likely only make it more difficult to have separate groupings. However, the interviewees expressed interest in having a linkage to the customer segment, the maturity of market and margin as this would facilitate the forecasting.

4.5.3 Within-case analysis

The Master Thesis students have analyzed the interview with Company D in order to identify key learnings and other findings of interest. These are summarized below:

- It is important that the S&OP process has support and is trusted.
- The product families should be easily defined based on the organizational structure.
- The S&OP process in general must be linked to the organizational structure.
- It is important to have a person in charge of driving the S&OP process.
- Comprehend what is important for the organization. For example, R&D has a strong influence on the S&OP process for company D.
- The S&OP process should be cross-functional.
- It is important to have a close collaboration with the sales regions in order to comprehend the market.

4.6 Reference Company E

This interview was conducted with the Supply Operations Manager at Company E which is a small manufacturing company of electronic devices.

Company E supplies a wide portfolio of products and their products have a life cycle of approximately 20 years. The organization is currently changing the ERP-system, which in addition to the general benefits also will have some positive effects on their S&OP tools as well. This will hopefully make it easier for the Supply Chain Manager to plan the production. Company E is currently primarily using excel for their S&OP process. According to the Supply Operations Manager, the most important part of the S&OP process is that there

are mutual agreement and understanding from both Sales and Operations in the S&OP process. Sales work closely with the market and can create a better forecast than Operations, however, it is vital to communicate with each other in order for this to happen. The degree to which Sales correctly forecasts demand directly affects Operation's processes and thereby also service levels.

4.6.1 The Sales and Operation Planning Process

Company E started their S&OP process in 2016. The process includes three steps, as displayed in Figure 4.11 which cycles continuously on a monthly basis. During the process, the organization has one S&OP meeting. The Supply review phase and the Execution phase are conducted simultaneously due to that Company E has outsourced the production. The next step for Company E would be to include a follow-up phase.

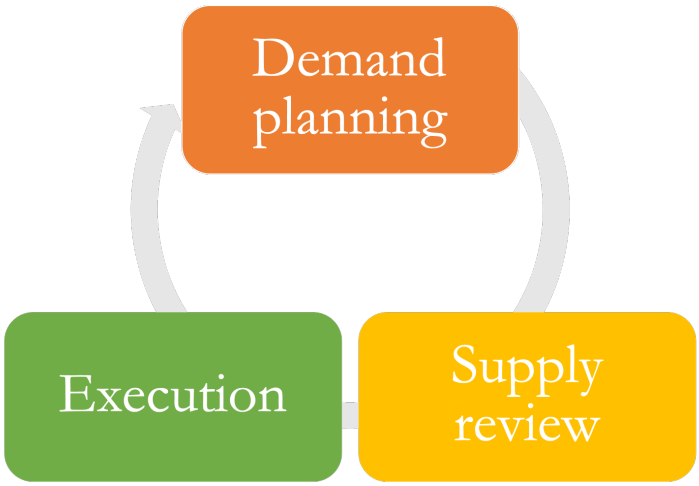

Figure 4.11: *A visualization of Company E's S&OP process (Roos & O'Meara, inspired by: Company E (2019)).*

Demand Planning

Company E's ERP system investigates the historical data and updates the *Last Twelve Months* (L12M) on a monthly granularity. This is done on the first day of every month. The ERP system together with the Master plan tool generates a forecast on the product family level. The first phase in the S&OP process takes approximately 2-3 weeks.

Supply review
Company E has outsourced the production to their suppliers. It is therefore important that the Demand planners update and communicate the forecast in order for their suppliers to estimate the needed capacity. They also discuss if there are any deviations in the forecast that are deviting from the normal. Communication and control is the main purpose of this phase.

Execution
The purpose of this phase is to execute on the information gathered in the previous phases. This means that all the purchase orders are placed, the updated forecasts are sent to the suppliers and the safety stock is updated.

4.6.2 Product families

Company E has three business units that are divided into three market segments respectively, see Figure 4.12. These market segments are based on customer and product type. The market segments are broken down to 14 Master product lines that are based on the split marketing does it, the majority is functionality, but could also be customer, product design, and manufacturing process. At the next step Company E has 28 production lines, which is the level of discussion and planning in the S&OP process. The final level is individual products.

Ideally, Operations would prefer to receive the forecast on the product level. However, this would be too time-consuming and would also result in low accuracy. The Sales department can create a relatively accurate forecast in regards to how many electronic devices that are to be sold, however due to country-specific functionalities a more detailed forecast becomes much more complex. Operations and Sales have therefore agreed to a forecast based on the Productions line level.

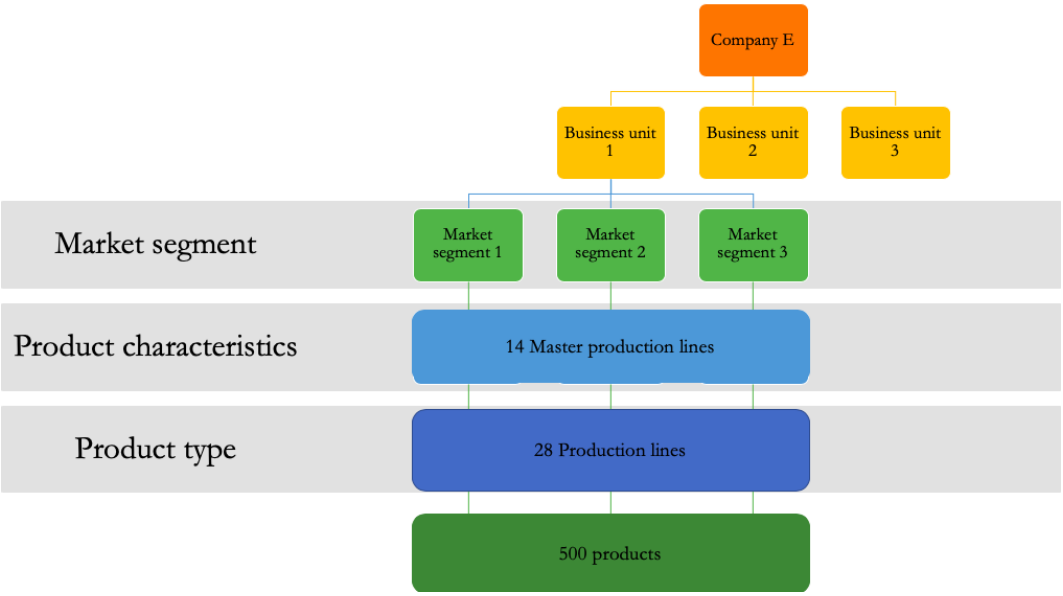

Figure 4.12: *A visualization of Company E's product hierarchy structure (Roos & O'Meara, inspired by: Company E (2019)).*

4.6.3 Within-case analysis

The Master Thesis students have analyzed the interview with Company E in order to identify key learnings and other findings of interest. These are summarized below:

- Having a high-quality data system improves the S&OP process.
- The S&OP process must be trusted and agreed upon.
- The S&OP process should be linked to the Sales department.
- Communication is vital.
- It is important that the S&OP process and product families are not discussed on a too detailed level.
- Discuss product families that have deviated from the normal.
- Product families exceed the recommended number.

- The product families have a strong connection to Operations.

4.7 Reference Company F

The interview was conducted with the S&OP Manager and Supply Planner at Company F which is a large manufacturing company. Company F supplies a wide range of products which all have a life cycle of approximately 60 years.

4.7.1 The Sales and Operations Planning Process

Company F started with S&OP in 2018 with the purpose to support their growth strategy, which for supply chain means to be responsive and competitive. The reason for introducing S&OP originated in that there was a gap between strategic and operational planning. This gap made it difficult for Company F to meet their growth goals, due to factors such as slow reaction time, firefighting in execution, growth plan not being linked to operations, bottlenecks in the supply chain not being defined, working in different directions and low trust. There is currently no specific data system for the S&OP process and the organization is instead using Excel.

The S&OP process at Company F is a monthly cycle consisting of four steps, see Figure 4.13. The process starts with Demand Planning and then goes through the following steps during the next four weeks. One important aspect is that the process is trusted and has support from top management. Having at least one person in charge of promoting and developing S&OP is one of the best ways to facilitate this. Furthermore, emphasizing the importance of collaboration and cross-functionality is central in order to make S&OP work.

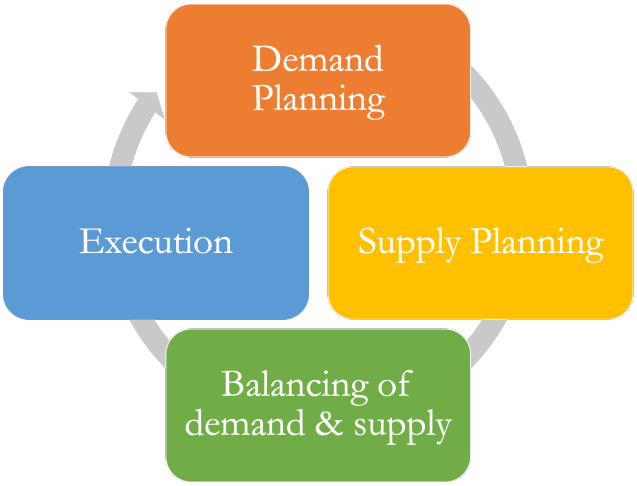

Figure 4.13: *A visualization of Company F's S&OP process (Roos & O'Meara, inspired by: Company F (2019)).*

Demand Planning

The purpose with the first step in the S&OP process is currently to create a sales forecast 15 months ahead based on local sales input. The Heads of the BU discuss and sign off the forecast before forwarding it to Operations. The output of the Demand Planning is at the moment a committed sales forecast 15 months ahead as well as the number of complete units in monthly buckets on article level. In the future Company F wants to be able to increase the horizon of the forecast to 24 months. This will however require further implementation of the S&OP process in general, new forecasting tools and especially a more sophisticated data system.

Supply Planning

The purpose of the second step is to balance local demand-supply plans, align the need for components between factories within the network, and create supply forecasts towards suppliers. The output of Supply Planning is the demand-capacity outlook for the coming 12-15 months which includes gaps, component forecasts (internal and external), and local recommendations of gap closure. At the Supply Planning meeting, the Supply planner and managers for the different production departments attend.

Balancing and decisions making

The purpose with the third step is to develop the best and most aligned decisions for the whole network built on an evidence-based demand-capacity plan

supported by scenario analysis and risk assessment. Coordination and collaboration are important in this part of the process. The output is one final committed S&OP plan. Decisions on which options to implement are based on the scenario analysis. The actual processes during this stage do not necessarily always align with the stated the purpose as Company F is still in the early stages of S&OP.

Execution
In the Execution phase actions are taken based on the output from the decision meeting in the previous step and if relevant carried into the next monthly cycle with the new forecast review. The final committed plan is communicated and executed upon. At the S&OP Execution meeting the S&OP Manager, Head of Sales/Service, Finance Manager, Head of Product Management/Marketing, Vice President of Production (Operations), and Business Unit Manager attend.

4.7.2 Product families

The categorization that is used today for forecasting is visualized in Figure 4.14. Company F has three categories based on size, which are broken down to approximately 400 product families.

The product families are based on material, size, manufacturing process, product type, sales, and finance. A challenge mentioned by the Supply planner relates to the large number of product families that have a high level of detail. This also affects the Demand planners that need to create forecasts on a very detailed level. Using product size instead of product type as product families would however lead to planning on a too aggregated level. At the moment there is an ongoing effort to create a new categorization of products which would be located between these two levels of aggregation. An aspect that is vital for the Supply planner is to comprehend the capacity needed in the production, since production lead time is not directly proportionate to the number of products in production.

The final challenge is a mismatch in communication between Sales and Operations due to having two different definitions of the categorization Product size. If the Demand planner and Supply planner do not keep these two defini-

tions separated correctly many problems can potentially arise. However, there is an ongoing discussion in regards to a name-change of these categories in order to simplify communication cross-functionally and to eliminate the risk of unnecessary problems.

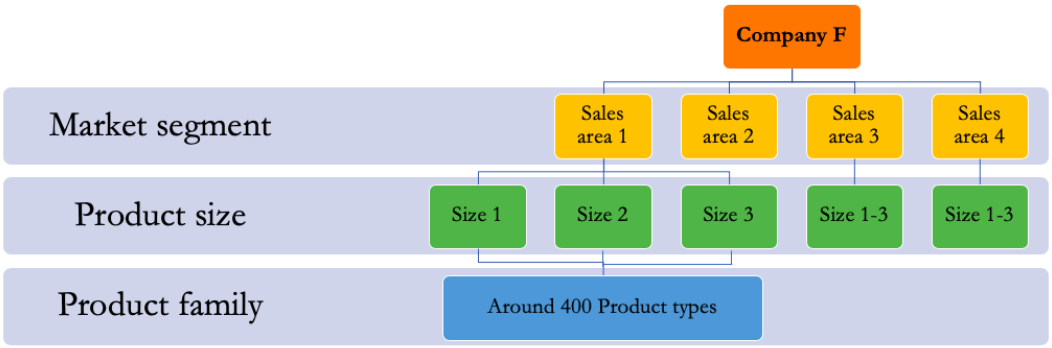

Figure 4.14: *A visualization of Company F's product hierarchy structure (Roos & O'Meara, inspired by: Company F (2019)).*

4.7.3 Within-case analysis

The Master Thesis students have analyzed the interview with Company F in order to identify key learnings and other findings of interest. These are summarized below:

- Problems occur if S&OP is conducted on the wrong level.
- Alignment and collaboration is important for the S&OP process.
- It is important that the S&OP process is not discussed on a too detailed level.
- It is vital that different departments use similar language and groupings of product families.
- Product families exceed the recommended number according to academic literature.
- Conscious decisions are important during meetings.

- The process must be trusted and cross-functional.
- Top management support is required.
- It is important to have a person in charge of driving the S&OP process.

4.8 Cross-case analysis

The purpose of the cross-case analysis is to gather information about key aspects about product families in order to strengthen the argumentation when proposing the process for identifying and creating product families in the next chapter. But first, an explanation of the result from the within case analysis is going to be presented. Thereafter, the factors of most significance will be further analyzed.

From the within-case analysis a table is created where all the listed key aspects from each benchmark are included, see Table 4.1. In the table, it is also possible to see that each company that has indicated that a statement is important is marked with an X and there is also a comparison to if the statement is backed by the academic literature. Lastly, the result of how many companies that have agreed with the statement is listed.

It should be noted that in the cases where the company did not specify a certain factor as important it does not mean that this specific factor is unimportant. Rather, the factors that the interviewee mentioned are the factors that he/she brought up during the interview or specified when asked which factors he or she believed to be the most important. Another aspect to consider is that the interviewees come from different departments and this might influence the degree to which he or she believes certain aspects to be important. It is possible that if asked, the interviewee would agree that a factor that was not mentioned also is important.

The analysis drawn is instead the magnitude of importance, as these answers are based on what the interviewee believed to be the most central to the S&OP process and the creation of product families. The reason for not asking every interviewee if they believed a certain factor was important was that the Master

Thesis students did not want to affect the answers by locking the responses to a certain number, area or type. Furthermore, one of the main reasons for doing the benchmarking was to see how the processes in practice deviated from the academic literature. The Master thesis students believed that providing certain answers before the interviewee had the possibility to answer the questions would risk skewing the responses through bias. The Master Students also did not want to bring up answers that previous companies had brought up, partly due to the same reasons mentioned above, but also since it was believed that the most methodically solid approach would be to have the same structure for each benchmarked company. The factors taken up in the cross-case analysis are therefore factors that were found after the benchmarking took place by investigating the answers recorded by audio and by notes.

As seen from Table 4.1 the degree to which the different factors were seen as the most important varies substantially from 0/6 to 6/6. For example, the importance of an advanced S&OP system might be dependent on the maturity of the S&OP process. In those companies where the process is not fully implemented or the employees involved have not fully understood the benefits, there is no point in complicating the process with a new system. In order for the system to work properly, it is vital that the data is correct, clean, and validated or else the system will most likely harm rather then benefit the process.

One interesting factor to note is that the recommended amount of 6-12 product families is not applied or discussed as important by any of the companies. According to the literature 6-12 product families is optimal since it would be too time-consuming to discuss more product families. Company A, B, and C have around 4-5 product families that are discussed at the S&OP meeting, while Company D, E, and F has around 20-40 product families. One reason for this could be that the number of product families is not prioritized and that there instead exist other functions that are more important. Some competing aspects can, for example, be that it should be logical for the organization to use these product families and that there should be enough information available at the S&OP meeting in order to make decisions. Another aspect of this is that the organizations have not challenged the current product families and that there is a possibility, especially for Company D, E, and F, to aggregate there product families more.

Table 4.1: *A Cross-Case Analysis of important factors from the six benchmarked companies.*

Within-Case factors	**A**	**B**	**C**	**D**	**E**	**F**	**Supported by theory**	**Result**
Use the same terms to describe processes and product families	X		X			X	yes	3/6
Conscious decisions	X		X			X	yes	3/6
Trust is vital	X	X	X	X	X	X	yes	6/6
The processes must be cross-functional	X	X	X	X	X	X	yes	6/6
Having a high quality data system improves the S&OP process			X		X		Maturity and data quality dependent	2/6
It is important that the data is correct, clean and validated			X		X		yes	2/6
The S&OP process needs top management's support in order to be successfully	X		X	X		X	yes	4/6
Having a person that drives the S&OP process				X		X	yes	2/6
Discuss product families that have deviated from the normal	X	X			X		yes	3/6
6-12 Product families							yes	0/6
The S&OP meetings should be discussed at an aggregated level					X	X	yes	2/6
Product families need to be linked to Operations		X			X		yes	2/6
Product families need to be linked to Finance	X		X				yes	2/6
Product families need to be linked to the organizational structure	X	X	X	X			yes	4/6
Product families need to be linked to Sales		X		X	X		yes	3/6

In Table 4.2 the ranking of the result from Table 4.1 is visualized. Highest listed is ”Trust is vital” and ”The process must be cross-functional”. These factors together with ”The same terms needs to be used to describe processes and product families”, is highly linked to the literature. In order to have a successful S&OP process, communication and trust is of highest importance and it is crucial that both Sales and Operations have the same definition for the product families. If not, it becomes difficult to communicate for example during the meetings, conversion from units to the allocation of capacity in production becomes complex and it complicates root cause analysis if they are to be performed.

From the table, it is also possible to see that almost all companies agree that the product families should be linked to organizational structure and thereafter Sales and Operations. This is in line with the subject above, in order for the product families to work they must be logical for both Sales and Operations. The reason that Finance has not been as prioritized is that its importance depends on the maturity of the process in the organization. There is a successor to S&OP that is called Integrated Business Planning where finance is much more integrated in the process.

Table 4.2: *The Cross-case factors listed by result from Table 4.1.*

Rank	**Cross-case factors**
1	Trust is vital The processes must be cross-functional
2	Product families need to be linked to the organizational structure The S&OP process needs top management’s support in order to be successfully
3	Conscious decisions Use the same terms to describe processes and product families Discuss product families that have deviated from the normal Product families need to be linked to Sales
4	Product families need to be linked to Operations Having a high quality data system improves the S&OP process It is important that the data is correct, clean, and validated Having a person that drives the S&OP process The S&OP meetings should be discussed at an aggregated level Product families need to be linked to Finance
5	6-12 Product families

Lastly, the interviewees also mentioned that there are different aspects that are important for the organization. This affects the product families significantly, depending on what is vital for the organization to control and achieve. In Table 4.3 each company has been listed with a factor that is important for the organization when choosing product families (as the Master Thesis Students have interpreted it).

Table 4.3: *A visualisation of the different aspects that is important for each of the organizations.*

Company	**Important for the organization**
Company A	Promotions
Company B	Max capacity
Company C	Industry
Company D	R&D
Company E	Market specification
Company F	Allocation of capacity

Company A

Company A sell a large amount of products through promotions in order to have better control over the demand by creating their own seasonality. This makes it crucial for the organization to have control over their production lines, as it would overload the production if the Sales department would promote products that share the same production line.

Company B

For Company B it is important to maximize the capacity, which means to always have 100 % capacity at their terminals. This makes it vital for the organization to have control over which product that is going to be produced in order to know its characteristics such as seasonality, and production rate, etc.

Company C

For Company C it is important to know which industry the product is associated with, since this affects the composition at SKU level. The organization can create a large variety of products by changing just a few components, which makes it important to know which application area the final product is going to be used in.

Company D

Company D is an innovation company and has new product launches every month. It is therefore vital to have a connection between R&D and the product families. This especially facilitates the process for adding new products into product families.

Company E

For Company E it is important to comprehend market specifications as this is what the production lines are built up by. As different markets have different rules and regulations this is central to how the organization plans their production.

Company F

The key aspect for Company F is capacity allocation. In order to meet their supply chain strategy of being more responsive and competitive, it is vital to be able to have control over the lead time in the production. By understanding where in the production to allocate capacity, their service levels accuracy are significantly improved.

The conclusion that can be drawn from the important aspects discussed is that the essence is to simplify the production through knowledge of the market. With the help of product families, it becomes easier to comprehend and control unexpected changes. The final goal is to have satisfied customers and by allocating the right capacity in the production it becomes much easier to meet the demand.

Another interesting observation is that the organizations have not changed their product families since they started with the S&OP process unless organizational structure has changed. For all the organizations the grouping has been logical and it would not make sense to organize the product families is in any other way.

Chapter 5

Building the solution

Based on the information from the theory and benchmarking companies a workshop was performed at Alfa Laval. The purpose of the workshop was to comprehend if it would be of value to include it in the final process for creating product families. The outline of the workshop is going to be presented in this chapter. Note: in order to preserve company secretes specific details are kept confidential.

5.1 Workshop

As previously statet, the purpose of the Master Thesis is to create a process for how to create product families as well as creating product families for Alfa Laval Lund GPHE. The workshop was held in order to investigate if a workshop would add value to the process and to investigate if the product families developed by the Master Thesis students for Alfa Laval Lund GPHE were applicable. Due to the confidential material, the suggested product families will not be discussed in this section.

5.1.1 Participants of the workshop

Employees from different departments participate in the workshop in order to get as many relevant viewpoints as possible. The participants are presented in Table 5.1.

Table 5.1: *A list of the participants from Sales and Operations.*

Operations	**Sales**
S&OP Manager	Product and Application Engineer
Supply planner	Product and Market Engineer
Product Group Planner	
Unit Managers from the different departments	
Factory manager	

5.1.2 Outline of the workshop

The recommended product families will be presented to the workshop. The participants were then divided into smaller groups, where all the groups had participants from both Sales and Operations. The groups were then to answer the following questions:

1. What are the advantages of the new product families?
2. What are the risks of the new product families?
3. Is there any grouping of products that do not work? If so, why not?
4. Is there another way to group the products into product families?

When all the groups have discussed the product families they are going to present their result and there will be a group discussion.

5.2 Discussion

5.2.1 Workshop result and evaluation

The workshop exceeded the expectations and all the participants were dedicated and offered many constructive ideas. Overall the participants approved of the product families, however there were some groups that were changed due to specific restrictions from either Sales or Operations. The primary objections regarded products that could be seen as obsolete or rare, products that could be manufactured in the same production line, or products with specific functionalities. The suggested respective solutions were to remove some of these product families, to combine products with similar production process in the same product families and to add new families for those with specific functionalities.

5.2.2 Evaluation of the workshop participants

It was very productive to have representatives from both Sales and Operations attend since they could explain and discuss why it was important to include or exclude certain products from the product families. This was primarily valuable as this challenged both departments pre-conceived notions of what the most significant factors were and to take other views into account. This made it possible for the Master Thesis students to improve the groupings as knowledge of important aspects and prioritization became available.

The workshop could be improved further by having additional employees from the Sales department attend. The representatives that were present were very knowledgeable within their field, however a matching number to the representatives from Operations would probably have facilitated the discussions even more. It would also have been beneficial to have employees from Finance to attend in order to get an additional perspective.

5.2.3 Evaluation of the workshop questions

The primary aspect that could have been improved was related to the fourth question ”Is there another way to group the products into product families?”. This question garnered a lot of response, but the Master Thesis students would have wished a more in-depth discussion regarding *why* the workshop's improved product families were to be grouped the proposed way. This question was answered to a large extent, but further investigation into this issue would have been very valuable. The change is displayed in Table 5.2:

Table 5.2: *Old and new formulation of question 4*

Old formulation	Is there another way to group the products into product families?
New formulation	Is there another way to group the products into product families and why should it be grouped in this way?

5.2.4 Concluding remarks

Skriva en avslutade reflektion kring genomförandet av workshoopen. Vad var bra? Vad kunnde ha gjort annorlunda?

Chapter 6

Recommendation

In this chapter, the suggested process of how to create product families is going to be presented. First, the process is going to be presented followed by an in-depth explanation of the steps. Lastly, two additional processes are going to be presented that relates to following up the accuracy of the new product families and how to add new product in the product families.

6.1 Generic process for identifying product families

This Master Thesis project has used primarily three aspects in order to develop a process for creating product families. These are theoretical research, empirical research and the experience gained from creating product families at Alfa Laval. The combination of these aspects has given the Master Thesis students an extensive and multi-faceted insight into how a company should proceed when creating product families. The developed process is based on these findings, which also takes observed common pitfalls into consideration.

6.2 Generic process

The developed process consists of six stages which is shown in Figure 6.1 below.

Figure 6.1: *A visualization of the Product Family Process (PFP) (J. Roos & E. O'Meara, 2019)).*

6.2.1 Gather data

The first step is to understand the affected department's processes and to define what factors that are important in their work. This lays the foundation for comprehending the internal needs of each department. Without this understanding future suggestions might not be applicable or integrable with the company. This does not mean that certain changes within the company will not be warranted, however, such changes must also be based on the organization's current situation. The Master Thesis students suggest that interviews should be conducted at least once with preferably more than one key person from the affected departments. The departments and employees of interest are listed in Table 6.1.

Table 6.1: *Departments and employees of interest*

Department	**Employee**	**Purpose**
Sales	Demand Planning Manager, Application Engineer	Comprehend market segmentation and product requirements from a Sales perspective
Operations	S&OP Manager, Supply Planning Manager, Department Managers	Comprehend product requirements and production requirements from an Operations perspective
Finance	Controller, Global Processor	Comprehend the connection between finance and products

Recommended questions to ask the employees mentioned above can be found in Appendix A.1.

6.2.2 Production Flow Analysis

A method presented in the literature is PFA, which helps finding patterns between for example products and production lines, see figure 6.2. This method can be modified after what makes the most sense for the company, for example finding patterns between products and equipment, products and markets, production lines and markets, etc.

The next step in the process is to create a PFA in order to comprehend similarities in the company. If it is not obvious which parameters to use on the axes, different scenarios can be created with different PFA, where it might be easier to understand what is vital for the company.

PRODUCT	PRODUCTION LINE				
		LINE 1	LINE 2	LINE 3	LINE 4
	PRODUCT 1	X	X		
	PRODUCT 2	X	X		
	PRODUCT 6	X	X		
	PRODUCT 3			X	X
	PRODUCT 4			X	X
	PRODUCT 5			X	

Figure 6.2: *Production Flow Analysis (Roos & O'Meara, inspired by:(Olhager, 2000)).*

6.2.3 Map the current product family structure

The third step is to map the current product family structure. This is done with the information retrieved from previous steps. The Master Thesis students have found that most companies have some kind of internal hierarchy of aggregation, even if it not necessarily is stated.

6.2.4 Modification

The purpose of the stage is to investigate if the current product families are appropriate and if they can be grouped in a more advantageous way. There are several aspects to take into consideration when investigating this matter and when creating new product families.

The first aspect is that the product families must have a connection to the organizational structure and needs. Product families have a functional purpose and must, therefore, be aligned with the company in general. If an overall structure and product hierarchy exist, the suggested product families must at least in part make sense from this perspective. The same applies to the needs of the company, a product family categorization that does not facilitate the overall business plan is not useful. For example, if a company relies on running

promotions in order to control demand, the product families should support or at least not complicate this performance.

It is highly recommended that the product families are linked to Sales, Operations, and Finance, meaning that it is important to take factors from all these departments into consideration. What these factors are, depends on the organization and should be discovered in the previous stages. The main logic is that even if one department strongly advocates for a certain categorization, this categorization must also work for the other departments. The goal is to find common denominators between the different viewpoints. For example, Operations may want to divide the products by product lines while Sales wants to divide the products by market. Can there be any reconciliation between these categorizations? Is there, at least in part, overlap between the different suggestions? These are the kind of questions that should be investigated during this stage. Being able to connect the product families to financial terms makes it easier to motivate changes to top management.

The organization must use the same categorization and terms. This has partly to do with alignment with the organization in general, but primarily with facilitating communication. Clear communication within S&OP is very important since it is a cross-functional process which relies on effective meetings where not everyone has the same expertise. If different departments have different categorizations this will only further confusion during the process.

It is important to have a reasonable number of product families. Academic literature suggests 6-12 product families as an approximate amount. This number should precisely be seen as just an approximate amount as it is more important that the product families fulfill the previously mentioned aspects. However, the logic behind this number is correct; make sure that the company has a reasonable amount of product families. Too few will not facilitate the allocation of resources and too many will not be manageable during meetings.

The final aspect is to remember that not every single product needs to be included in the product families. The focus should instead be on products that are relatively common, drive large volumes, have high financial impact and/or create bottlenecks in the production. The purpose of S&OP is to balance demand and supply and the product families should facilitate this.

With these aspects in mind, a reasonable categorization of product families can be created. This will require balancing some of the different interests in order to create an overall structure that works for the company as a whole.

6.2.5 Workshop

The fourth step is to evaluate the suggested solution. This is best done by conducting a workshop where representatives from the departments of interest attend. The workshop should be focused on evaluating the proposed product families where the representatives discuss the benefits and disadvantages of the new product families. It is also important that alternative groupings for product families are suggested if the proposed solution is lacking. The attendees should be divided into groups consisting of employees from different departments in order to bring different perspectives into the discussions. A key aspect is to precisely define the questions in order to keep the discussion on track and to give the attendees a clear sense of purpose. A suggested template of questions is displayed below.

1. What are the advantages of the new product families?

2. What are the risks of the new product families?

3. Is there any grouping of products that do not work? If so, why not?

4. Is there another way to group the products into product families and why should it be grouped in this way?

When all the questions have been answered it is very beneficial to have a general discussion between the groups where the solutions are presented and evaluated.

During the workshop, it is important that the groups write down their ideas and answers to the questions. It is suggested that the groups are given clear models for how to write down their solutions, for example by condensing the answers to benefits/disadvantages as well as proposed improvements. This makes an overview of the workshop easier, especially when analyzing the results afterward. During the final discussion, it is suitable for at least one of the

workshop hosts to take notes, as new aspects may emerge that have not been written down.

6.2.6 Final revision & Decision

The input from the workshop should now be analyzed. If any questions have arisen after the workshop it is important to contact the appropriate person to clear up these issues. The recommendations should thereafter be applied to the previous product family groups. The final solution has now been created.

6.3 After the process

When the product families have been created it is important to follow up and investigate if the categorization works. Additional changes may be needed. It is also important to make a plan for how new products are to be introduced to the product families and how obsolete products are to be removed. If it is decided to not include certain products in the product families due to for example rarity, a plan for how to handle these should also be made.

6.3.1 Follow up

It is important to follow up and investigate if the created product families actually facilitate the S&OP process. The purpose with the product families is to make it easier for the Demand planner to forecast and the Supply planner to plan production. However, there are a lot of factors that can have an impact on the success of the product families. These are primarily:

- The reliability of the forecast
- The reliability of the product plan
- The reliability of the conversion keys that the Demand planner and Supply planner might use

If the factors above are performing correctly but the product family still has a low performance score it is important to analyze the product families. For example there might be a product that has significantly lower performance compared to the other products in that family, as visualized in Table 6.2. There are many other ways in which the product families might not be accurate, for example if they are not applicable to the situations that arise during the planning process.

Table 6.2: *A visualization of a product family that has scored low in performance.*

Product family A	**S&OP Commitment (units)**	**Actual (units)**	**Performance**
Product 1	5000	4550	91%
Product 2	500	495	99%
Product 3	4000	3905	98%
Product 4	4500	2000	44%
Total			**83%**

6.3.2 New product introduction

When a new product is to be introduced it is vital to investigate whether a new product family is needed, if it can be grouped in an existing product family or if it should not be grouped into any product family at all. The decision process and steps required to determine which of these scenarios is to be implemented is described by a process visualized in Figure 6.3.

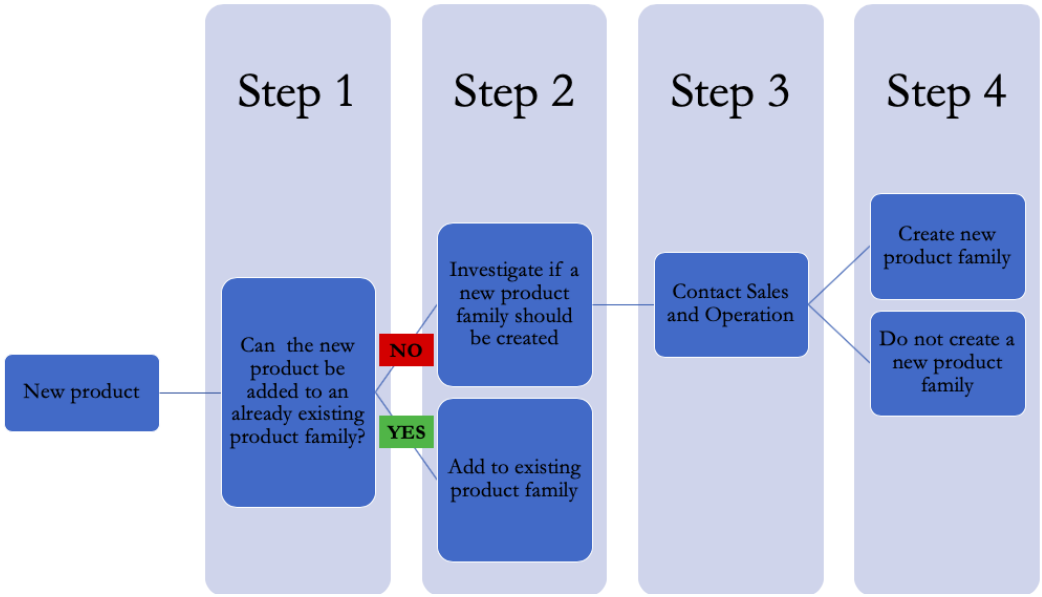

Figure 6.3: *A visualization of the process for identifying if a new product family is needed (J. Roos & E. O'Meara, 2019).*

Step 1

The first step is to investigate if the new product can be added to an existing product family. Based on the decided logic of how the product families should be categorized this should not be a big problem. It can however be beneficial to have a dialogue with Sales, Operations and/or any other department responsible for introducing it in order to make sure that there are no new characteristics which makes this product differentiate from the existing product families.

Step 2

If there are no characteristics which makes the product unfit for current product families, it should be added to an existing product family. However, if this is not possible the next step is to investigate if a new product family should be created or if no product family is needed. In order to determine which of these scenarios to proceed with it is important to ask the following questions:

- Will the product drive high volume?
- Will the product have high financial impact?
- Will the product drive high capacity in production?

If the answer to all of these questions are no there is no need to create a new product family. However, if the answer is yes to any of these questions, a new product family should be created.

When creating a new product family it is important to investigate which characteristics the product has which makes it unfit for the current product families. It is probable that the logic of the new product family is associated with this aspect. It may also be beneficial to add the new product in the PFA in order to find similarities with the old products and resources. This creates a deeper understanding of the product. The last part of this step is to prepare a suggestion for Sales and Operations regarding if the product needs a new product family or why no product family is needed.

Step 3
The purpose with this step is to check with Sales and Operations if the suggestion created in step 2 works for both departments. If a new product family has been developed, make sure that this is an appropriate categorization. Do necessary revisions based on the feedback.

Step 4
Execute the decision made in step 3.

Chapter 7

Conclusion

The conclusion of the Master Thesis project is presented in this chapter. Firstly, the research question is answered. Secondly, the limitations of the Master Thesis project are discussed, which is followed by an examination of future research and the project's contribution to theory.

7.1 Answer to the research question

When initiating the Master Thesis project, a research question was formulated in order to specify the goal of the study. This research questions is in summary answered in this section.

What should the generic process for identifying and creating product families be?
Through theoretical studies, empirical studies and experience at Alfa Laval the Master Thesis students have developed a generic process for identifying and creating product families, shown in Figure 7.1.

Figure 7.1: *The Product Family Process for identifying and creating product families (J. Roos & E. O'Meara, 2019)).*

The process consists of six steps which starts with gathering relevant data about the current processes and departments, evaluating and mapping the situation and finally developing a categorization for the product families. This categorization is then assessed and discussed with key representatives for the departments of interest during a workshop. Based on the feedback, a final revision is conducted. It is also suggested to do a follow up of the process and develop a plan for how to deal with new and obsolete products as well as eventual products not included in the product families.

7.2 Limitations

The main limitations of the study were primarily caused by the limited time frame. If the project would have proceeded longer a more in-depth analysis could have been made. For example, this concerns the number of companies investigated, the number of people of interest interviewed and the number of times each individual person was interviewed. Conclusions drawn from a too small data-set may be misleading.

Since this project was concluded when the proposed solution was completed, there has been no possibility to evaluate the outcome of implementing the process. Furthermore, due to scope, this study did not include any calculations, financial or otherwise. Had such been performed the proposed solution would have an additionally strong foundation.

7.3 Future research

The most evident future research would be to investigate the outcome of the proposed process on a large scale. It would also be interesting to explore if there were different areas for organizations to focus on depending on the maturity of the company and the maturity of their planning process.

7.4 Contribution to theory and Alfa Laval

The study seeks to develop an understanding of how to create product families. The subject has in previous literature, though mentioned and to a certain degree investigated, not been explored to a great depth compared to for example the S&OP process in general. The Product Family Process has been created in order to expand this academic area. The purpose has been to create a process which is as generic as possible, while simultaneously containing processes and guidance to the degree which also addresses more specific problems.

The study also seeks to explore the S&OP process in general. Even though the Master Thesis project was aimed at how to create product families, this involved several aspects of the S&OP process. Through the empirical studies, information regarding the key factors for successful S&OP was obtained.

The contribution to Alfa Laval is the proposed categorization of product families. In addition, a Handbook has also been created which contains the generic process developed for identifying and creating product families, with specific advice for Alfa Laval. This can be used in order to develop product families at other Alfa Laval sites.

References

Alfa Lavala. (2018). *About alfa laval.* Retrieved from https://www.alfalaval.com/about-us/

Alfa Lavalb. (2018). *How gasketed plate heat exchangers works.* Retrieved from https://www.alfalaval.se/microsites/packningsforsedda-plattvarmevaxlare/verktyg/hur-packningsforsedda-plattvarmevaxlare-fungerar/

Alfa Lavalc. (2018). *About alfa laval.* Retrieved from https://www.alfalaval.com/investors/in-brief/

Björklund, M., & Paulsson, U. (2012). *Seminarieboken.* Studentlitteratur AB.

Chapman, S. N. (2006). *The fundamentals of production planning and control.* Pearson Education, Inc., Upper Saddle River, New Jersey.

D'Alessandro, S. (2018). *Align your decision-making with sap ibp - implement consulting group.* Retrieved from https://implementconsultinggroup.com/align-your-decision-making-with-sap-ibp/

Grimson, J. A., & Pyke, D. F. (2007). Sales and operations planning: an exploratory study and framework. *The International Journal of Logistics Management,*, *18*(3), 322–346.

Höst, M., Regnell, B., & Runeson, P. (2006). *Att genomföra examensarbete.* Studentlitteratur AB, Lund.

Höst, M., Runesson, P., Dybå, T., & Cruzes, D. (2014). Case studies synthesis: a thematic, cross case, and narrative synthesis worked example. *Springer Science+Business Media New York.*

Laerd Statistics. (2012a). *Construct validity.* Retrieved from http://dissertation.laerd.com/construct-validity.php

Laerd Statistics. (2012b). *External validity.* Retrieved from http://dissertation.laerd.com/external-validity.php

Laerd Statistics. (2012c). *Internal validity.* Retrieved from http://dissertation.laerd.com/internal-validity.php

Laerd Statistics. (2012d). *Reliability in research.* Retrieved from http://dissertation.laerd.com/reliability-in-research.php

Olhager, J. (2000). *Produktionsekonmi.* Studentlitteratur, Lund.

Olhager, J. (2018). Sales and operations planning, lecture material. *Lund University*.

Olhager, J., Rudberg, M., & Wikner, J. (2001). Long-term capacity management: Linking the perspectives from manufacturing strategy and sales and operations planning. *Int. J. Production Economics*, *69*, 215–225.

Pentz, K. (2016). *The differences between demand planning, forecasting and s&op.* Retrieved from `http://demand-planning.com/2016/05/30/the-difference-between-demand-planning-forecasting-and-sop/`

Sheldon, D. H. (2006). *World class sales & operations planning; a guide to successful implementation and robust execution.* Co-published with APICS.

Surbhi, S. (2016). *Difference between primary and secondary data.* Retrieved from `https://keydifferences.com/difference-between-primary-and-secondary-data.html`

Tuomikangas, N., & Kaipia, R. (2014). A coordination framework for sales and operations planning (s&op): Synthesis from the literature. *Int. J. Production Economics*, *154*, 243–262.

Vereecke, A., Vanderheyden, K., Baecke, P., & Steendam, T. V. (2018). Mind the gap – assessing maturity of demand planning, a cornerstone of s&op. *International Journal of Operations & Production Management*, *38*(8), 1618–1639.

Wallace, T. F., & Stahl, R. A. (2008). *Sales & operations planning - the how-to handbook.* Wallace & Company, United States of America.

Yin, R. K. (2006). *Fallstudier:design och genomförande.* Liber AB.

Ånell, H. (2019). *Supply planning at alfa laval.*

Appendix A

Protocols

A.1 Internal interview at Alfa Laval

- **Introduction**
  - Presentation of the students
  - Presentation of the purpose of the thesis project
  - Presentation of the purpose and agenda for the interview
- **Introductory questions**
  - Interviewees position and responsibilities within the company
- **Main questions - S&OP manager**
  - When did Alfa Laval start with the S&OP process?
  - Has Alfa Laval made any major changes since the start (e.g. change the product families, change the system, or etc)?
  - Can you describe the S&OP process at Alfa Laval?
  - What is the purpose of the steps?

- Who attends the meetings?
- What is the outcome of the steps?
- What decisions should the participants be able to take at the meetings?
- What information is needed in order to take these decisions?
- What do you think is most important in order to have a successful S&OP process?
- If you would have created product families how would you have grouped them?
- Why would you have grouped them this way?

- **Main questions - Sales and Finance**
  - How does the Demand Planning process work at Alfa Laval?
  - What is important to know regarding forecasting?
  - What is the ”ideal” level of information when forecasting?
  - If you would have created product families how would you have grouped them?
  - Why would you have grouped them this way?
  - What names do you have on the products and aggregation levels?
  - What is important to know about the products?
    - Are there any products that can not be grouped together?
    - Are there any products with special functionalities that needs to be separated in order to forecast correctly?
    - Customer related regulations?

        - High volume products or standard products?
        - Project base products?
        - etc.
    - *Ask for help in order to create a PFA.*

- **Main questions - Operations**
    - How does the production work at your department?
    - What is important to know about your department?
    - Is there any bottlenecks that are important to know?
    - How would you preferred to group the products?
    - Are there any similarities between the products?
    - Which production lines can produce which products?
    - *Ask for help in order to create a PFA.*
    - If the interviewee participate in the S&OP meetings ask:
        - What decisions do you want to take at the meetings?
        - In order to take these decisions what information do you need?
    - If the interviewee is involved in the supply planning ask:
        - How does the planning work today?
        - Is this the right level of detail on the information you receive?
        - Is there any problem today?
        - How would you group the products?

- **Main questions -**

- **Conclusion**
    - Final comments
    - Verification and summary of the interviewees answers

Any notes taken from the interview were to be transcribed at the latest one day after the interview.

A.2 Benchmarking

- **Introduction**
    - Presentation of the students
    - Presentation of the purpose of the thesis project
    - Presentation of the purpose and agenda for the benchmarking study
- **Introductory questions**
    - Interviewees position and responsibilities within the company
- **Main questions - S&OP Process**
    - When did Company X start with the S&OP process?
    - Have you done any major changes since the start (e.g. change the product families, change the system, etc)?
    - Can you describe the S&OP process at Company X?
    - Does you process include the ”normal” steps? If not, can you describe the steps in Company X process?
        * Data Gathering

    - Demand Planning
    - Supply Planning
    - Pre-Meeting S&OP
    - Executive meeting
  - What is the purpose of the steps?
  - Who attends the meetings?
  - What is the outcome of the steps?
  - How long is the process? One month in total?
  - What do you think is most important in order to have a successful S&OP process?

- **Main questions - Products**
  - How many products does Company X have today?
  - How often do you introduce a new product to the market?
  - Can Company X produce different products in different production lines?
  - Do you have any specific bottlenecks that affect the S&OP process?

- **Main questions - Product family**
  - What does the product structure look like at Company X (i.e. product families)? *Show the hierarchy list from Acme Widget, see 3.3.1.*
  - How did Company X create product families?
  - What is Company X's product families based on?

  - How many product families does Company X have on the S&OP level?
  - How many product families does Company X have on the Master Planning level (i.e. product subfamilies)?
  - Was it hard to find the right level of aggregation (i.e. how much information is going to be available at each level)?
  - Are Company X's product families based on any bottlenecks?
  - Does the interviewee have any tips when creating product families?

- **Does the interviewee wish to add anything?**
- **Conclusion**
  - Final comments
  - Verification and summary of interviewees answers

Any notes taken from the interview were to be transcribed at the latest one day after the interview.