Improving capacity planning in outsourced manufacturing through sales and operations planning

A case study at Axis Communications

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Abstract

This master’s thesis explores how capacity planning in outsourced manufacturing can be improved through sales and operations planning (S&OP). The master’s thesis was done in collaboration with Axis Communications AB, where the capacity planning and S&OP processes were analyzed. Managing manufacturing capacity in high technology industries is one of the most important aspects to consider for achieving business success and is part of the strategic level in manufacturing planning and control systems. S&OP is often cited as an effective method to jointly balance supply and demand, including manufacturing capacity. However, little research has been done exploring the link between capacity planning and S&OP, and even less research exists when manufacturing operations are outsourced.

The purpose of this master’s thesis was achieved through a single-case study with the collaborating partner, Axis. A literature review was conducted to establish knowledge within capacity planning, S&OP, outsourcing, supply chain collaboration, and the link between capacity planning and S&OP. An analytical framework was developed based on the literature review to guide the empirical data collection and analysis. Empirical data was collected through 12 interviews with employees at Axis, five observations of S&OP meetings, and extensive archival research within Axis’ intranet. Axis’ current capacity planning and S&OP processes were identified and mapped using the empirical data collected and analyzed using the literature review's theoretical lens.

Fourteen propositions were developed for Axis, facilitating the capacity planning process through the S&OP process. The propositions developed are specific to Axis; however, some takeaways may be applicable in other cases and highlight important aspects. First, this master’s thesis highlights the importance of supply chain collaboration when manufacturing activities are turnkey outsourced. Second, there is a need to develop differentiated capacity planning strategies when product portfolios are broad as there is no “one size fits all” solution. Third, decision-making in the S&OP process is critical to balancing supply and demand successfully, and top management involvement is critical in achieving decision-making. Fourth, this master’s thesis highlights the need for performance measures that have been heavily discussed in academic research as critical for business success for decades but are still underdeveloped in practice.

The existing research on capacity planning and S&OP is limited to in-house manufacturing, and little research exists addressing the link between capacity planning and S&OP. This master’s thesis shows that business environment, management, and strategy seem to be the most significant factors when planning manufacturing capacity in an outsourced context. Further, S&OP is often influenced by contextual factors, and insights are provided on S&OP design affected in a context where manufacturing is outsourced. Last, insights are provided on how capacity planning and sales and operations can be linked by integrating capacity planning into the S&OP process.

Keywords: Capacity planning, Strategic capacity planning, Manufacturing, Outsourcing, Sales and operations planning, S&OP, Electronic manufacturing services, EMS

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Lukas Andersson and Mikael Janslätt Axelsson

Table of contents

List of figures

List of tables

Abbreviations

AFP	Annual financial plan
ATO	Assemble-to-order
CODP	Customer order decoupling point
CPFR	Collaborative planning, forecasting and replenishment
CSF	Critical success factor
EMS	Electronics manufacturing services
ERP	Enterprise resource planning
ETO	Engineer-to-order
FIFO	First-in, first-out
KPI	Key performance indicator
MPC	Manufacturing planning and control
MTO	Make-to-order
MTS	Make-to-stock
NPI	New product introduction
PET	Production engineer and technology
PLC	Product life cycle
PoS	Point of sales
R&D	Research and development
RO	Research objective
S&OP	Sales and operations planning
SKU	Stock-keeping-unit
VMI	Vendor managed inventory
WIP	Work in progress

Chapter 1 – Introduction

This chapter describes the background to this master's thesis and states the problem at hand. Further, the introduction chapter presents the purpose and research objectives, followed by the master's thesis's focus and delimitations.

1.1 Background

Managing manufacturing capacity in high-technology industries is one of the most important aspects to consider for achieving business success (Martinez-Costa et al., 2014; Wu et al., 2005). In high-technology industries, a short product life cycle is a typical product characteristic (Davies and Brush, 1997; Wu et al., 2005) caused by rapidly changing customer demands and constant new product innovation (Davies and Brush, 1997; Kotler et al., 2016). Consequently, the need for companies to persistently manage capacity efficiently and align supply chain capabilities with new product introductions (NPI) is increasing (Martinez-Costa et al., 2014; van Hoek and Chapman, 2007; Wu et al., 2005). A mismatch between capacity planning and NPI can lead to excessive inventories and stockouts, resulting in negative business performance (Jacobs et al., 2011).

Capacity planning is part of the manufacturing planning and control (MPC) system, commonly divided into three levels: strategic, tactical, and operational (Hopp and Spearman, 2008; Kiran, 2019; Martinez-Costa et al., 2014; Wu et al., 2005). Decisions regarding capacity planning on the strategic level concern a long-term perspective (Hopp and Spearman, 2008). Long-term capacity planning may include, e.g., capacity size, capacity location, and equipment decisions (Hopp and Spearman, 2008; Martinez-Costa et al., 2014). Meanwhile, considered more short-term levels of the MPC, the tactical and operational levels concern production tactics and day-to-day operations (Hopp and Spearman, 2008) and, by some companies, considered non-core activities (Lahiri et al., 2022). Over the past 30 years, outsourcing non-core activities have increased due to the increasing competitiveness in the global market (Hopp and Spearman, 2008).

An effective method to manage capacity planning is sales and operations planning (S&OP) (Olhager et al., 2001; Småros and Falck, 2013; Thomé et al., 2012a) and is often cited as a critical business process to increase organizational performance (Lapide, 2007; Swaim et al., 2016; Thomé et al., 2012a). Effective S&OP can help organizations realize fundamental supply chain goals such as reducing inventory and minimizing costs while still meeting customer demand and expectations (Lapide, 2004; Thomé et al., 2012b). Other mentioned critical drivers for implementing S&OP are an increased ability to react to sudden demand changes (de Kok et al., 2005; Kaipia et al., 2017; Thomé et al., 2012b), to reactively deal with disruptions (Dittfeld et al., 2020) and increased manufacturing performance (Kaipia et al., 2017; Thomé et al., 2014). Business processes, such as S&OP, are considered a critical differentiator (Seethamraju, 2010), and managing these can result in significant improvements in business performance (Hammer, 1990; Rummler and Brache, 1991; Seethamraju, 2010; Shapiro, 1977). New product innovation, forecasting, and planning are common conflict areas (Shapiro, 1977). Strengthening the functions can be accomplished through cross-functional processes (Rummler and Brache, 1991; Shapiro, 1977), and capacity planning is no exception; integrating decisions on capacity planning cross-functionally is imperative (Martinez-Costa et al., 2014).

1.2 Problem formulation

Axis Communications AB, hereafter Axis, is a global actor that provides security network solutions, such as video and audio surveillance, mainly through advanced high-technology network cameras. In the Operations department at Axis, an area with opportunities for improvement is the capacity planning in manufacturing. Manufacturing operations at Axis are outsourced to electronics manufacturing services (EMS) sites, enabling the company to focus on its core competence, research and development (R&D). However, the capacity planning for manufacturing at the EMS sites, hereafter solely capacity planning, remains within Axis.

Currently, Axis is basing its capacity planning at the EMS sites on sales forecasts, to which the company adds an arbitrary "margin" to ensure room for surges in demand. This margin is generic, and the same margin is applied regardless of the product. The margin is also static and used throughout the product's entire life cycle. Consequently, a mismatch between supply and demand occasionally occurs, causing excessive inventory and stockouts. Additionally, unutilized manufacturing capacity incurs unnecessary costs.

Because of Axis' emphasis on R&D, new product introductions are frequent and have enabled Axis to experience significant growth in sales over the past years. It is common for organizations to be complacent when business is thriving and thus ignorant of changes in the business environment and threats from the competition (Anupindi et al., 2012), which emphasizes the need to look at current processes in a new light (Hammer, 1990). When companies have an S&OP process the capacity planning is usually performed in the process (Olhager et al., 2001), as S&OP aims to balance supply and demand (e.g., Bower, 2005; Grimson and Pyke, 2007; Lapide, 2007; Olhager et al., 2001; Thomé et al., 2012a; Tuomikangas and Kaipia, 2014). However, in the case of Axis, capacity planning is not addressed in the S&OP process.

1.3 Purpose and research objectives

The purpose is to improve the process for capacity planning for manufacturing at EMS sites and investigate how S&OP can facilitate these improvements. The purpose is addressed through three research objectives (RO).

RO1: Identify and map the processes for capacity planning and S&OP.

For both the capacity planning and S&OP processes to be changed, they must first be understood. By identifying and mapping the central components of both processes, we can clearly understand their respective current state.

RO2: Evaluate opportunities to improve the capacity planning and S&OP processes.

Once the capacity planning and S&OP processes are understood, we can evaluate the processes by comparing them to the literature. After that, we can identify improvement opportunities.

RO3: Propose changes to facilitate the capacity planning process through the S&OP process.

The last step is to identify tangible changes to the current processes to achieve the purpose of this master's thesis. The structure and link between the three ROs are illustrated in Figure 1.1.

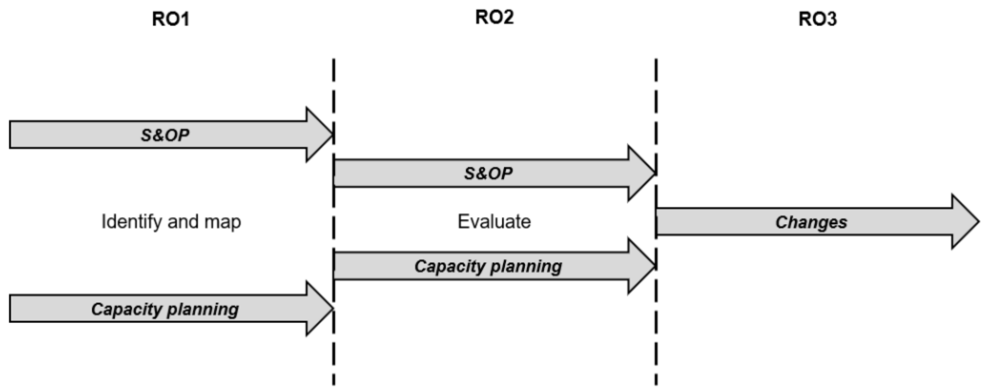

Figure 1.1 Purpose and research objective illustrated

1.4 Focus and delimitations

Five delimitations narrowed the focus of this master's thesis. First, we are only concerned with the capacity planning concerning manufacturing capacity at the EMS sites, and thus we did not address other forms of supply chain capacity. Second, we focused on the S&OP process in Axis' Americas sales region since it is representative of the direction Axis wants to take with its S&OP process in the other sales regions. Consequently, we believed it would add more value to provide a roadmap to further improve the Americas S&OP process rather than pinpointing already known issues to Axis. Third, we focused on the as-is situation at Axis and therefore ignored ongoing internal improvement projects which bordered or partly overlapped our scope to simplify our analysis. Fourth, due to the limited time frame of this master's thesis, we did not implement any solutions, nor did we give any attention to developing an implementation plan; instead, we focused our efforts on developing solutions. Last, after discussions with employees at Axis and our supervisors, we deemed analyzing quantitative data too time-consuming and complex given the given time frame of the master's thesis and was therefore not included. Figure 1.2. illustrates the considered scope of the master's thesis.

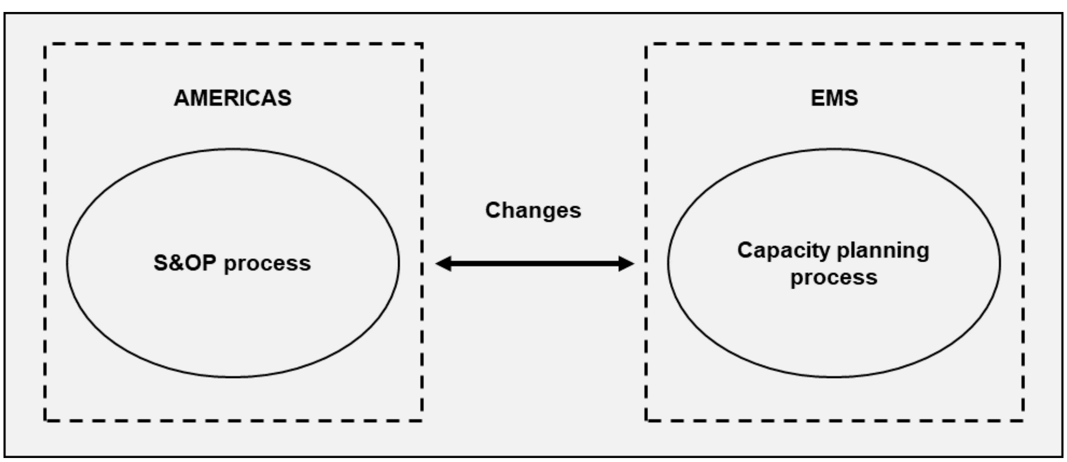

Figure 1.2 Scope of the master's thesis

1.5 Thesis outline

Chapter 1 – Introduction

This chapter describes the background to this master's thesis and states the problem at hand. Further, the introduction chapter presents the purpose and research objectives, followed by the master's thesis's focus and delimitations.

Chapter 2 – Methodology

This chapter explains the methodology used throughout this master's thesis. First, we will explain the chosen research strategy, followed by a more in-depth explanation of the applied research design and methods. The chapter will conclude with a transparent walkthrough of the analysis and measures to ensure high research quality.

Chapter 3 – Frame of reference

This chapter presents a rigorous literature study that has been conducted to achieve the purpose of this master's thesis. It covers the central theoretical findings related to the research area and the research objectives. The frame of reference introduces terminology, concepts, and frameworks that will be applied to execute the empirical study and analysis. Four main areas of interest were identified: capacity planning, S&OP, linking capacity planning to sales and operations planning, and outsourcing and supply chain collaboration. Last, findings are synthesized into an analytical framework that will guide the data collection and analysis.

Chapter 4 – Empirical data

The empirical study will deliver the findings of the conducted data collection in a structured and descriptive way. First, we will present the supply chain set up at Axis. Second, we will describe how capacity planning is currently carried out at the EMS sites. Last, the study will present Axis' current sales and operations planning process. The empirical research is based on data gathered through interviews, archival data, and observations. The findings from the frame of reference chapter will serve as guidance.

Chapter 5 – Analysis and findings

The analysis and findings chapter will present our findings and analysis of Axis' capacity planning and S&OP processes. We will apply the theoretical models from our analytical framework, which will guide the analysis. Each section will be summarized through one or more propositions. The chapter starts with the capacity planning process, followed by the S&OP process. Last, we will present a proposition linking the capacity planning and S&OP processes together.

Chapter 6 – Conclusions, limitations, and future research

The conclusions and future research propositions chapter will summarize our findings and analysis of Axis' capacity planning and S&OP processes. First, we will revisit the purpose and answer our research objectives. Second, the implications of this master's thesis from a managerial and theoretical perspective will be discussed. Last, we will spotlight the limitations of this master's thesis and submit a future research agenda.

Chapter 2 – Methodology

This chapter explains the methodology used throughout this master's thesis. First, we will explain the chosen research strategy, followed by a more in-depth explanation of the applied research design and methods. The chapter will conclude with a transparent walkthrough of the analysis and measures to ensure high research quality.

2.1 Research strategy

The research strategy for this master's thesis is a case study (Yin, 2018). When choosing a research strategy, it must align with the purpose of the study. Thus, it is vital to thoroughly understand the phenomenon to be researched (Voss et al., 2002). When describing case study methodology, Voss et al. (2002) mention four different types of research as suitable: exploration, theory building, theory testing, and theory extension/refinement. Since RO3 aims to propose changes to facilitate the capacity planning process through the S&OP process, RO3 is deemed explorative.

Further, a case study is the most appropriate method when searching for answers to a *how* question (Meredith, 1998; Voss et al., 2002; Yin, 2018), which indirectly aligns with how the formulation of research objectives of this master's thesis. The case study methodology is versatile and applicable in many different situations and areas (Yin, 2018). The strengths of case study research are many, perhaps the most important one being the high level of the potential impact it can bring as it may lead to new, creative insights and theories (Voss et al., 2002). Case studies further allow researchers to study the phenomenon in its natural environment (Meredith, 1998; Voss et al., 2002). While case research has many advantages, there are also several disadvantages. Meredith (1998) argues that case research often lacks generalizability, that validation is poor, and that the constructs tend to be flawed. These characteristics have several implications as measures are needed to counteract them. Using a multiple-case design (Yin, 2018) or literature (Voss et al., 2002) can help increase the generalizability, while a rigorous research design can mitigate construct error (Yin, 2018).

Another applicable methodology for research in operations management is action research (Coughlan and Coghlan, 2002). The fundamental idea behind action research is change: a problem is identified and solved, and after that, the solution is implemented to facilitate the desired change. The third research objective, RO3, "proposes changes to facilitate the capacity planning process through the S&OP process," aligns well to solve a problem. However, implementation and evaluation are two critical steps in action research (Coughlan and Couglan, 2002). Due to the limited timeframe of this thesis (20 weeks), it is not possible to perform action research as change management projects often are time-consuming. Thus, the conclusion is that a case study methodology is the best choice to achieve the purpose of this study.

2.2 Research design

We chose a single-case study design since it allows for a greater depth of observations, although it lacks the generalizability of conclusions that a multiple-case study brings (Eisenhardt and Graebner, 2007; Voss et al., 2002; Yin, 2018). There needs to be a robust rationale to justify a single-case study when pursuing a single-case study rather than a multiple-case study. Multiple-case studies are, when applicable, the preferred choice (Yin, 2018). We decided against using a multiple-case study for four reasons:

First, we decided that there was not enough time or resources available to achieve a multiple case study and still gain the necessary depth in the empirics. Second, as this master's thesis aims to improve Axis' capacity planning, we argued that other potential case companies would not be interested in sharing their practices to achieve this purpose. Capacity planning and S&OP are both of strategic character and thus can provide competitive advantages if executed well. This kind of information is unlikely to be shared with outsiders with a clear agenda of using that information to help another competitor. Third, we had special access to key informants at Axis, which we did not have at other potential case companies. We argue that this discrepancy may have led to lower quality skewed empirics, as the depth and nature of the empirics for different cases would likely have varied. E.g., we might only be able to obtain qualitative data at one case company while another would be willing to provide data of both qualitative and quantitative nature. Last, the purpose aims to improve practices at Axis and not generalize, making a multiple-case study redundant to achieve the purpose.

An embedded case design was chosen, consisting of one main unit of analysis and two subunits. The main unit of analysis is "the link between capacity planning and S&OP processes," which connects to RO3 and serves the purpose. The two subunits are "the capacity planning process" and "the S&OP process," which address RO1 and RO2. Figure 2.1 illustrates the embedded case design. Defining the unit of analysis, i.e., the focus of the study (Miles and Huberman, 1994), is a crucial part of the research design process in any case research (Yin, 2018). Case research is not strictly limited to a single unit of analysis but can include embedded units of analysis to enable more profound insights into the chosen case (Yin, 2018). A single unit of analysis can be beneficial when it is difficult to identify any subunits that make sense or when the literature of relevance is holistic (Yin, 2018). However, this was not the case for us.

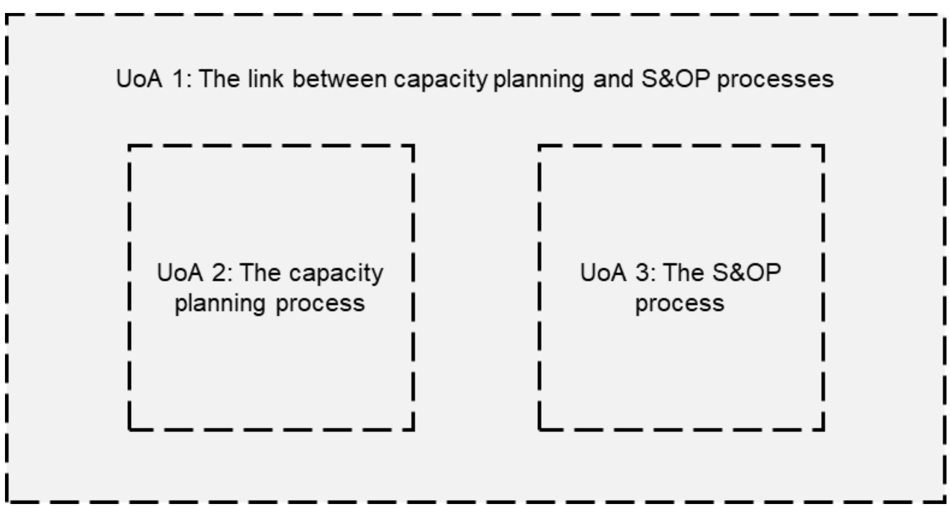

Figure 2.1 The embedded case design

Further, additional issues with a holistic approach are that the case study may be very abstract and unclear (Yin, 2018). Along the way, the focus of the case study can shift due to, e.g., data collection pointing towards something else than the initial questions were supposed to capture. This flexibility can be a strength but is also subject to criticism and needs to be accounted for when choosing a case design. Thus, we opted for an embedded design with clearly specified subunits to maintain focus. However, it is essential to consider all units of analysis and connect the subunits back to the overall unit of analysis. Failure to go back to the main unit of analysis is a common pitfall when using an embedded design and thus necessary to give attention.

Moreover, we developed an analytical framework inspired by Miles and Huberman (1994) to guide the research. Case research should start with developing an analytical framework and research questions with the analytical framework leading up to the research questions or vice versa, as we did (Voss et al., 2002). Such an analytical framework can either be graphic or narrative to explain the main entities studied (Miles and Huberman, 1994; Voss et al., 2002). One key benefit of starting the research by developing an analytical framework is that it forces researchers to think carefully and be selective of what to include in the research to a greater extent.

The research design was divided into three parts: define and design, prepare and collect, and analyze and conclude (Yin, 2018). During the first part of the study, we defined the purpose, research objectives, unit of analysis, and subunits, followed by a review of the available theory. The second phase of the research was to prepare and collect relevant data. We designed a data collection protocol to structure the data collection and deposited all collected data into the established case study database. Last, we compiled the collected data and prepared it for analysis. We performed a within-case analysis during the last stage and concluded our findings to answer our research objectives. To support the research process and illustrate the research design, we adapted the following case study method framework from Yin (2018), see Figure 2.2

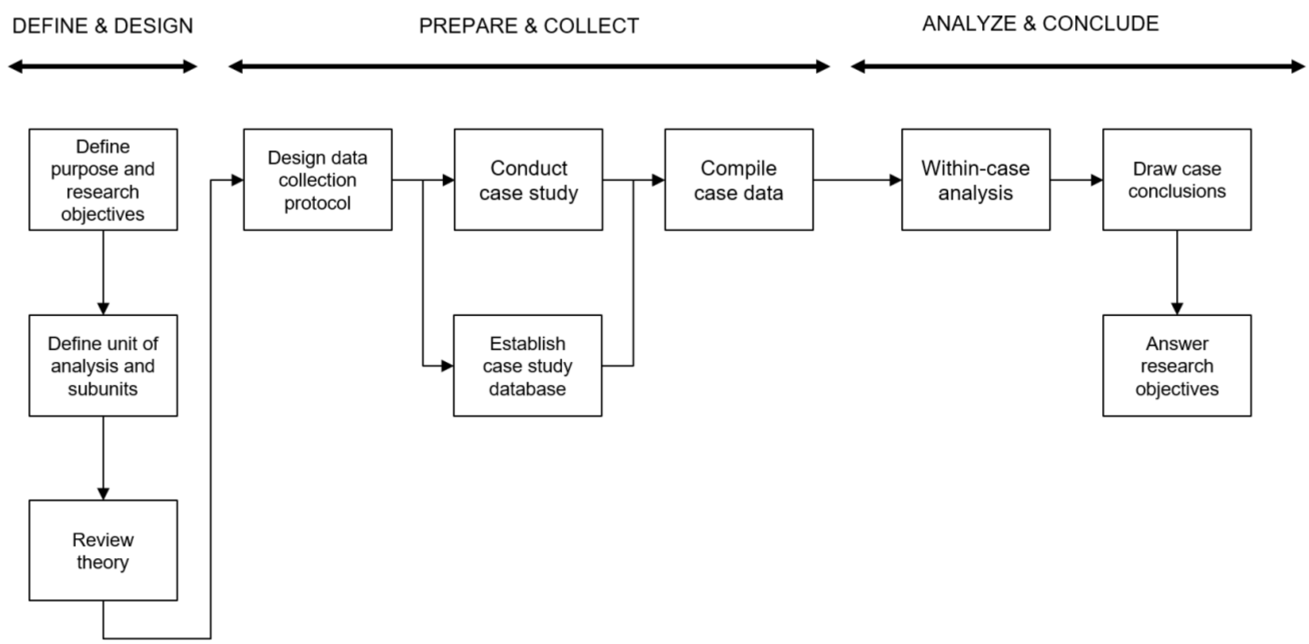

Figure 2.2 Case research design, adapted from Yin (2018)

2.3 Data collection

We used various data sources as part of the data collection, including literature reviews, archival data, interviews, and observations (Eisenhardt and Graebner, 2007; Meredith, 1998; Voss et al., 2002; Yin, 2018). When conducting case research, it is common to draw upon several data sources of both qualitative and quantitative nature to collect the necessary empirics. No quantitative data were included in the data collection since it was deemed too time-consuming to collect and analyze within the given timeframe. Further, using a combination of different data collection methods, known as triangulation, significantly increases the reliability of the collected data (Runeson and Höst, 2009; Voss et al., 2002; Yin, 2018), which further strengthens the case for using multiple sources of data. As suggested by Yin (2018), a case study database with all the collected data was developed to make analysis more manageable and ensure rigor. We will elaborate further on the different types of data collection methods chosen. Figure 2.3 illustrates the relationship between the research objectives and the chosen data collection methods.

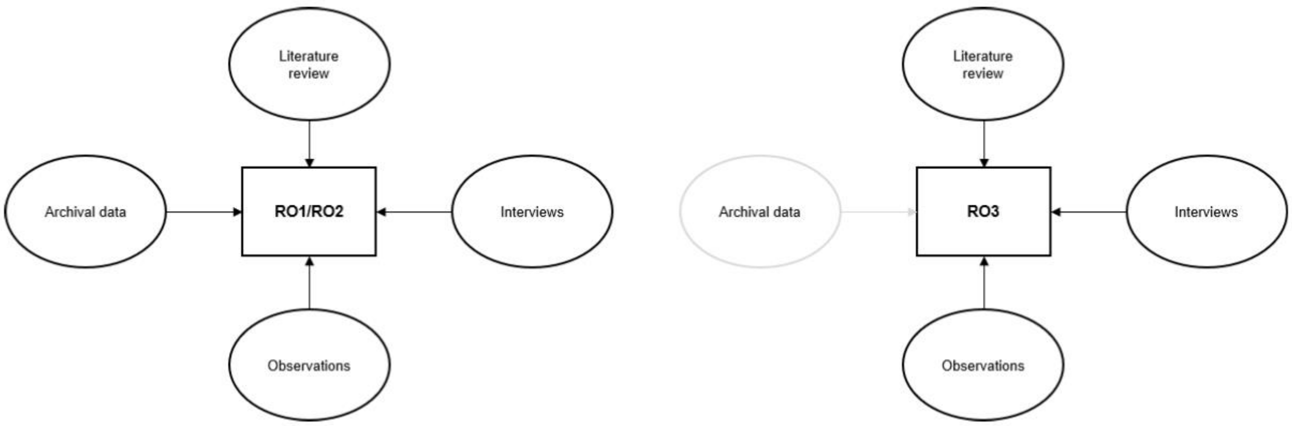

Figure 2.3 Research objectives and the data collection methods

2.3.1 Literature review

We carried out two separate literature reviews serving two different specific purposes. First, the initial review aimed to build knowledge within the relevant subjects, identifying keywords and creating the background for the analytical framework, interview guides, and observation schedule. Eisenhardt and Graebner (2007) argue that research generally should start with a strong foundation in the related literature. Second, the follow-up literature review was conducted later to fill any potential knowledge gaps left by the first literature review, illustrated in Figure 2.4. Voss et al. (2002) state that literature can help researchers increase the quality of the findings. Thus, there is a strong motivation for the second literature review.

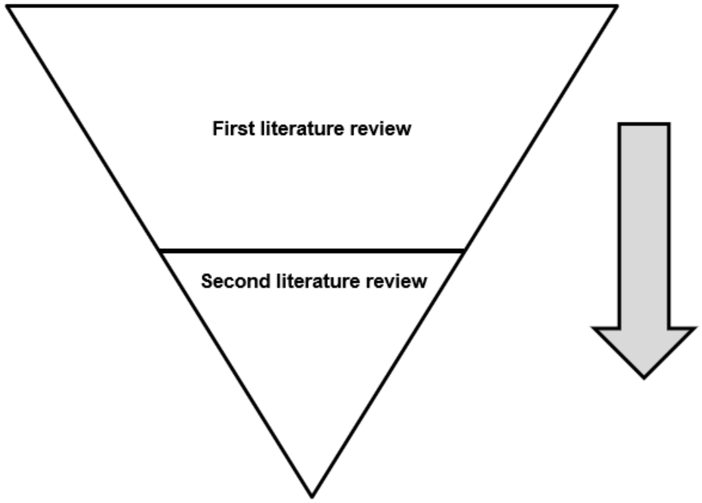

Figure 2.4 Illustration of the literature review process

The first literature review was carried out in the database *Google Scholar,* and the strategy was to brainstorm keywords that could be of potential relevance for this master's thesis. We wrote down the search terms, the number of hits, and the search relevance (estimated by the authors with a 1-5 scale based on the title) for each search. By filtering based on search relevance, we were able to identify relevant keywords and build knowledge within the subject. A sample of the search terms used can are presented in Table 2.1. There are two key takeaways from the first literature review. First, the concept of S&OP is a widely researched area that has developed over the past few decades, including, e.g., extended models and evaluation frameworks. Second, searches that included *capacity planning* (of some sort) generated several hits, proving there is much research conducted within the general field. However, there is limited literature on capacity planning connected to outsourcing, related to organizational structures and strategic decision-making, and are not mathematical models, which is the focus of this master's thesis.

Table 2.1 Search term sample from the first literature review

Category	Search term
Capacity planning	capacity planning capacity planning operations management strategic capacity planning capacity planning new product introduction capacity planning outsourcing capacity planning electronics manufacturing services capacity planning electronics manufacturing capacity planning manufacturing capacity planning high-tech long-term capacity planning capacity reservation capacity reservation contract manufacturing production capacity planning manufacturing capacity planning
S&OP	sales and operations planning sales and operations planning design sales and operations capacity planning sales and operations planning maturity sales and operations planning high-tech industry sales and operations planning performance measures global sales and operations planning sales and operations planning critical success factors

The second literature review was carried out in the database *Web of Science*, and the strategy was to leverage the "forward citation" function based on a few central pieces of the literature identified during the first literature review. The key pieces of literature used for the second literature review are listed in Table 2.2.

Table 2.2 Key literature

Category	Key literature
Capacity planning and S&OP	Olhager, J., Rudberg, M. and Wikner, J. (2001), "Long-term capacity management: Linking the perspectives from manufacturing strategy and sales and operations planning", *International Journal of Production Economics*, Vol. 69 No. 2, pp. 215–225.
Capacity planning	Hopp, W.J. and Spearman, M.L. (2008), *Factory Physics*, Third Edition, Waveland Press, Long Grove, IL, USA. Kiran, D.R. (2019), *Production Planning and Control*, Butterworth-Heinemann, Kidlington, Oxford, United Kingdom. Martínez-Costa, C., Mas-Machuca, M., Benedito, E. and Corominas, A., (2014), "A review of mathematical programming models for strategic capacity planning in manufacturing", *International Journal of Production Economics*, Vol. 153, pp. 66-85. Wu, D., Erkoc, M. and Karabuk, S. (2005), "Managing Capacity in the High-Tech Industry: A Review of Literature", *The Engineering Economist*, Vol. 50 No. 2, pp.125-158.
S&OP	Grimson, J.A. and Pyke, D.F. (2007), "Sales and operations planning: An exploratory study and framework", *The International Journal of Logistics Management,* Vol. 18 No. 3, pp. 322–346. Jacobs, R.F., Berry, W.L., Whybark, D.C. and Vollmann, T.E. (2011), *Manufacturing Planning and Control for Supply Chain Management*, McGraw-Hill, NY, USA. Kristensen, J. and Jonsson, P. (2018), "Context-based sales and operations planning (S&OP) research: A literature review and future agenda", *International Journal of Physical Distribution and Logistics Management*, Vol. 48 No. 1, pp. 19–46. Thomé, A.M.T., Scavarda, L.F., Fernandez, N.S. and Scavarda, A.J. (2012a), "Sales and operations planning: A research synthesis", *International Journal of Production Economics*, Vol. 138 No. 1, pp. 1-13.

Furthermore, to laying the foundation for the interview guides and the observation schedule used for additional data collection, the purpose of conducting the literature review was to create building blocks for the research objectives of this master's thesis. RO1 benefited from the literature review through frameworks and concepts which explain how real-life practices theoretically are structured. The literature also gave us a roadmap to conduct the analysis needed to attack challenges in RO2. Last, the literature gave us inspiration and strategic guidelines for RO3 and helped us generate solutions to the issues identified in RO2.

2.3.2 Archival data

Yin (2018) acknowledges documentation and archival records as two standard methods of collecting evidence in case studies and can be treated as the same entity (Runeson and Höst, 2009). Archival data can refer to many different data sources, such as financial records, organizational records, service records, administrative documents, letters, and meeting minutes (Runeson and Höst, 2009; Yin, 2018). Some advantages of archival data are that they are precise and have a broad coverage (Yin, 2018). Runeson and Höst (2009) stress the importance of combining archival data research with other data sources to increase reliability since these records often can be incomplete, and the researcher cannot control the quality of the data.

Archival data were collected mainly in two ways. First, we browsed Axis' intranet for various documents similar to how we conducted the literature review. Second, we collected various documents of relevance from the informants during the interviews. The gathered documents consisted mainly of various spreadsheets and presentations. The archival data helped us answer our research objectives during each step of the process. For RO1, we leveraged existing process maps and meeting material to further our perception of the current situation within Operations at Axis. This material illustrates Axis's previous and ongoing work; thus, it gives an extra nuance to the holistic perspective and highlights focal points of different areas. Meeting material and documentation on some previous analysis performed by Axis employees was used to get a perspective on, e.g., how processes perform and how they have developed, which was extra support to RO2.

2.3.3 Interviews

We used semi-structured interviews (e.g., Miles and Huberman, 1994; Runeson and Höst, 2009; Voss et al., 2002; Yin, 2018) as our primary source of empirical data for two main reasons. First, interviews are by many researchers considered to be fundamental to case research (e.g., Runeson and Höst, 2009; Voss et al., 2002; Yin, 2018). Second, interviews efficiently gather empirical data when the phenomenon studied is relatively infrequent and concerns strategic decision-making (Eisenhardt and Graebner, 2007). Further advantages of interviews are that they generally provide a high response rate, produce valuable insights, and are a highly flexible data collection method (Denscombe, 2010).

We scheduled each interview for 60 minutes, with some exceptions, and if deemed necessary (and possible), another 30-minute session was added for potential clarifications or to collect missing information. As Voss et al. (2002) suggest, both authors were present at all interview sessions. The interview guide was sent out before the session to give the interviewee time to prepare appropriately. Both authors actively participated as interviewers during each interview, enabling more interactive sessions, e.g., by spontaneously asking follow-up questions. Interviews took place both in-person and online through Microsoft Teams. If allowed by the interviewee, we recorded the conversation and transcribed it after every session (Runeson and Höst, 2009; Voss et al., 2002; Yin, 2018). Before performing any forms of analysis, the transcribed text was sent to the interviewee for confirmation to ensure nothing was misinterpreted or by any other means incorrect. When the conversation was not allowed to be recorded, responsibilities were divided between the authors. Thus, one acted as an interviewer while the other took notes. Important to note is that this internal division did not limit either the interviewer or data collector to take notes or ask follow-up questions.

The questions for the interview guide were compiled from the literature reviews (Kallio et al., 2016; Miles and Huberman, 1994; Yin, 2018) and structured. We based the structure on a few main themes that covered the main contents in a logical order aligned with the funnel style session structure (Runeson and Höst, 2009; Voss et al., 2002) with pre-designed follow-up questions to go along with each central theme (Kallio et al., 2016). Pilot testing of the interview guide using internal testing (Kallio et al., 2016) was conducted before the actual interviews to improve the quality of the data collection. An outside expert within the field further assessed the interview questions related to S&OP. To mitigate bias, we strived to use multiple informants from different hierarchical levels and functional areas wherever possible, as Yin (2018) suggests. Gathering information from different perspectives was a significant factor when deciding whom to interview. Informants were deliberately selected based on their roles and potential insights, which is a viable sampling strategy when the purpose is to explore rather than generalize findings (Denscombe, 2010). Table 2.3 presents the interviewed persons and the wide range of functional areas and hierarchical levels captured in the interviews. Final interview guides can be seen in Appendix A and Appendix B.

Table 2.3 Interview persons

Interview date	Duration	Interviewee role	On-site/virtual
2022-03-08 2022-03-18	57 min 29 min	S&OP and Material Supply EMS Manager	On-site
2022-03-07	51 min	EMS Supply Lead	On-site
2022-03-07	45 min	Industrial Lead	On-site
2022-03-22	47 min	Manager Production Systems – High Volume	On-site
2022-03-11	41 min	Operations Manager Americas/Director Operations Development and Digitalization	Virtual
2022-03-07	76 min	Manager Industrial Lead	On-site
2022-03-16	26 min	Industrial Lead	On-site
2022-03-18	73 min	Manager, Demand Planning and Enterprise Sales Projects	On-site
2022-03-24	48 min	Process Developer – Material Supply	On-site
2022-03-21	24 min	End Customer Coordinator	Virtual
2022-03-21	54 min	Supply Chain Lead	On-site
2022-03-22	81 min	Sales & Operations Planner	On-site

The interviews were the primary data collection method to gather empirical data internally at Axis, thus enabling us to handle RO1. As interviewee representation was diverse in roles and functions, the interview data gave us a broad as-is picture. Additionally, during the interviews, strategic priorities and business concepts were explained to us, helping us better understand Axis as a company. Later, we consolidated and leveraged the interview data to evaluate the current processes, i.e., RO2. Last, discussions during interviews generated ideas that served as inspiration when developing proposed changes to current practices to serve the purpose of RO3.

2.3.4 Observations

Empirical evidence gathered from observations can be an excellent source of additional data when conducting a case study (Runeson and Höst, 2009; Yin, 2018). One significant advantage of observations is that they can lead to a deeper understanding of the phenomenon studied. Yin (2018) further points out that observations can add new dimensions to allow the researcher to understand both the phenomenon and its context better. Another advantage is that observations can prove helpful when there is a reason to believe there are irregularities in how things are done in practice versus how things officially should be done, allowing researchers to uncover the "truth" (Runeson and Höst, 2009). We used direct observations as participant observation often is challenging to achieve and may increase the risk of producing bias (Yin, 2018).

We developed an observation schedule to mitigate the risks associated with conducting observations and ensure the data collected was consistent between the authors and the observed events (Denscombe, 2010). This observation schedule was developed based on the literature review and critical insights gained from the interviews. As the observations were mainly associated with the S&OP process, we mapped the current S&OP process before participating in the meetings. Although we had an observation schedule, we did not limit ourselves to taking notes on, e.g., contextual factors that are otherwise difficult to capture with observations (Denscombe, 2010). We strived to avoid any interaction during the observations to keep the setting as natural as possible (Denscombe, 2010). Both authors were present at all observations to increase the reliability of the observational evidence (Yin, 2018). The observation sessions are listed in Table 2.4, and the observation schedule can be seen in Appendix C.

Table 2.4 Observation sessions

Date	Type	Topics	Occurrence
2022-03-25	Meeting	Demand Review – S&OP Americas	Monthly
2022-04-12	Meeting	Forecast Handshake – All regions	Monthly
2022-04-14	Meeting	Material Shortage	Weekly
2022-04-20	Meeting	Forecast Presentation	Monthly
2022-04-28	Meeting	Supply Planning Review	Monthly

Observing meetings in action gave us an additional dimension in understanding the current processes and their parts. More specifically, it helped us identify "softer" aspects and insights on concrete issues surfacing during different stages to handle RO1. The observations also helped us with RO2 and RO3, as we could identify gaps, which enabled us to develop change propositions to fill these gaps.

2.4 Data analysis

Since the data collection was limited to qualitative data, so was the analysis. In this section, we strived to explain the data analysis process in the most straightforward possible manner to establish transparency (Ketokivi and Choi, 2014) and to create a logical sequence of the empirical evidence (e.g., Eisenhardt and Graebner, 2007; Miles and Huberman, 1994; Runeson and Höst, 2009; Yin, 2018). The qualitative data analysis strategy included data reduction, data display, data coding, drawing conclusions, and verifying them (Miles and Huberman, 1994). When analyzing the qualitative data, we adopted the tactics from (Kembro and Norrman, 2019) and performed all analyses individually at first to achieve investigator triangulation (Yin, 2018). Then we compared our analysis and agreed (Kembro and Norrman, 2019). Since we opted to conduct a single-case study, we did not perform any cross-case analysis; instead, we performed within-case analysis exclusively.

We performed the coding process a bit differently for the two embedded units. Since the first embedded unit of analysis (the capacity planning process) was of a more explorative nature, we decided to perform the coding a bit differently than we did for the second embedded unit of analysis. For the first embedded unit of analysis, we used the Gioia methodology (Gioia et al., 2013) and used a data display inspired by Saiah et al. (2022) and Corley and Gioia (2004), see Figure 2.5. We analyzed by first breaking down each interview into several 1^{st} order concepts (number of 1^{st} order concepts varying with each interview, and representative 1^{st} order concepts were chosen for the data display due to space limitations). We wrote down statements, quotes, themes, and other information thought to be relevant. Thereafter, we clustered the 1^{st} order concepts into 2^{nd} order themes based on the literature review by assigning each 1^{st} order concept with the most relevant 2^{nd} order theme. After each 1^{st} order concept had been assigned a 2^{nd} order theme, we used Pivot Tables in Excel to rank the 2^{nd} order themes from the most frequent to the least frequent. Based on how frequently the different 2^{nd} order themes appeared, we concluded whether they seemed to have a strong influence, moderate influence, or no influence. The factors deemed to have no influence were outliers occurring only a few times, while factors with a strong influence occurred more than 30 times and minor influencing factors 10-15 times. The 2^{nd} order themes we deemed to have little to strong influence were finally aggregated into four dimensions based on the literature review. Both researchers performed this analysis individually, first for each interview, and then the coding was compared and discussed before reaching a consensus. Once we had a consolidated coding for every interview, we continued to use the tactics proposed by Miles and Huberman (1994) until we could reduce it down to one single data display.

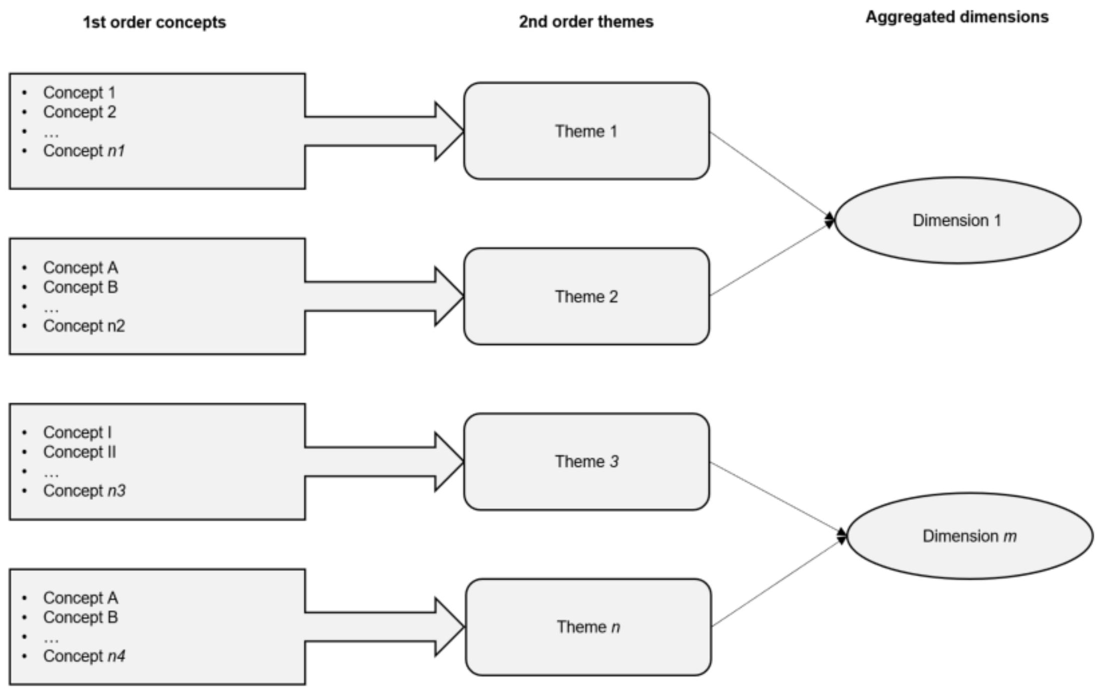

Figure 2.5 Data display used for the second embedded unit of analysis (based on Corley and Gioia, 2004; Gioia et al., 2013; Saiah et al., 2022)

We started the coding process for the second embedded unit (the S&OP process) by breaking down the data into categories (Corbin and Strauss, 1990) according to the analytical framework (Miles and Huberman, 1994). The data display used to conduct the analysis can be seen in Figure 2.6. Statements, quotes, patterns, themes, and other relevant information were placed in one of the five horizontal categories and matched with the appropriate vertical S&OP stage for each interview to find meaning within the cases (Miles and Huberman, 1994). Thereafter, we compared all data displays and discussed them until we could collectively agree upon one consolidated data display. We revisited both the transcripts and audio recordings when further clarification was necessary to ensure we had not misinterpreted anything. Once we had a consolidated data display for every interview, we continued to use the tactics proposed by Miles and Huberman (1994) until we could reduce it down to one single data display. The consolidated data display was then compared to the observation schedules and obtained archival data until we collectively reached a consensus on a final data display explaining the process.

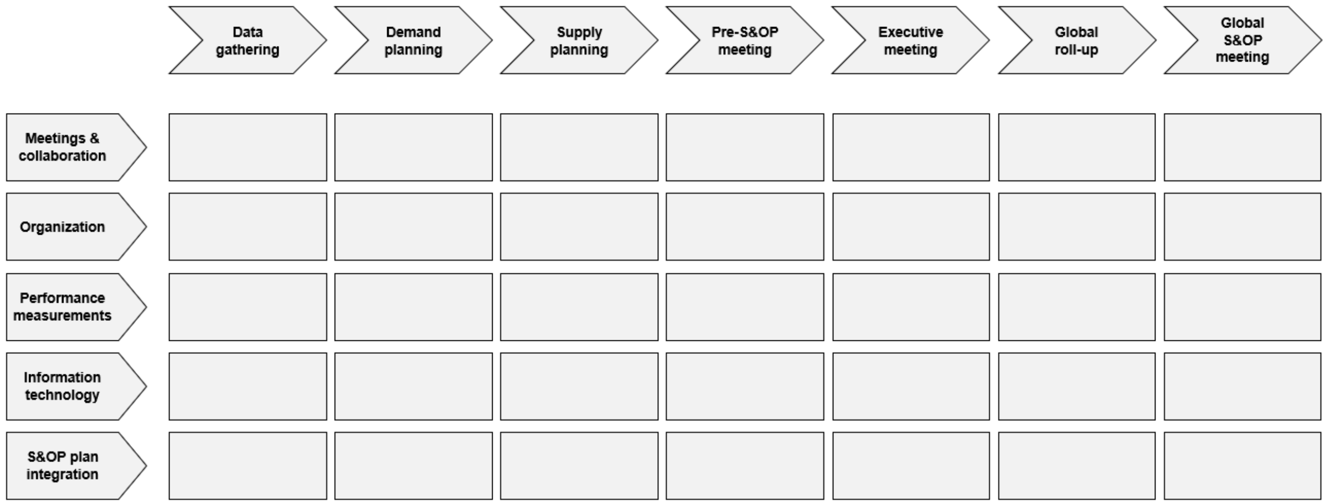

Figure 2.6 Data display used for the first embedded unit

2.5 Research quality

We applied four criteria for evaluating the research quality of this thesis: internal validity, construct validity, external validity, and reliability (Miles and Huberman, 1994; Voss et al., 2002; Yin, 2018). Although internal validity is downplayed for case studies of exploratory and descriptive nature by Yin (2018) and external validity is difficult to achieve for single-case studies (Voss et al., 2002), we still strived to achieve a rigorous approach throughout the research. To ensure the research quality was of the best possible quality, we were inspired by the case study tactics Yin (2018) and Kembro and Norrman (2020) proposed for each of the four criteria, which we will explain in more detail in this section.

2.5.1 Construct validity

Construct validity refers to using adequate procedures for the concepts studied (Yin, 2018). During the design and data collection stage, we took four specific measures to increase the construct validity. First, we used multiple sources of data (literature, observations, interviews, and archival data) to achieve triangulation which significantly increases the reliability of the collected data (Runeson and Höst, 2009; Voss et al., 2002; Yin, 2018). Second, we used informants from different functions and hierarchical levels to triangulate responses (Yin, 2018). Third, we strived to maintain a transparent chain of evidence (e.g., Eisenhardt and Graebner, 2007; Miles and Huberman, 1994; Runeson and Höst, 2009; Yin, 2018) by framing the ROs in a logical sequence. Last, the interview guide was tested internally and sent to an outside expert for feedback to increase the quality (Kallio et al., 2016).

We took five specific measures during the data analysis phase to increase the construct validity. First, we strived to clearly explain the data analysis process in a structured manner to establish transparency (Ketokivi and Choi, 2014), explicitly explaining and illustrating all data displays used. Second, we adopted the tactics used by Kembro and Norrman (2020) and conducted all analyses individually at first, comparing notes and then jointly agreeing before moving on to achieve investor triangulation (Yin, 2018). Third, we strived to maintain a transparent chain of evidence (e.g., Eisenhardt and Graebner, 2007; Miles and Huberman, 1994; Runeson and Höst, 2009; Yin, 2018) by using graphic data displays and aligning to the logical sequence of ROs. Fourth, we sent all transcripts to the informants before conducting any analysis to confirm (Runeson and Höst, 2009; Yin, 2018). Last, we strived for an iterative data analysis process to continuously look for and build explanations (Kembro and Norrman, 2020).

2.5.2 Internal validity

Internal validity refers to establishing causal relationships (Yin, 2018). Although internal validity is not the most crucial test when conducting case research of explorative nature, we still took appropriate measures to increase the internal validity. We took two specific measures during the design and data collection stage. First, multiple informants responded identically to the phenomenon studied, implying causal relationships. Second, we derived the research framework used to guide the research explicitly from theory (Miles and Huberman, 1994).

During the data analysis phase, we used four specific measures. First, we used open and axial coding to find meaning within the collected data (Corbin and Strauss, 1990; Miles and Huberman, 1994). We used open coding for all data collected relating to capacity planning since the purpose was explorative due to the lack of relevant theory. In contrast, we axially coded all data collected relating to S&OP using pre-determined data displays explicitly derived from theory. Second, the research was reviewed continuously by peers during bi-weekly seminars. Third, we used theory to interpret and validate all findings. Last, we conducted a workshop with relevant stakeholders where we presented a first draft of the findings to gain feedback and insights to increase the internal validity further.

2.5.3 External validity

External validity essentially shows if the findings can be generalized or not (Yin, 2018). One of the significant disadvantages of a single-case study is that it is difficult to generalize the findings. Thus, external validity is not the most critical test in this case. Nevertheless, we strived to use theory to the greatest extent possible to increase the external validity during the design and data collection phase. During the data analysis phase, we took two specific measures. First, we presented detailed case company data and context (with some limitations due to confidential information) to allow for certain generalizability as the case context is known. Second, we were transparent with the limitations in generalizability.

2.5.4 Reliability

Reliability shows if the same methods can be used again to achieve the same results (Yin, 2018). We took two measures to achieve reliability during the design and data collection stage. First, we used a structured and standardized case study protocol (Yin, 2018) explicitly derived from theory, including an interview guide, observation schedule, and an analytical framework. Second, we developed a structured and detailed case study database (Yin, 2018) consisting of, e.g., audio recordings, transcriptions, archival data, and observation notes. We strived to consistently explain and illustrate the logic and frameworks used to generate our conclusions during data analysis. A summarizing overview of the methodology for this master's thesis, including the analysis process and tactics used to increase research quality, can be seen in Figure 2.7.

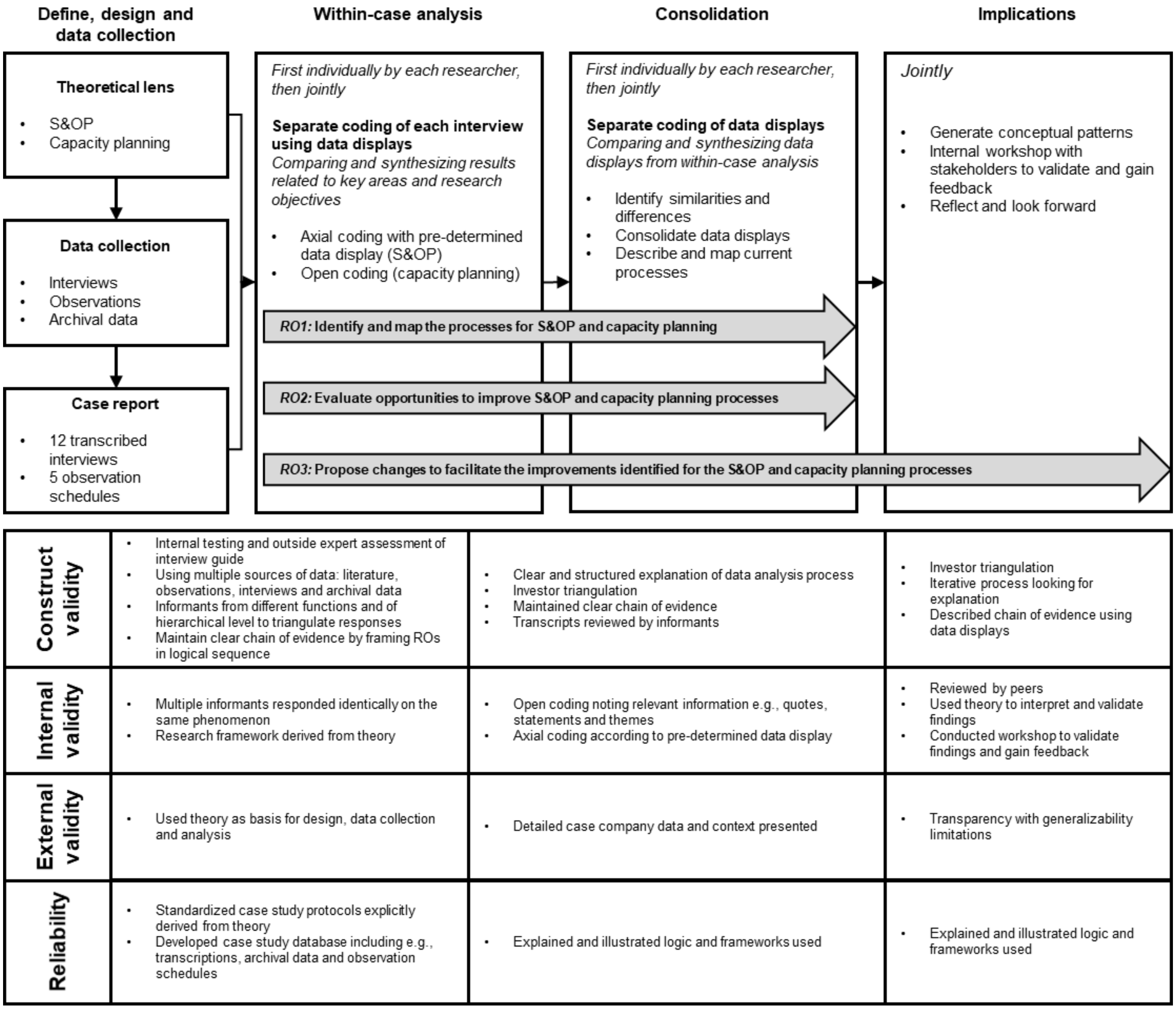

Figure 2.7 Overview of the analysis process inspired by Kembro and Norrman (2020)

Chapter 3 – Frame of reference

This chapter presents a rigorous literature study that has been conducted to achieve the purpose of this master's thesis. It covers the central theoretical findings related to the research area and the research objectives. The frame of reference introduces terminology, concepts, and frameworks that will be applied to execute the empirical study and analysis. Four main areas of interest were identified: capacity planning, S&OP, linking capacity planning to sales and operations planning, and outsourcing and supply chain collaboration; see Figure 3.1 *for a summary. Last, findings are synthesized into an analytical framework that will guide the data collection and analysis.*

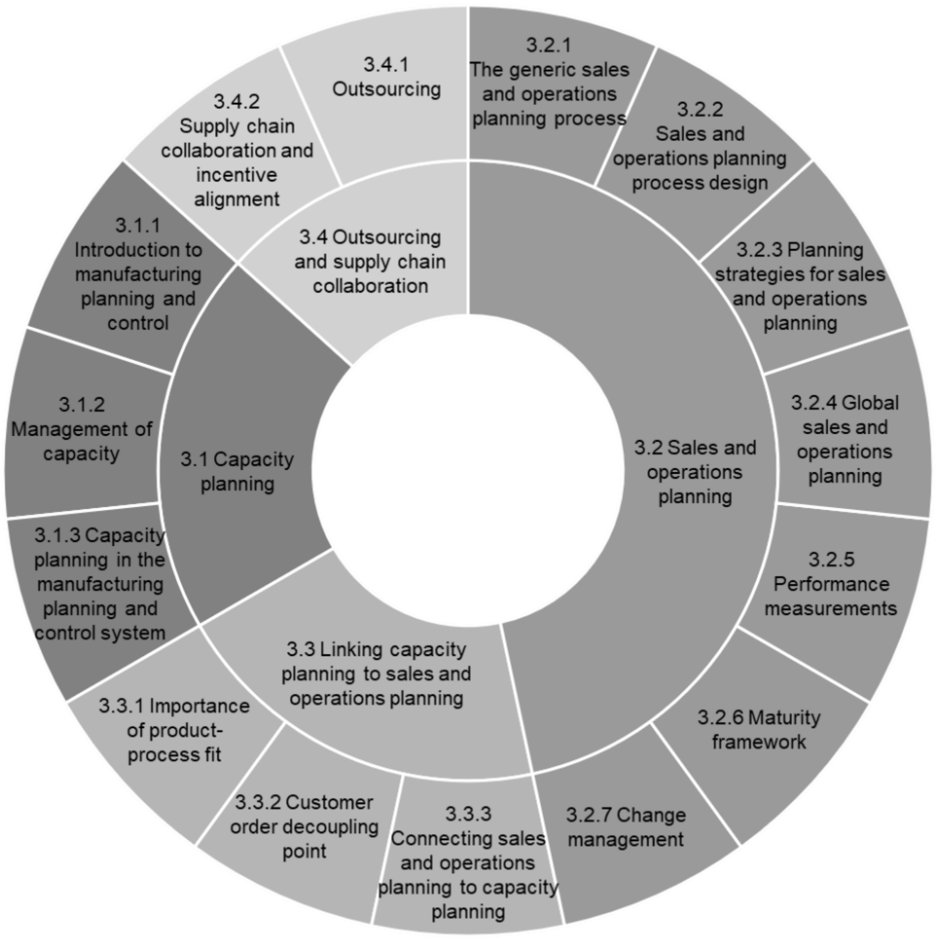

Figure 3.1 Frame of reference content

3.1 Capacity planning

3.1.1 Introduction to manufacturing planning and control

Capacity planning is a part of manufacturing planning and control (MPC), also known as production planning and control (PPC) (e.g., Jacobs et al., 2011; Olhager et al., 2001). MPC is defined as "the brain and the nervous system of the production program and is responsible for ensuring the availability all materials, part of assembly at the right time, at the right place, and in right quantities to enable the progress of operations according to the predetermined schedules at the minimum possible costs" (Kiran, 2019, p. 1). MPC is a critical system needed to plan and control production effectively (Olhager and Wikner, 2000; Zäpfel and Missbauer, 1993).

Hopp and Spearman (2008) divide the MPC system into a strategic, a tactical, and an operational level, see Figure 3.2. The levels are divided based on the time horizon each planning function cluster corresponds to (Hopp and Spearman, 2008). Kiran (2019) does not structure the planning activities into the same levels; however, he clustered them into preplanning, planning, and control phases. The preplanning phase includes product process-related functions such as product design, process design, product specifications, and plant layout (Kiran, 2019). Hopp and Spearman (2008) also discuss the preplanning phase functions and label most of the preplanning phase functions as part of product development and business planning. The product development and business planning functions are highlighted as essential but not part of the plant strategy, i.e., the responsibility lies within other business functions than manufacturing.

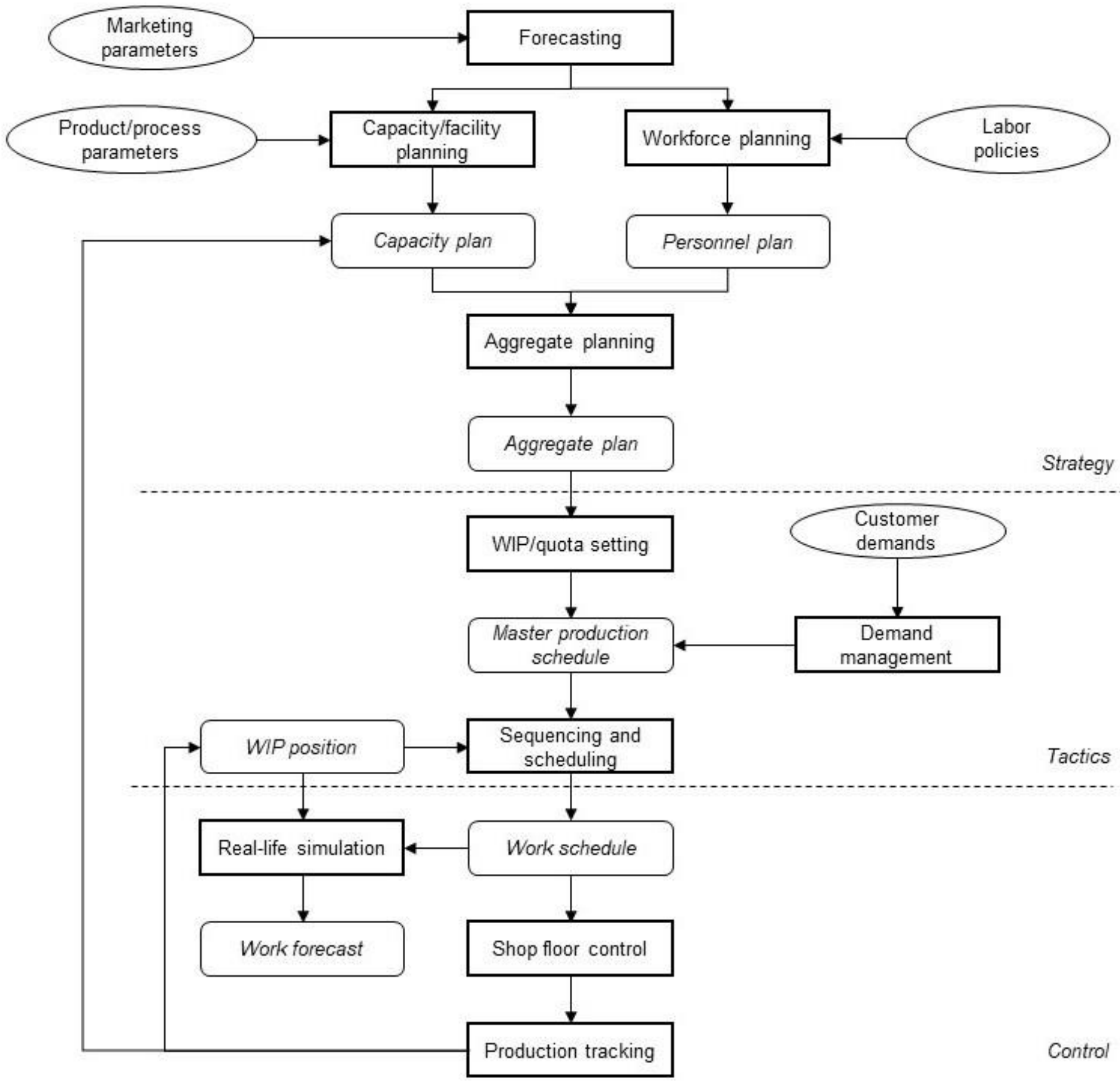

Figure 3.2 Planning levels and activities in MPC adapted from Hopp and Spearman (2008)

3.1.2 Management of capacity

Superior manufacturing has for a long time been considered a "secret weapon" to fight fierce competition as it can contribute significantly to the competitiveness of a company (Hayes and Wheelwright, 1985). From a strategic perspective, production capacity is one of the most critical internal manufacturing capabilities to plan (Hopp and Spearman, 2008; Olhager et al., 2001). A long-term mindset is vital when managing capacity to ensure competitive performance in cost, delivery speed, dependability, and flexibility (Olhager et al., 2010). Strategic problems for capacity management include, e.g., how much capacity to have, length of cycle times, type of capacity, and required throughput. (Hopp and Spearman, 2008). The strategic problems can link to problems on a tactical level, such as minimizing cost or cycle times, depending on the strategic objective (Hopp and Spearman, 2008).

Nevertheless, having a strategy for capacity before making strategic capacity decisions is vital (Hopp and Spearman, 2008). Olhager et al. (2001) define strategies for managing capacity using three variables: *amount*, *type*, and *timing*, which impact if there is a need to add or deduct capacity. Hopp and Spearman (2008) also mention amount, type, and timing. However, they add the variable of *where*. Olhager et al. (2001) describe that capacity type and amount are often labeled a sizing problem, and that scale consideration is critical. Both Olhager et al. (2001) and Hopp and Spearman (2008) explain how capacity usually is increased or decreased through incremental steps, e.g., adding a new machine to a production line will not increase the production capacity linearly. The third variable of capacity timing concerns whether capacity should be after demand has developed or as a "cushion" to hedge against potential demand growth (Hopp and Spearman, 2008; Olhager et al., 2001). Olhager et al. (2001, p. 217) express capacity strategy as "a trade-off between high utilization (low-cost profile) and maintaining a capacity cushion (flexibility)." It should further answer questions such as whether to add the capacity change to an existing facility or build a new facility (Hopp and Spearman, 2008). If multiple facilities exist, a choice needs to be made on where to place the capacity.

When managing capacity, there are decisions on whether there should be excess capacity supply, excess capacity demand, or a balance between the two. These decisions translate into three capacity strategies: *leading demand*, *lagging demand*, and *tracking demand* (Kiran, 2019; Olhager et al., 2001). The *lead strategy*, illustrated in Figure 3.3, implies that more than necessary capacity is planned for, aiming to improve service levels and reduce lead times (Kiran, 2019; Olhager et al., 2001). A leading capacity strategy implies having a safety margin that prevents capacity from being the bottleneck in manufacturing operations. Olhager et al. (2001) state that a lead strategy enables volume flexibility and secures more reliable lead times, meaning that the opportunities to satisfy customers should increase. However, a lead strategy comes at a price. Having more than necessary capacity implies a low utilization rate, resulting in extra costs, such as equipment and personnel costs. A lead strategy is preferred when quality, flexibility, and design are order winners (Olhager et al., 2001).

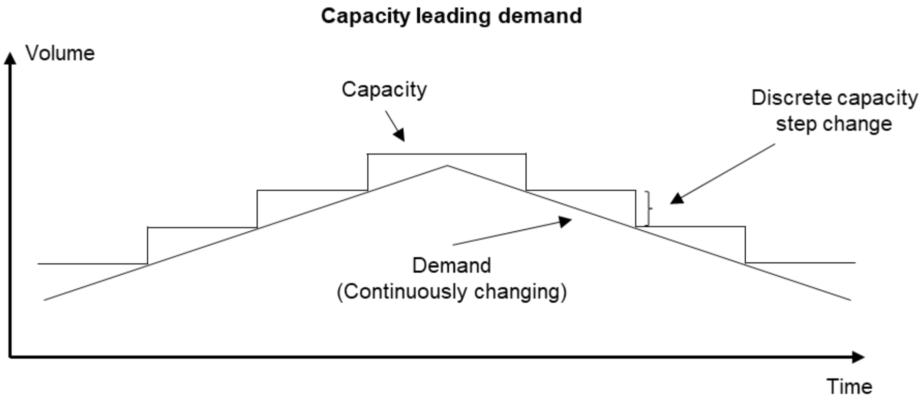

Figure 3.3 Leading capacity strategy, adapted from Olhager et al. (2001)

The *lag strategy*, illustrated in Figure 3.4, is the opposite of a lead strategy. Instead of having a cushion of capacity, the aim is to have less capacity than the market demand desires. Having "little" capacity aims to produce as much as possible with the resource available and thus achieve maximum utilization of equipment, personnel, and other resources, as it implies a lower cost profile (Olhager et al., 2001). Olhager et al. (2001, p. 218) further state that "focus on a low cost per unit is central" for a lag strategy. Thus, a lag strategy is most suitable in cost-pressured environments where the price is the order winner (Olhager et al., 2001) as it results in less waste. However, it also increases the risk of lost sales due to poor service levels (Kiran, 2019).

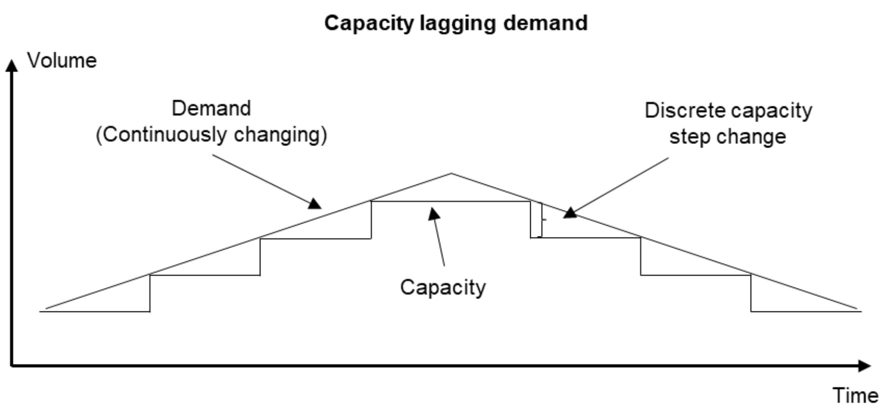

Figure 3.4 Lagging capacity strategy, adapted from Olhager et al. (2001)

The *tracking strategy* (see Figure 3.5 for illustration) mixes the previous two, where capacity is adjusted with small amounts to match and track the demand (Olhager et al., 2001). A tracking strategy aims to have the capacity to follow the demand as best as possible, i.e., focusing on the sizing problem (Olhager et al., 2001). Olhager et al. (2001) point out that both the leading and lagging demand strategies are challenging to maintain in practice, resulting in tracking demand being the reality for most companies. Nevertheless, lead and lag are foundational strategies to consider when deciding on capacity investments.

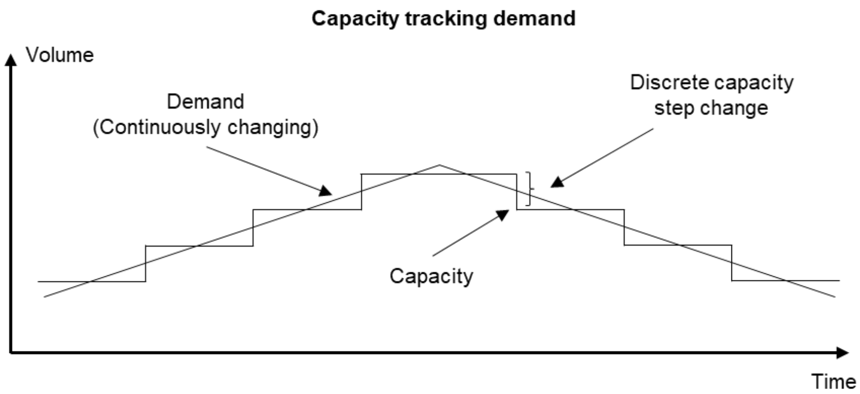

Figure 3.5 Tracking capacity strategy, adapted from Olhager et al. (2001)

There are several aspects impacted by capacity decisions that need to be considered. These aspects include cost, throughput, mean cycle time, cycle time variance, and quality (Hopp and Spearman, 2008). Additional factors to consider are lead times and work in progress (WIP) levels, which continuously increase when increasing the utilization of production machinery, i.e., the production flexibility decreases when utilization is increased (Hopp and Spearman, 2008). These decisions are managed in the tactical and operational parts of MPC.

As labeled by Hopp and Spearman (2008), planning functions at the top-level or strategic level have a long-term time perspective. The main objective of this level is to meet the production facility's overall goals by establishing a production environment capable of doing so (Hopp and Spearman, 2008). The top-level functions include forecasting, capacity planning, workforce planning, and aggregate planning (Hopp and Spearman, 2008; Kiran, 2019). The tactical level is the planning level with an intermediate timeframe. It is an action plan for the upcoming production, generated from the input from the strategic level combined with information on customer orders (Hopp and Spearman, 2008). It consists of a quota/WIP module that turns the aggregate plan from the strategic level into so-called Kanban card counts, which become part of the master production schedule (Hopp and Spearman, 2008). The MPS also consists of the forecast performed at the strategic level, which is then adjusted by demand management. After that, the master production schedule turns into sequencing and scheduling plans that decide the production plan for the next days or weeks. The last level, the control (or operational) plan, is the short-term plan that manages the shop floor control, i.e., tracking the real-time production flow and how it aligns with the production schedule, planned at the tactical level (Hopp and Spearman, 2008).

3.1.3 Capacity planning in the manufacturing planning and control system

The literature addressing capacity planning in a high-tech context is generally limited (Wu et al., 2005). Most of the literature focuses on complex mathematical models of deterministic and stochastic character (Martinez-Costa et al., 2014; Wu et al., 2005). The increasing importance of capacity planning in high capital-intensive industries has led to most research attention directed to the semiconductor industry (Martinez-Costa et al., 2014; Wu et al., 2005), while new product introduction in this context is yet to be studied (Martinez-Costa et al., 2014). Kiran (2019) states that when introducing a new product or when the demand for an existing product increases, capacity planning is the first thing the company must address. Martinez-Costa et al. (2014, p. 68) define capacity as "not the volume of outputs that the system can generate in a given time, but the availability of various types of productive resources."

Like MPC, capacity planning can be divided into three different levels: strategic, tactical, and operational (Kiran, 2019; Martinez-Costa et al., 2014). The strategic level is characterized by a long-term view and concern decisions such as capacity size, capacity type, location, capacity expansion or reduction, and production equipment (Martinez-Costa et al., 2014) both in terms of the perspective of the own firm but also other supply chain partners (Wu et al., 2005). The tactical level concerns decisions of a medium-term horizon and includes, e.g., modifying staff size and the amounts of working time but does not concern decisions on, e.g., equipment. The operational level is the lowest and concerns decisions with a short-term view.

High-tech products are generally affected by demand uncertainty and short product life cycles, two critical factors considered in most mathematical models (Wu et al., 2005). Wu et al. (2005) identified four categories of models in literature: newsvendor-style, multi-period, option-based, and risk-sharing contracts. As often is the case with mathematical models, these approaches to capacity planning decisions are based on assumptions. E.g., most newsvendor-style models fail to consider multiple products and resources, while the models based on risk-sharing contracts generally assume that all supply chain actors have all the information at all times.

In their literature review of the available mathematical models, Martinez-Costa et al. (2014) identified a series of aspects that to address in the strategic capacity planning decision: capacity size, capacity location, capacity allocation, capacity configuration, technology selection, production and inventory decisions, backlogging, workforce planning, new product development, and financial planning. Further, they identified external factors that also affect the decision: uncertainty, economies of scale and economies of scope, learning effect, scale-up time and qualification time, lead times, set-up times and lifetimes, the correlation between the demand of multiple products, risk, finite budget and time value of money, taxes, regulatory factors on import-export and exchange rates. Meanwhile, Kiran (2019) mentions five factors influencing capacity planning: demand forecasts, plant and labor efficiency, subcontracting, multiple shift operations, and management policies. A summary of the identified factors that may affect the generic capacity planning decision can be seen in Figure 3.6. Note that it is the authors' categorization of factors, and thus it has not been based directly on literature.

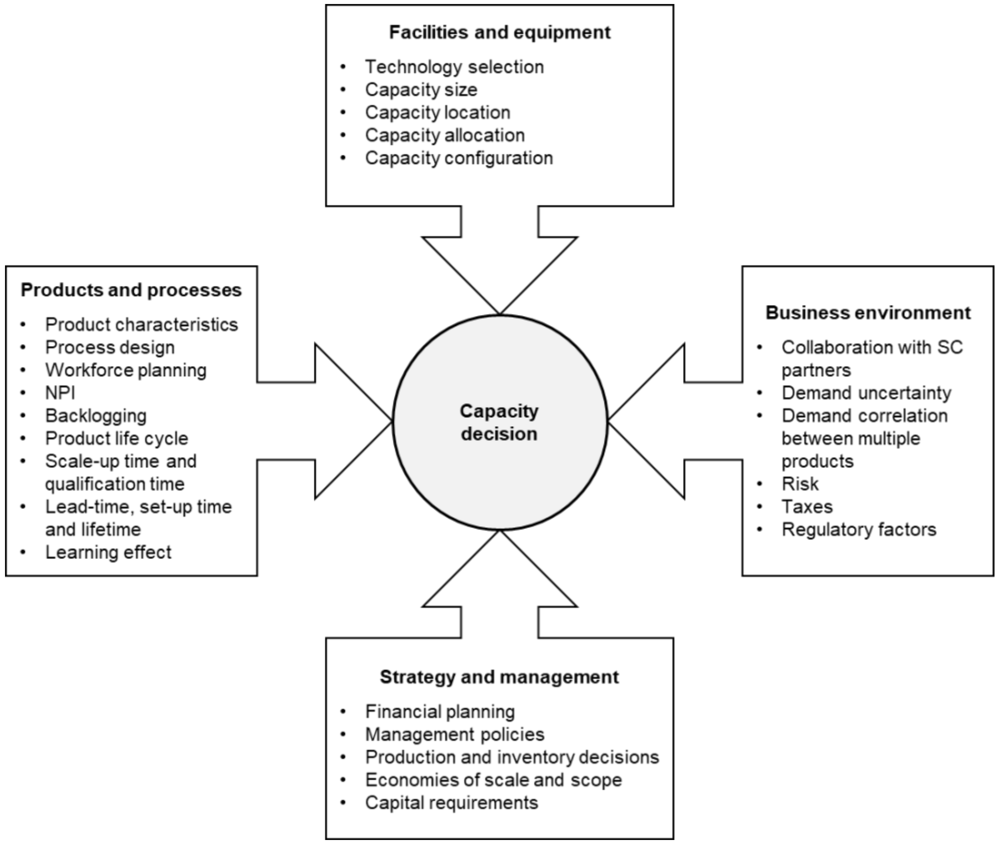

Figure 3.6 Identified factors that may affect the generic capacity planning decision

3.2 Sales and operations planning

In its essence, S&OP is a cross-functional business process that aims to balance supply and demand in organizations by linking the overarching corporate strategy to the daily operations (e.g., Bower, 2005; Grimson and Pyke, 2007; Lapide, 2007; Olhager et al., 2001; Thomé et al., 2012a; Tuomikangas and Kaipia, 2014). The S&OP process consists of forums where different functions within the company gather to establish an operations plan aligned with the sales plan and the company's overall strategy (Olhager et al., 2001; Småros and Falck, 2013). The essence of an S&OP process is illustrated in Figure 3.7. While S&OP often facilitates improved information flow between different functions, Småros and Falck (2013) argue that the main benefit of adopting an S&OP process is that it creates actionable decisions. Småros and Falck (2013) further state that "if the S&OP process does not directly result in improved decision making then, to put it bluntly, you're wasting your time" (Småros and Falck, 2013, paragraph 12).

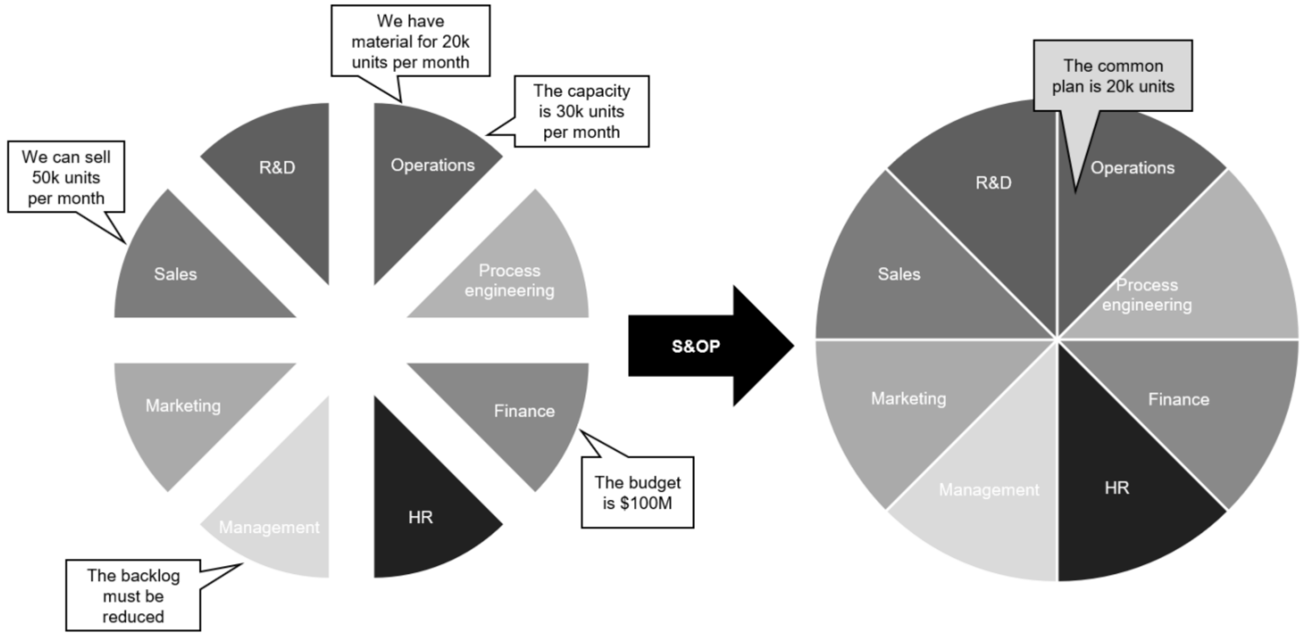

Figure 3.7 The essence of S&OP, inspired by Småros and Falck (2013)

Many consider S&OP to be a crucial business process and one of the most effective ways to overcome functional silos (Lapide, 2007; Tuomikangas and Kaipia, 2014; Swaim et al., 2016), but as a concept, S&OP is not new and has been around for a long time (Lapide, 2004; Grimson and Pyke, 2007; Thomé et al., 2012a; Hulthén et al., 2016). Despite the longevity and interest in S&OP, many companies have struggled to realize the promised benefits literature suggests (e.g., Lapide, 2004; Bower, 2005; Grimson and Pyke, 2007; Tuomikangas and Kaipia, 2014). Thomé et al. (2012b) identified several sources (55) of academic literature claiming S&OP increases firm performance. However, only six of the studied papers had empirical evidence to support the hypothesis that S&OP increases firm performance, highlighting the gap between literature and practice. Thus, there is a need from a researcher's perspective to gain more in-depth knowledge of S&OP practices and implementation in practice.

3.2.1 The generic sales and operations planning process

The generic S&OP process identified in the literature consists of five steps: data gathering, demand planning, supply planning, pre-S&OP meeting, and an executive S&OP meeting (Bower, 2005; Grimson and Pyke, 2007; Jacobs et al., 2011; Lapide, 2004) see Figure 3.8. The first three steps of the process are work that must be done in advance to make the most out of the two last steps, which usually consist of formal meetings.

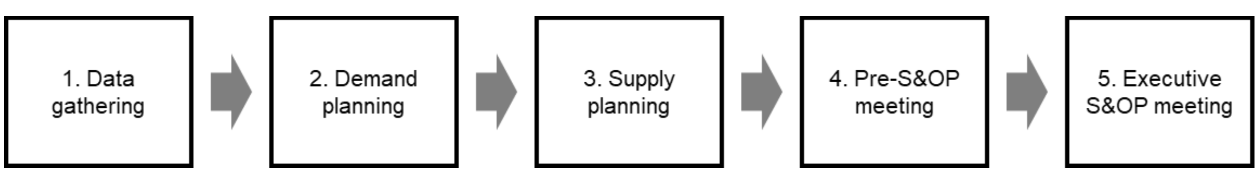

Figure 3.8 The generic S&OP process adapted from Jacobs et al. (2011)

Step 1: Data gathering

The first step of the S&OP process is data gathering (Grimson and Pyke, 2007; Jacobs et al., 2011). This step is carried out just after the scheduled meeting cycle has ended, i.e., if meetings are scheduled monthly, the data gathering happens at the end of the month. The fundamental goal of this step is to gather data to be used as a basis for developing the forecasts later in the S&OP process.

Step 2: Demand planning

The second step of the S&OP process is the demand planning phase (Lapide, 2004; Grimson and Pyke, 2007; Jacobs et al., 2011). In this step, marketing and sales gather to generate a demand forecast, serving as a baseline for the rest of the process. It is essential to consider that this forecast should be unconstrained and thus should reflect what the company thinks it can sell to customers in the case of manufacturing not being a constraining issue (Bower, 2005; Grimson and Pyke, 2007; Lapide, 2004). The baseline forecast should also be unbiased, and by leveraging statistical forecasting methods, this is often achieved (Lapide, 2004). The forecast should consider every aspect that could potentially impact the customer demand (Bower, 2005; Lapide, 2004). Thus, it is often appropriate to adjust the baseline forecast depending on relevant factors (Grimson and Pyke, 2007; Jacobs et al., 2011). This demand forecast is typically focused on an aggregate level, such as a single product family but can also focus on individual stock-keeping-units (SKUs) (Grimson and Pyke, 2007; Thomé et al., 2012a). The planning horizon varies, and Thomé et al. (2012a) argue that most academic papers point toward a 3-18 month planning horizon.

Step 3: Supply planning

The third step of the S&OP process is the supply planning phase (Lapide, 2004; Grimson and Pyke, 2007; Jacobs et al., 2011). In this step, people within operations gather to generate an initial operations plan which is essentially a rough output plan (Lapide, 2004; Grimson and Pyke, 2007; Jacobs et al., 2011) and should constrain the demand plan (Lapide, 2004). Important to understand is that the developed operations plan is not a forecast in the same sense as the plan developed in the demand planning stage. Instead, it is a statement of the desired output for the period (Jacobs et al., 2011). Aspects to consider in the supply planning phase are, e.g., inventory strategy, capacities, and backlogs (Grimson and Pyke, 2007; Jacobs et al., 2011; Lapide, 2004). Potential issues and essential points to discuss from the supply planning phase are brought to the next step in the process.

Step 4: Pre-S&OP meeting

The fourth step is the pre-S&OP meeting which generally is the first formal meeting of the S&OP process and should involve people from different functions (Grimson and Pyke, 2007; Jacobs et al., 2011; Lapide, 2004). At this stage, pre-S&OP participants discuss and, if possible, resolve potential issues with the S&OP plan. The ultimate target of the pre-S&OP meeting is to make decisions that top management can review and act upon in the executive S&OP meeting.

Step 5: Executive S&OP meeting

The final step is the executive S&OP meeting which concludes the S&OP process (Jacobs et al., 2011). One significant distinction from the previous step is that this meeting, as the name implies, involves senior management (Grimson and Pyke, 2007; Jacobs et al., 2011). The concluding meeting aims to make final decisions on the developed sales and operations plans, resolve issues the pre-S&OP meeting was unable to resolve, and measure process performance (Lapide, 2004; Grimson and Pyke, 2007; Jacobs et al., 2011). If all previous steps are carried out correctly, Jacobs et al. (2011) argue that a productive two-hour meeting is enough to make the necessary decisions.

It is often suggested in the literature that one crucial aspect of the S&OP process is to make the meetings routine (Grimson and Pyke, 2007; Lapide, 2004), with most companies generally aiming toward having monthly meetings (Bower, 2005; Grimson and Pyke, 2007; Jacobs et al., 2011; Lapide, 2004). Although much of the literature suggests monthly meetings, Grimson and Pyke (2007) argue that companies pivot towards more frequent meetings than monthly. Companies with leading S&OP practices are moving away from scheduled meetings and instead strive for an event-driven S&OP process where the S&OP team simply meets when they need to act upon deviations to the process. Further, it is a prerequisite for successful implementation of the process that the S&OP teams are genuinely cross-functional and not only include various business functions throughout the organization (Grimson and Pyke, 2007; Jacobs et al., 2011; Lapide, 2004) but also encourage them to participate in the meetings actively (Lapide, 2004).

3.2.2 Sales and operations planning process design

The process described above is a generic framework for the S&OP process and serves as a foundation for companies to build their S&OP practice (Kristensen and Jonsson, 2018). However, it is essential to understand that no universal S&OP design exists, and it is necessary to adapt the process design to the focal firm's situation (Goh and Eldridge, 2019; Dittfeld et al., 2020; Kristensen and Jonsson, 2018). Despite this need, Kristensen and Jonsson (2018) and Thomé et al. (2012a) argue that most academic papers disregard this aspect. Most papers are descriptive, present little empirical evidence, and fail to consider contextual factors affecting S&OP design (Kristensen and Jonsson, 2018; Thomé et al., 2012a).

Kristensen and Jonsson (2018) argue in their extensive literature review of 68 papers that S&OP design is affected by three factors: industry, complexity, and organizational characteristics, illustrated in Figure 3.9. First, industry aspects concern, e.g., activity structures, planning object details, and planning horizons. In terms of the planning horizon, Grimson and Pyke (2007) state that the choice of planning horizon depends on several contextual factors related to industry and product. Industries characterized by long manufacturing lead times or high seasonality, such as the automotive, apparel, and pharmaceutical, typically aim toward longer planning horizons. In contrast, short manufacturing lead times and low seasonality are typical in industries such as the commodity. Thomé et al. (2012a) identified that the literature suggests a need to formalize S&OP teams and procedures.

On the contrary, Goh and Eldridge (2019) argue that highly formalized S&OP procedures harm supply chain performance with increasing firm size and S&OP experience boosting this negative impact, while Grimson and Pyke (2007) identified no correlation between firm size and S&OP maturity. Further, Goh and Eldridge (2019) identified that it is less critical for technology companies to formalize S&OP processes than, e.g., the automotive industry, thus relating the degree of standardization to industry aspects. Thomé et al. (2012a) state that a great deal of the literature argues that the chosen customer order decoupling point (CODP) (Olhager, 2010) affects S&OP design, while Grimson and Pyke (2007) identified no correlation between S&OP maturity and the product-process matrix (and as described above, firm size).

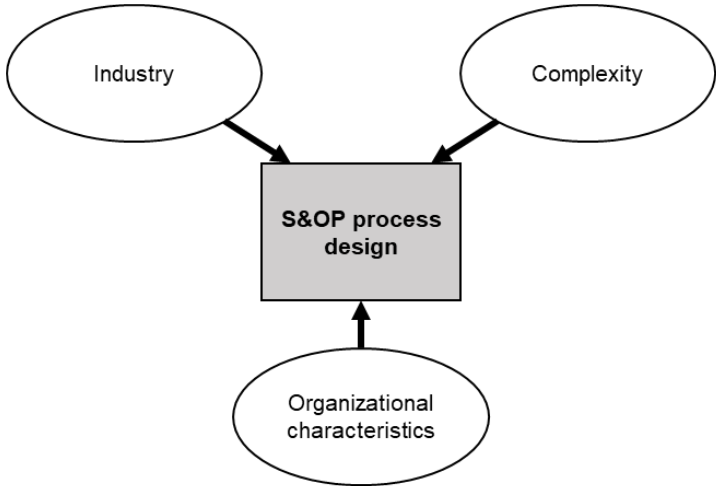

Figure 3.9 S&OP process design factors (Kristensen and Jonsson, 2018)

Second, the level of dynamic complexity (demand and supply uncertainty) and detail complexity (multiple markets) affect the S&OP design (Kristensen and Jonsson, 2018). In terms of dynamic complexity, Kristensen and Jonsson (2018) identified that higher dynamic complexity requires more cross-functional and horizontal coordination in the S&OP process. They propose scenario planning to manage potential risks in organizations with high dynamic complexity no matter the maturity of the S&OP process, despite most maturity frameworks arguing that only the later stages require scenario planning. Bagni et al. (2022) identified that significant cost reductions could be achieved by establishing a separate S&OP process for new product introductions to counteract the demand and supply uncertainty associated with new product introductions. Dittfeld et al. (2020) argue that managing risk through S&OP boils down to the S&OP design and state that it may include, but is not limited to, scenario planning. Instead, adopting a risk-focused S&OP design through, e.g., multi-level S&OP design, temporary design changes, and crisis S&OP meetings can significantly increase organizations' ability to proactively and reactively manage risks with the S&OP process.

To deal with detail complexity, Kristensen and Jonsson (2018) identified that most literature suggests companies parse their S&OP processes, i.e., divide one S&OP process into multiple S&OP processes. Lapide (2012) proposes parsing the S&OP process in the light of increased globalization and argue that many companies have outgrown the practice of having one single S&OP process. The S&OP divide should align with the organization's detail complexity, i.e., each parsed S&OP process should represent a profit and loss center such as a region or business unit.

Last, organizational aspects, e.g., orientation, culture, and involvement, can enable or act as a barrier to S&OP (Kristensen and Jonsson, 2018). In terms of how design is affected by organizational characteristics, Kristensen and Jonsson (2018) identified that they impact the ability to take advantage of information technology (IT) and enable external integration. Thomé et al. (2012a) argue that information systems are crucial to implementing S&OP. However, there is no consensus in the literature on how much an organization would need to invest in information systems. Further, Thomé et al. (2012b) argue that internal and external supply chain integration is key to S&OP implementation, while Swaim et al. (2016) identified empirically that internal integration positively influences standardized S&OP processes to act as an enabler to effective S&OP.

Currently, most S&OP processes strictly use internal data, but external integration may allow companies to leverage external data as inputs to the S&OP process. External data such as vendor managed inventory

(VMI), collaborative planning, forecasting and replenishment (CPFR), or point of sales (PoS) further highlight the benefits of supply chain integration to S&OP (Lapide, 2004). Goh and Eldridge (2015) identified that S&OP with supplier integration could reduce inventory levels by 30 % and improve forecast accuracy by 52 %, highlighting improvements possible by actively involving suppliers. Interestingly enough, the case company used contract manufacturing, although a single case makes it difficult to generalize the findings. Kaipia et al. (2017) further pointed toward the value of using PoS data in a collaborative S&OP process, especially when introducing new products to coordinate against demand uncertainty. Consequently, IT and supply chain integration are two key design features related to organizational aspects, although the literature fails to deliver on how to implement them.

3.2.3 Planning strategies for sales and operations planning

A central function of the S&OP process is to coordinate and balance the production plan and the sales plan (Chapman, 2006; Olhager et al., 2001). Two types of decisions characterize this issue: demand modification to align with the production set-up and its capacity constraints or supply modification to align with the sales plan (Olhager et al., 2001). The first issue, adopting demand after the existing operations, is usually managed from the sales side by applying tools from marketing practices such as promotions, pricing, and new product introduction (Chapman, 2006; Olhager et al., 2001). Both Chapman (2006) and Olhager et al. (2001) divide the latter issue (matching supply with the sales plan) into planning strategies that are either leveling or chasing the forecasted demand or a mix of the two, see Figure 3.10 for an issue breakdown. The level and the chase strategies can be seen as two extremes and are unusual to see used isolated in practice (Chapman, 2006; Olhager et al., 2001), e.g., a set level strategy might become a mix strategy leaning towards level.

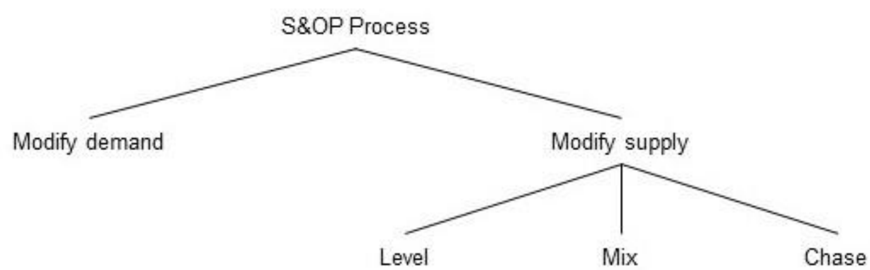

Figure 3.10 Modification decisions in the S&OP process, adapted from Olhager et al. (2001)

There is a link between companies' CODP (Olhager, 2010) and how companies usually lean with their planning strategy (Olhager et al., 2001). In make-to-order (MTS) environments, such as in the process industry, a level strategy is typically applied, while in a make-to-stock (MTO) or an engineer-to-order (ETO) environment, the chase strategy is more commonly found (Olhager et el., 2001).

A *level planning strategy* aims to "achieve a uniform and high utilization of production resources, including a minimization of costs related to changes in production rates" (Olhager et al., 2001, p. 220). On a tactical level, a level strategy translates into steady production output during the entire planning period (Chapman, 2006) while minimizing changes in the production output rate that result in additional costs (Olhager et al., 2001). Meanwhile, changing the sales plan while keeping the production steady makes inventory levels fluctuate to adapt the operations to the sales plan changes (Olhager et al., 2001). Increased sales volumes lead to a decrease in inventory, and vice versa, making inventory a vital tool in adaption to demand changes. Chapman (2006) stresses the importance of building inventory during low-demand periods. If changes in inventory levels do not solve the entire issue, other options to manage fluctuations in sales are outsourcing or subcontracting (Chapman, 2006; Olhagre et al., 2001). A pure level planning strategy is illustrated in Figure 3.11.

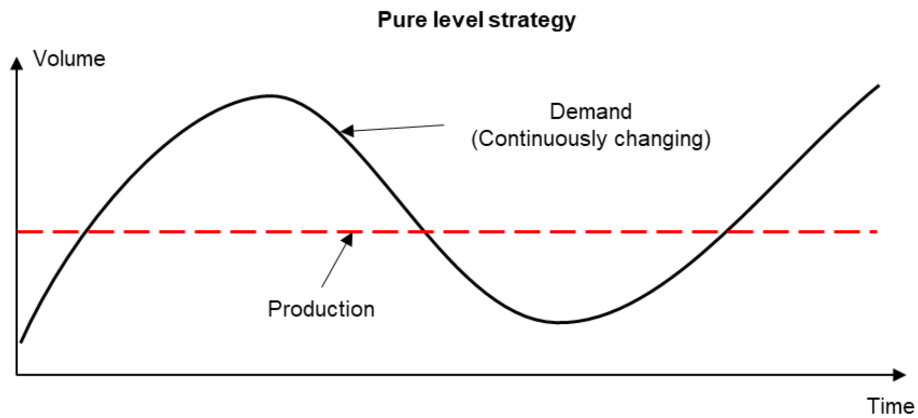

Figure 3.11 Level planning strategy, figure by the authors

In contrast to the level planning strategy, the main objective of the *chase planning strategy* is to produce products following the sales plan to minimize the order backlog and the tied-up capital in inventories (Chapman, 2006; Olhager et al., 2001). That said, the essence of the chase strategy is to adjust the production output when changes in the sales plan occur, rather than experiencing fluctuations in inventory levels (Chapman, 2006; Olhager et al., 2001), see illustration in Figure 3.12. Keeping inventory levels stable helps keep inventory investments and the costs of having an order backlog in check (Olhager et al., 2001). Chapman (2006) states that the focus shift from inventory management towards capacity management when agreeing on sales orders in MTO environments, i.e., when using a chase planning strategy. A flexible and adaptable production operation is often achieved by lower production equipment and resource utilization, resulting in higher costs related to production output changes **(**Olhager et al., 2001). Other than low resource utilization, Hopp and Spearman (2008) mention higher inventory levels and short cycle times downsides with keeping the production flexible. If adjusting production output does not solve the issue, changes in the number of workers, temporary workers, overtime, and being flexible in employer working hours as options to stay flexible when adopting a chase planning strategy (Chapman, 2006; Olhager et al., 2001).

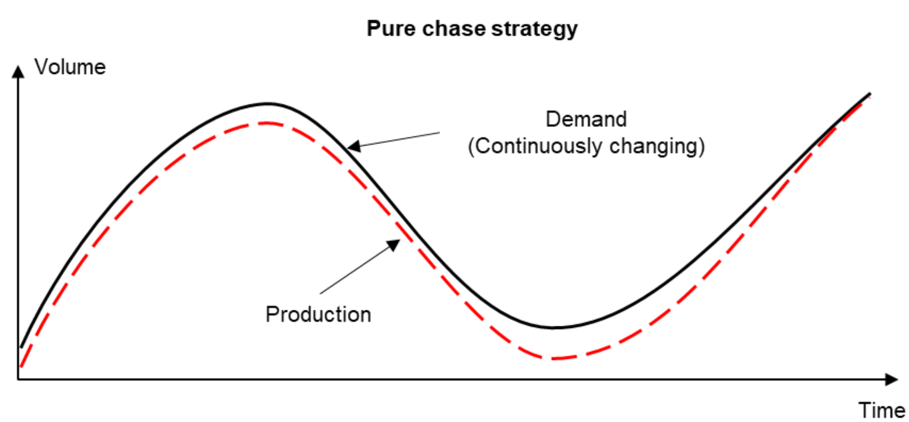

Figure 3.12 Chase planning strategy, figure by the authors

The *mix planning strategy* includes the entire spectrum between the level and chase strategies and combines the strength of the two (Chapman, 2006; Olhager et al., 2001), as illustrated in Figure 3.13. It leads to less fluctuation in the production output than the chase strategy and better synchronization between the production output and the sales plan than the level strategy (Olhager et al., 2001). Chapman (2006, p. 53) explains the strengths of a mix strategy as "companies using this approach will "mix and match," altering demand and resources in such a way to maximize performance to their established criteria, including profit, inventory management, and the impact on people." A company should base its decision on what planning strategy to use by making tradeoffs between and evaluating the respective strengths of the extreme strategies at each end of the spectrum (Olhager et al., 2001).

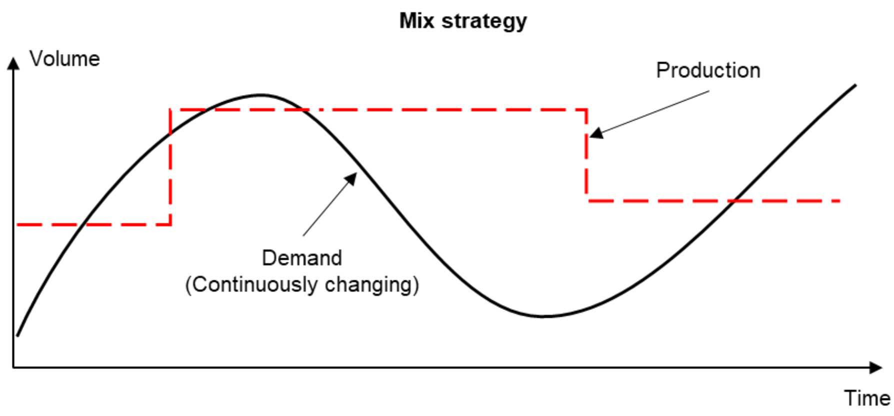

Figure 3.13 Mix planning strategy, figure by the authors

3.2.4 Global sales and operations planning

Increased globalization has led to companies adopting more global practices (Lapide, 2012; Seeling et al., 2021). Consequently, S&OP processes should be more strategic than tactical (Seeling et al., 2021) and may even require parsing the S&OP process along different dimensions (Lapide, 2012). According to Seeling et al. (2021), the expected benefits of adopting a global S&OP process are increased vertical alignment and global visibility, better integration of worldwide plans, benchmarking opportunities, synergies among management practices, and overall, a means to achieve the global corporate strategy. Meanwhile, challenges include an increased need to coordinate activities across business units, manage the information flow in terms of the significant increase in amounts of data and different information systems, and the need to deal with an unexpected turn of events. To achieve global S&OP, Seeling et al. (2021) propose adding two additional steps to the generic five-step S&OP process: global roll-up and global executive meeting, see Figure 3.14.

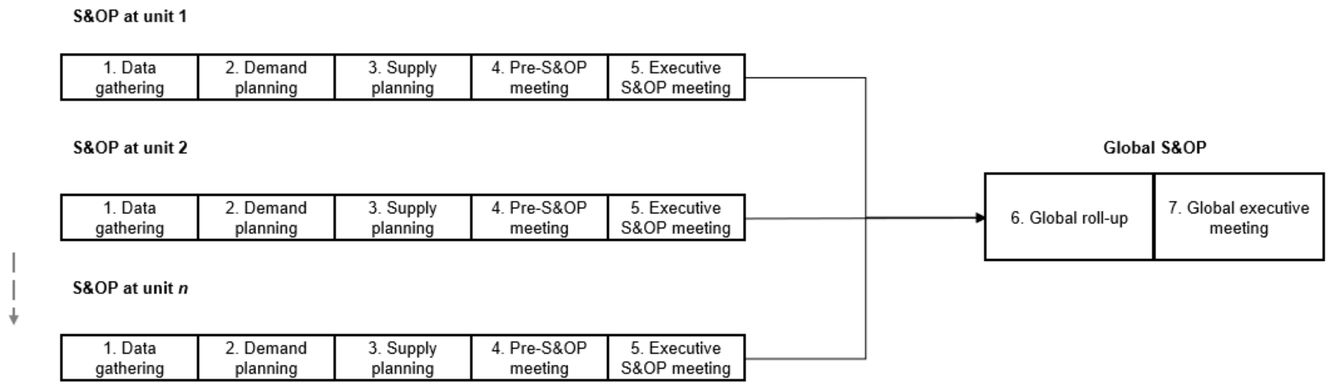

Figure 3.14 Global S&OP process, adapted from Jacobs et al. (2011) and Seeling et al. (2021)

Global roll-up

The coordination of the first step of the extended global S&OP process should be done by a global S&OP leader (Seeling et al., 2021). Data from the units are collected, analyzed, and summarized in a report to be presented at the global executive meeting. The content of this report is, e.g., improvements made, implementation progress, performance measures, and best practices. A critical aspect of this step is to standardize performance measures across each unit's S&OP process to allow easier comparison.

Global executive meeting

The final step addresses the individual unit's S&OP processes and the global S&OP process (Seeling et al., 2021). Since this meeting involves executives at the highest level, it intends to be strategic rather than tactical, as the local S&OP meetings are. The point of discussion at this meeting is the material developed in the global roll-up stage. However, due to the strategic nature of the meeting, it may also involve decisions on potential issues or the identification of new opportunities.

Lapide (2012) presents four dimensions along which a single S&OP process can parse into multiple S&OP processes: single worldwide source, multiple regional sources, dedicated regional sources, and multiple shared sourcing, see Figure 3.15. The first scenario is the most basic, in which a single manufacturing plant supplies all business units, and there is no need to parse the S&OP process. The second scenario involves multiple plants across the globe. One single plant can supply multiple business units, but multiple plants do not simultaneously supply the same business unit. In this case, the S&OP process should parse so that all business units sourcing from a specific plant constitute one S&OP process. The third scenario is when each plant supplies a single business unit. Thus, no plant supplies more than one specific business unit. In this case, each business unit should have its S&OP process. The fourth scenario is the most complex and frequently used and is the case where each business unit sources from multiple plants. In this case, parsing should be done so that business units without a supply are grouped into business units that do, and units with a supply run its S&OP process.

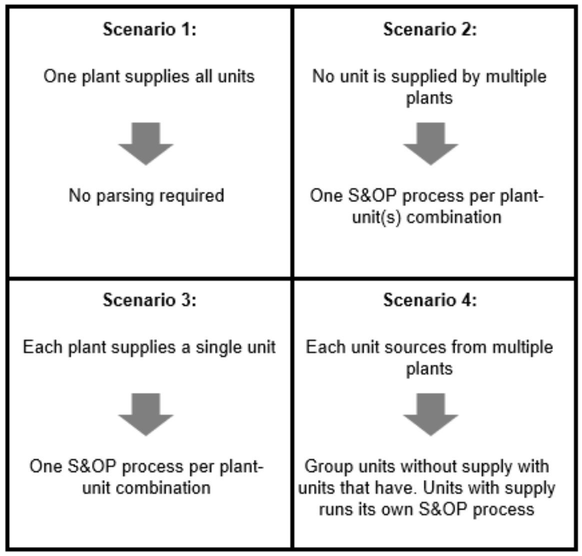

Figure 3.15 Parsing criteria for global S&OP, adapted from Lapide (2012)

3.2.5 Performance measurements

Measuring the performance of the S&OP process is emphasized as a crucial aspect of the S&OP process (e.g., Bower, 2005; Grimson and Pyke, 2007; Jacobs et al., 2011; Lapide, 2004; Pedroso et al., 2016; Thomé et al., 2012a; Tuomikangas and Kaipia, 2014). Despite the perceived importance of performance measurements in literature, there is no consensus on what metrics to use (Thomé et al., 2012a). Consequently, there is a significant need for standardized S&OP performance measures (Hulthén et al., 2016; Seeling et al., 2021). Grimson and Pyke (2007) further highlight this gap and argue that performance measures in practice are rare. Tuomikangas and Kaipia (2014) identified three different categories of performance measurements in S&OP literature: financial performance, operations performance, and process performance, while Thomé et al. (2012a) classified metrics according to the processes in the SCOR framework (plan, source, make, deliver) (ASCM, 2022), S&OP dashboard and end-results. Thomé et al. (2012a) identified that the most common performance measures in each category were inventory level, lead time, capacity utilization, on-time delivery of goods, the accuracy of forecast techniques, and company profitability. However, none of the literature reviewed identified any integrative framework for measuring S&OP performance (Thomé et al., 2012a; Tuomikangas and Kaipia, 2014). Since Thomé et al. (2012) and Tuomikangas and Kaipia (2014) performed their research, Hulthén et al. (2016) have developed a framework to address this gap (see Figure 3.16). The framework by Hulthén et al. (2016) categorizes performance measurements for S&OP in terms of effectiveness and efficiency while also addressing issues such as cross-functional tradeoffs and overall corporate strategy.

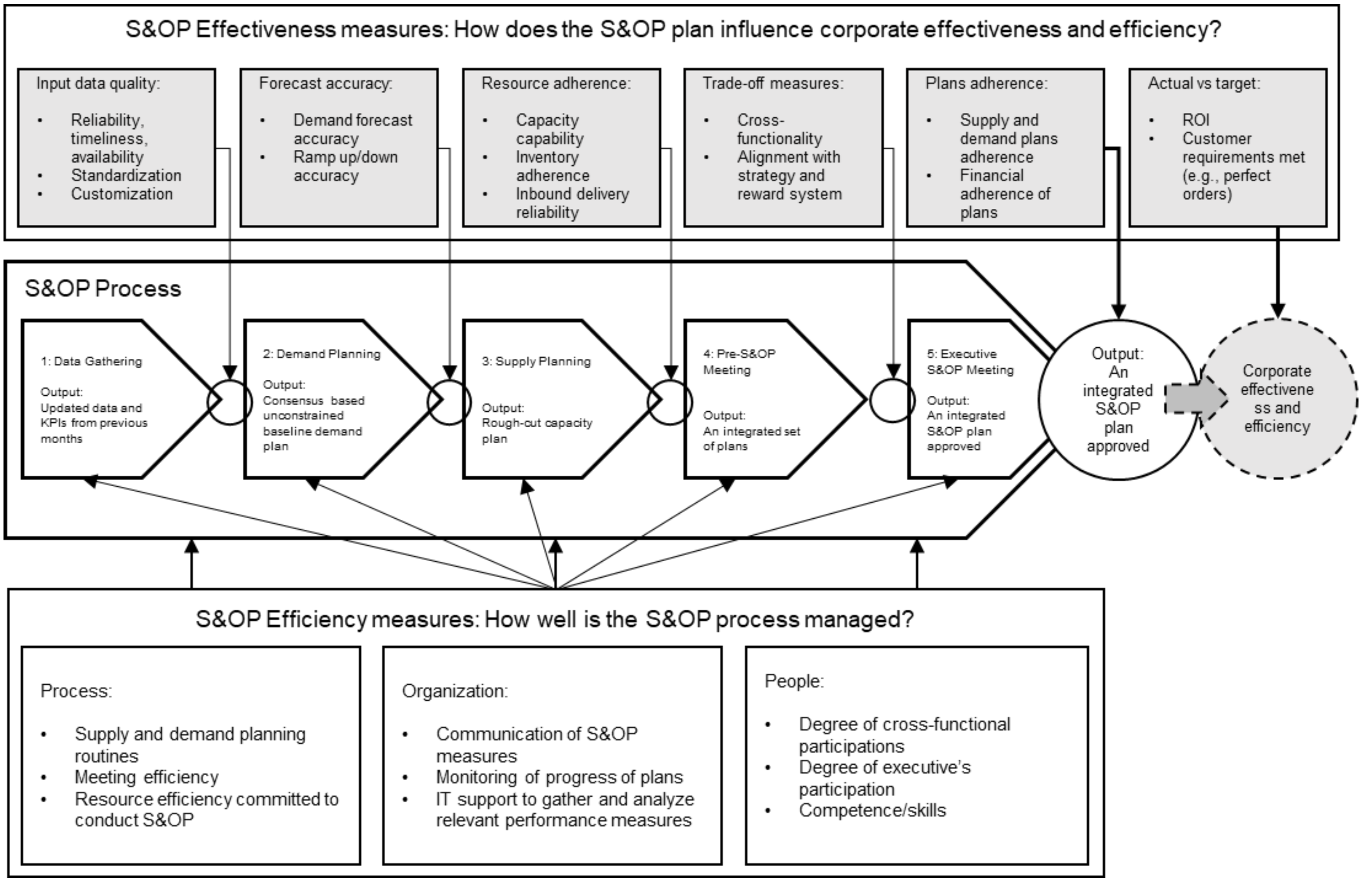

Figure 3.16 Framework of S&OP performance measurements, adapted from Hulthén et al. (2016)

3.2.6 Maturity framework

S&OP is a constant work in progress (Lapide, 2005, 2007), and companies are generally only reaching 60-70 % of S&OP potential, leaving a 30-40 % gap (Bower, 2005). Despite the difficulty of reaching an ideal process, companies should strive for continuous improvement, and maturity models are suitable tools for achieving this (Lapide, 2005). Thomé et al. (2012a) present an overview of seven different S&OP maturity models available in S&OP literature, including the model proposed by Grimson and Pyke (2007), which in turn is a synthesis of several of the frameworks identified by Thomé et al. (2012a) and empirical findings from interviews with companies practicing S&OP (Grimson and Pyke, 2007). The maturity model of Grimson and Pyke (2007) consists of five dimensions: meetings and collaboration, organization, measurements, information technology, and S&OP plan integration. Important to note is that a company may be in-between stages, and thus the placement is not binary in that sense. The maturity model is illustrated in Figure 3.17.

	Stage 1: No S&OP process	Stage 2: Reactive	Stage 3: Standard	Stage 4: Advanced	Stage 5: Proactive
Meetings and collaboration	• Silo culture • No meetings • No collaboration	• Discussed at top level management meetings • Focus on financial goals	• Staff pre-meetings • Executive S&OP meetings • Some supplier/customer data	• Supplier/customer data incorporated • Supplier and customers participate in parts of meetings	• Event driven meetings supersede scheduled meetings • Real-time access to external data
Organization	• No S&OP organization	• No formal S&OP function • Components of S&OP are in other positions	• S&OP function is part of other position	• Formal S&OP team • Executive participation	• Throughout the organization, S&OP is understood as a tool for optimizing profit
Measurements	• No measurements	• Measure how well operations meets the sales plan	• Stage 2 plus: • Sales measured on forecast accuracy	• Stage 3 plus: • New product introduction • S&OP effectiveness	• Stage 4 plus: • Company profitability
Information technology	• Individual managers keep own spreadsheets • No consolidation of information	• Many spreadsheets • Some consolidation but done manually	• Centralized information • Revenue or operations planning software	• Batch process • Revenue and operations optimization software – link to ERP but not jointly optimized • S&OP workbench	• Integrated S&OP optimization software • Full interface with ERP, accounting, forecasting • Real-time solver
S&OP plan integration	• No formal planning • Operations attempts to meet incoming orders	• Sales plan drives operations • Top-down process • Capacity utilization dynamics ignored	• Some plan integration • Sequential process in one direction only • Bottom-up plans – tempered by business goals	• Plans highly integrated • Concurrent and collaborative process • Constraints applied in both directions	• Seamless integration of plans • Process focuses on profit optimization for whole company

Figure 3.17 S&OP maturity model adapted from Grimson and Pyke (2007)

Meetings and collaboration

This dimension captures the human aspects of S&OP. Stage 1 is characterized by little to no collaboration between sales and operations. Each function works independently, and there is little interaction between the two. Stage 2 is characterized by increasing degrees of collaboration compared to stage 1. Sales and operations issues are now discussed at meetings, although the focus is on financial aspects and no emphasis on operations. Stage 3 is where S&OP processes become formal. Employees from sales and operations now have pre-meetings within their functions before the formal S&OP meetings and may even share information from their separate plans. At this stage, the formal S&OP meetings instead focus on the integrated S&OP, and there may be data from major suppliers and customers used throughout the process. Stage 4 is essentially the same as stage 3 with the addition of active participation of customers and suppliers in meetings. Stage 5 includes everything from the earlier stages and event-driven meetings. In the case of, e.g., disruptions, the S&OP team will not wait for a regularly scheduled meeting to address the issue; instead, they will meet immediately. Employees and supply chain partners have real-time access to internal and external data.

Organization

This dimension captures the corporate S&OP structure. Stage 1 companies lack an S&OP function in its entirety, and there is little to no knowledge of S&OP among employees. Stage 2 also lacks an explicit S&OP function, but other functions carry out various tasks. At stage 3, companies have the S&OP function, although the function is not in the hands of a formal S&OP team but rather another position. Stage 4 has a formal S&OP team with executive participation, and each member has clear descriptions that S&OP is included in their jobs. Stage 5 is similar to stage 4 with the addition of a widespread S&OP

culture in the organization. At this final stage, all employees within the company understand and appreciate the benefits S&OP brings.

Measurements

This dimension captures performance measurements, both in terms of company and S&OP performance. In stage 1, there are no measurements used apart from standard measures related to accounting. Stage 2 companies evaluate performance monthly or quarterly in terms of operations' ability to meet the sales plan. Managers are yet to be held accountable for their plans. Stage 3 expands on the measures used in stage 2 and further adds measuring of forecast accuracy. Managers are now held accountable for their plans. Stage 4 further adds two new metrics to capture new product introduction and S&OP effectiveness. Stage 5 further adds profitability to the earlier introduced measures.

Information technology

This dimension captures the information process related to S&OP. Stage 1 companies only use, e.g. spreadsheets that are not shared among different managers or consolidated. Stage 2 companies still use spreadsheets, and the data is still owned individually, but there are some degrees of consolidation. In stage 3, the data is centralized through automation, and companies further use revenue or operations planning software. Stage 4 companies now have optimization software to optimize revenue and operations. Companies also use an S&OP workbench to which everybody has access. Stage 5 is characterized by seamless information sharing throughout the organization. Integrated real-time solutions will optimize sales and operations decisions allowing organizations to react quickly to changes in the environment.

S&OP plan integration

This dimension captures the effectiveness of how companies create and integrate their sales and operations plans. Stage 1 companies have no S&OP planning, and thus there is no effectiveness to measure at this stage. Stage 2 companies do not adjust the sales plan according to operations and thus disregard potential issues, such as operations lacking capacity. Essentially, the S&OP process only goes one way. In stage 3, the sales plan is still the main focus, although information from operations might lead to adjustments to the plan. Forecasts are now done in a bottom-up fashion. Stage 4 companies embrace the collaborative nature of S&OP, and joint development of all sales and operations plans, considering capacity constraints, is praxis. Stage 5 companies are characterized by an overall will to maximize profitability and let all S&OP team members bring their perspectives. All constraints are considered, and the entire planning process is seamless.

3.2.7 Change management

S&OP consists of two parts: one soft side concerning culture, commitment, trust, and collaboration, and one hard side concerning formal procedures, schedules, data, and performance (Tuomikangas and Kaipia, 2014). Implementing S&OP is change management, and the most challenging part of the implementation is culture-related (Grimson and Pyke, 2007). Commonly mentioned critical success factors (CSF) are top management support (Jacobs et al., 2011; Thomé et al., 2012a; Pedroso et al., 2016), performance measurements (Bower, 2005; Jacobs et al., 2011; Lapide, 2004; Pedroso et al., 2016), cross-functional integration (Jacobs et al., 2011; Pedroso et al., 2016; Swaim et al., 2016) and information systems and sharing (Lapide, 2004; Thomé et al., 2012a; Pedroso et al., 2016). In terms of information systems, Rai et al. (2006) identified that they have no direct impact on firm performance. However, appropriate supply chain process integration fully mediates the impact of IT integration on firm performance hence emphasizing information systems as a prerequisite for increased firm performance. Grimson and Pyke (2007) propose implementation in multiple stages. Implementation could, e.g., start with a pilot S&OP project using a single product family of low complexity yet high business value to ensure senior executives can see the effect S&OP has on business performance. It is crucial to embrace S&OP during implementation fully, and, e.g., joint balancing of supply and demand is critical; simply conducting one side of the process is not enough (Bower, 2005; Lapide, 2004).

3.3 Linking capacity planning to sales and operations planning

3.3.1 Importance of product-process fit

Traditionally, organizations that use the product life cycle (PLC) concept tend to focus too much on the marketing effect and thus neglect all other business aspects, such as the production process that also follows different stages (Hayes and Wheelwright, 1979). To better understand the strategic implications of manufacturing, Hayes and Wheelwright (1979) suggest using a concept called the process life cycle. The concept is illustrated through the product-process matrix, see Figure 3.18. The basic idea of the matrix is that a particular type of product structure ideally matches a particular process structure. For example, a small manufacturer of handcrafted furniture should not aim for a mass production process structure as this is too inflexible but instead for a job-shop structure. Although companies may seek a position off the diagonal and use it as a competitive advantage, it gets inherently challenging to maintain such a position, especially when not exploited correctly.

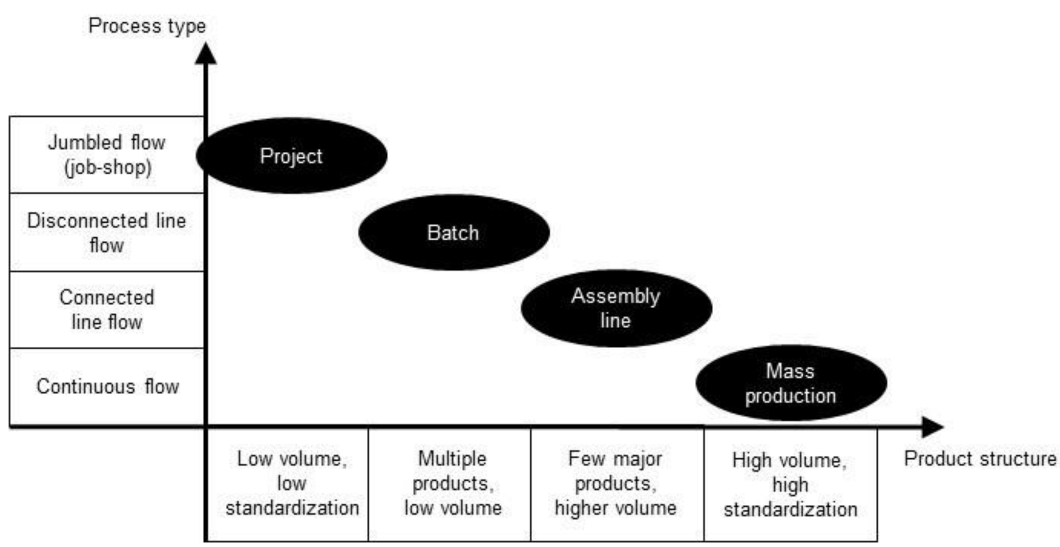

Figure 3.18 Product-process matrix, adapted from Hayes and Wheelwright (1979)

According to Hayes and Wheelwright (1979), using the product-process matrix has three distinct implications for companies: the competitive advantage, effects of the position, and organizing operations. First, the matrix allows companies to think about corporate strategy from the perspectives of marketing and manufacturing compared to simply the marketing side when using PLC. Pinpointing the competitive advantage from a two-dimension perspective allows companies to be more accurate about the competitive advantage than when considering it from only one dimension. Another potential benefit of this mindset is that it may provide new opportunities if companies can define their products in new ways.

Second, it is critical to consider the effects of the position in the matrix must as the competitive advantage changes when moving through the matrix. For example, a company focused on quality and new product development should seek a more flexible process structure than a competitor with the same product structure following a cost-leadership strategy. The matrix position has further implications, such as deciding when to enter and drop out of a market. Companies in the upper left corner of the matrix have more flexibility and thus need to decide when to drop a product or pull out of a specific market. In contrast, companies in the lower right can watch the market grow before entering, as they do not need the same flexibility. Third, management must align aspects such as manufacturing and performance measurements to the matrix position, and the chosen position will dictate what the central aspects to consider are.

While Hayes and Wheelwright (1979) present products in terms of volume and standardization level, Fisher (1997) categorizes product structures as either functional or innovative and lists a few specific criteria associated with either product type, see Table 3.1. Characteristics for product classification include product life cycle length, how many varieties a product may be configured into, and the contribution margin. For example, higher-margin products tend to have shorter PLCs and are usually considered innovative.

Table 3.1 Functional vs. innovative products, adapted from Fisher (1997)

	Functional (Predictable demand)	**Innovative (Unpredictable demand)**
Aspects of demand		
Product life cycle	More than 2 years	3 months to 1 year
Contribution margin	5-20 %	20-60 %
Product variety	Low (10-20 variants per category)	High (often millions of variants per category)
The average margin of error in the forecast at the time production is committed	10 %	40-100 %
Average stockout rate	1-2 %	10-40 %
Average forced end-of-season markdown as a percentage of the full price	0 %	10-25 %
Lead time required for made-to-order products	6-12 months	1-14 days

Fisher (1997) connects functional and innovative products to different supply chain strategies, similar to how Hayes and Wheelwright (1979) connect product structures to production processes in their product-process matrix. The strategies are to either be physically efficient or market-responsive, and similarly to the classification of products, Fisher (1997) describes the two using specific criteria, see Table 3.2. The main point of Fisher’s study is that the product structures must be aligned with the chosen supply chain strategy if companies are to remain competitive long-term. Innovative products should be paired with a market-responsive supply chain to find a supply chain fit, while functional products should be paired with a physically efficient supply chain. The other combinations are deemed a mismatch by Fisher (1997). The Fisher framework for supply chains can be seen in Figure 3.19.

Table 3.2 Physically efficient vs. market-responsive supply chains, adapted from Fisher (1997)

	Physically efficient process	**Market-responsive process**
Primary purpose	Supply predictable demand efficiently at the lowest possible cost	Respond quickly to unpredictable demand to minimize stockouts, forced markdowns, and obsolete inventory
Manufacturing focus	Maintain high average utilization	Deploy excess buffer capacity
Inventory strategy	Generate high turns and minimize inventory throughout the supply chain	Deploy significant buffer stocks of parts of finished goods
Lead time focus	Shorten lead times as long as it does not increase the cost	Invest aggressively in ways to reduce lead time
Approach to choosing suppliers	Select primarily for cost and quality	Select primarily for speed, flexibility, and quality
Product-design strategy	Maximize performance and minimize cost	Use modular design to postpone product differentiation for as long as possible

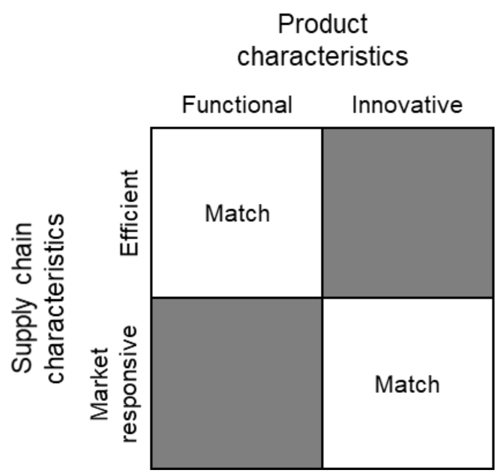

Figure 3.19 The Fisher framework for supply chains, adapted from Fisher (1997)

However, simply achieving a supply chain fit is not enough, and the supply chain strategy must also fit with the competitive strategy to achieve a strategic fit Chopra and Meindl (2007). Chopra and Meindl (2007, p. 24) define strategic fit as when "… both the competitive and supply chain strategies have aligned goals. It refers to consistency between customer priorities that the competitive strategy hopes to satisfy and the supply chain capabilities that the supply chain strategy aims to build." A company's value chain comprises countless processes and functions, and they are all interrelated and contribute to either business success or failure. Strategies, resources, and processes on a functional level must support each other and the overall supply chain and corporate strategies. According to Chopra and Meindl (2007), a strategic fit is achieved by understanding the customer and supply chain uncertainty, understanding the supply chain capabilities, and achieving a strategic fit.

3.3.2 Customer order decoupling point

Operations need to be strategically aligned to market requirements for a company to compete in its market successfully (Olhager, 2010). One way of achieving this is to consider the customer order decoupling point (CODP) and design operations around it. The CODP is the point in the supply chain where a product is attached to a specific customer. The basic choices of CODP are make-to-stock (MTS), assemble-to-order (ATO), make-to-order (MTO), and engineer-to-order (ETO). To compete successfully, a company must understand that the market requirements change at the CODP. Thus, the character of operations should significantly change at this point and separate customer order-driven activities from those that are forecast-driven. When customers are allowed to impact the product outcome backward in the production (i.e., from MTS to MTO), it will significantly impact the forecast (Chapman, 2006). Olhager (2010) proposes a framework to incorporate the CODP in production and supply chain design that considers the CODP position on the systems' design (see Figure 3.20. The implications of this on operations and supply chain design, e.g., an MTS item, is that an efficient supply chain is necessary for pre-CODP operations. Consequently, master planning should be forecast-driven, pre-CODP operations, and the CODP is the most critical stock point on the operational level.

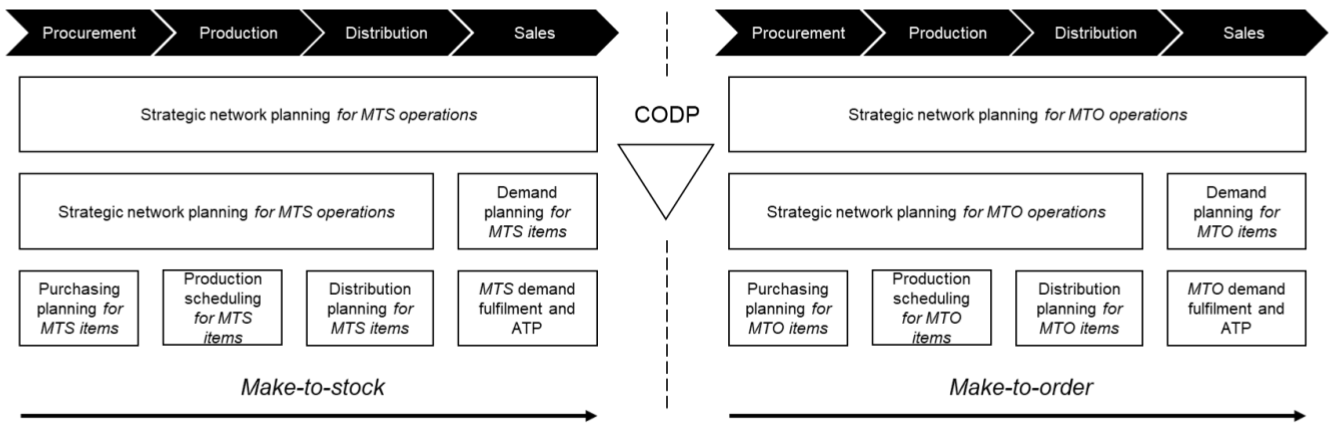

Figure 3.20 Framework for planning manufacturing and supply chain systems around the CODP, adapted from Olhager (2010)

3.3.3 Connecting sales and operations planning to capacity planning

Olhager et al. (2001) relate the perspectives of S&OP and manufacturing strategy, using the product-process matrix (Hayes and Wheelwright. 1979) as the starting point. The different concepts of CODP (Olhager, 2010), lead versus lag manufacturing capacity strategies (Kiran, 2019; Olhager et al., 2001), and chase versus level planning strategies (Chapman, 2006; Olhager et al., 2001) are all linked together, see Figure 3.21. Olhager et al. (2001) highlight that capacity decisions (when and how to change capacity) heavily influence the room in which S&OP can operate within.

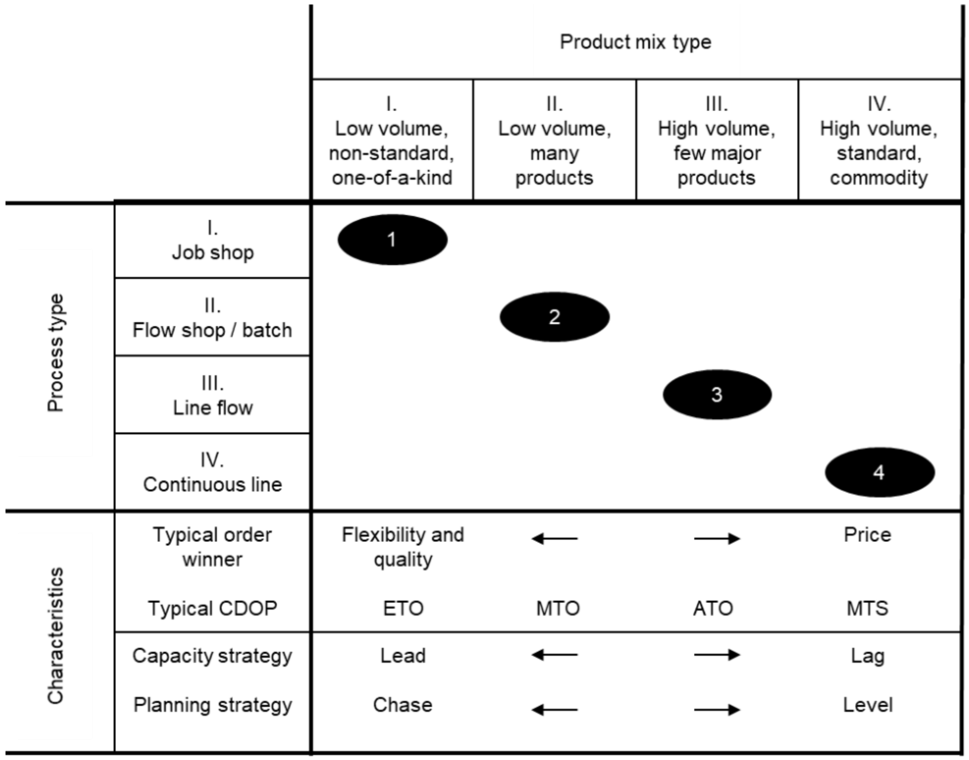

Figure 3.21 Relations of the CODP, capacity strategies, and planning strategies, adapted from Olhager et al. (2001)

A lead capacity strategy gives S&OP much action room, while a lag strategy will restrict the potential of a chase planning strategy. Meanwhile, if there is a desire for a chase planning strategy, Olhager et al. (2001) highlight the need for extra capacity, often solved through sub-contracting or short-term overtime (Chapman, 2006). A tracking capacity strategy, i.e., the mix between lead and lag, usually means that depending on the planning strategy, inventory will be built at some times (typically for MTS environments), and at other times there will be production over-capacity (typically for MTO environments) (Olhager et al., 2001). These perspectives are combined into a framework that describes how combinations of manufacturing capacity and planning strategies work together, see Figure 3.22. Some combinations are better suited than others, e.g., a lead capacity strategy combined with a chase planning strategy emphasizes resource availability and flexibility, while the objectives of a chase planning strategy and a lag capacity strategy work against each other.

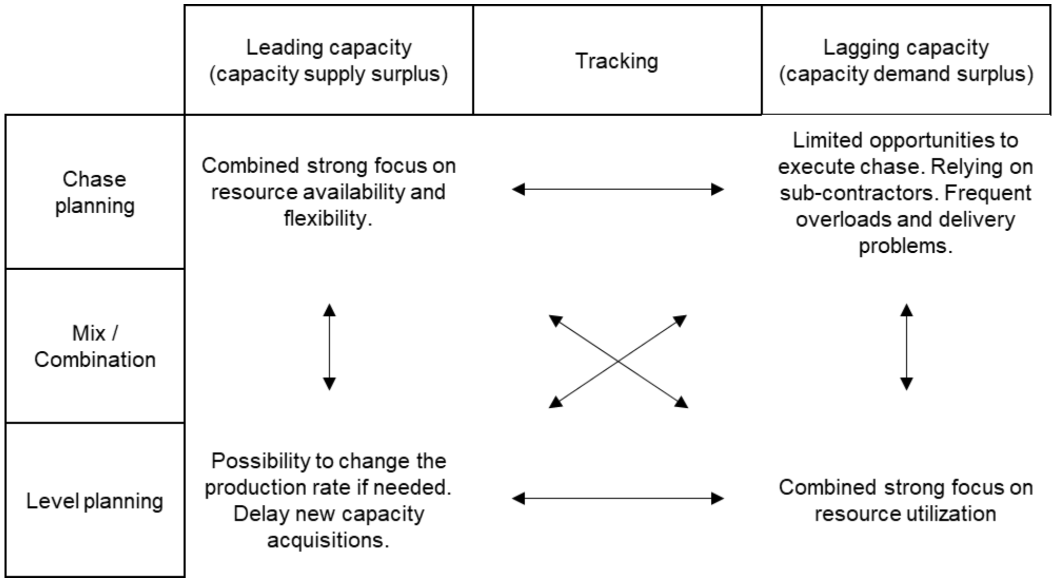

Figure 3.22 Framework matching capacity strategies to planning strategies, adapted from Olhager et al. (2001)

3.4 Outsourcing and supply chain collaboration

3.4.1 Outsourcing

van Weele (2014, p. 32) defines outsourcing as "the company divests itself of the resources to fulfill a particular activity to another company, to focus more effectively on its own competence." There are two types of outsourcing: partial outsourcing and turnkey outsourcing. Partial outsourcing refers to the case where only outsourcing parts of the function and the buyer still has the responsibility to coordinate the function and activities. On the other hand, turnkey outsourcing is when the entire function, including execution and coordination, is outsourced to an external party. Table 3.3 shows the various advantages and disadvantages of both types of outsourcing.

Table 3.3 Partial vs. turnkey outsourcing adapted from van Weele (2014)

	Advantages	**Disadvantages**
Turnkey outsourcing	The buyer has minimal responsibility for outsourced processes	The buyer has limited influence on the determination of the price and little insight in cost structure of provider
	The buyer doesn't need to have experience with similar projects	The buyer has limited influence on the staff, technology and materials used and their quality
	The project generally goes much smoother for the buyer	Large dependence of buyer on provider resulting in high commercial, technical and performance risks
Partial outsourcing	The buyer has more influence on prices, rates and costs	The buyer is required to have knowledge of the separate parts of the outsourced function/activities
	The buyer has more influence on the staff, technology and materials used and their quality	The buyer is required to have the organizational capacities to co-ordinate and integrate the outsourced function/activities
	Specific advantages can result in cost reductions	Communication and co-ordination problems between parties involved can be a cause of delay and disappointment

There are different reasons for companies to leverage outsourcing, and they can be of both strategic and tactical nature (van Weele, 2014). Key drivers of outsourcing include increased focus on core competencies (Hopp and Spearman, 2008; Kremic et al., 2006; van Weele, 2014), operational savings (Kremic et al., 2006; Matope and Mahove, 2021; van Weele, 2014), less tied-up capital (Matope and Mahove, 2021), potential to leverage economies of scale (Matope and Mahove, 2021), share risks (van Weele, 2014), get access to resources unavailable at the focal firm (Kremic et al., 2006; van Weele, 2014) and increased flexibility (Kremic et al., 2006; van Weele, 2014; Matope and Mahove, 2021), amongst others. Despite the rationale behind the outsourcing decision, the overall objective is to improve the overall firm performance (van Weele, 2014), although the expected benefits are not always given (Kremic et al., 2006). To achieve a successful outsourcing relationship, van Weele (2014) states that there are six core values and four supporting values. The core values are shared goals and objectives, mutual dependence, open lines for communication, concern for the other party's profitability, mutual commitment to customer satisfaction, and trust. Supporting factors are developing a personal relationship, having professional respect, investment of effort by top management, and a joint commitment to continuous improvement.

Three main types of contracts exist in outsourcing: fixed-price, cost-reimbursable, and unit-rate contracts (van Weele, 2014). Fixed-price contracts are governed by a pre-determined fixed price and completion date of the outsourced activities. Some advantages of using a fixed-price contract are that the buyer knows the exact cost and when the services are expected to be completed. Due to the nature of this contract type, it is in the contractor's interest to finish the work as quickly and efficiently as possible. Disadvantages include little transparency of the contractor's cost structure and that a fixed-price contract generally requires much effort to prepare. In a fixed-price contract, the majority of the risk lies with the contractor. Cost-reimbursable contracts combine a fixed rate (often hourly), a pre-determined percentage covering overhead costs, and a profit margin. The buyer pays for potential material that is needed and pays when the outsourced activities are completed, upon which the contractor provides detailed reports on all incurred costs. The main advantage of cost-reimbursable contracts is that the buyer receives a transparent picture of the cost structure. Disadvantages include uncertainty about the total cost, lack of incentives for the contractor to complete the activities as efficiently as possible, and a need to review invoices. Due to the many disadvantages of cost-reimbursable contracts, combining them with incentives to better manage the situation is common. In a cost-reimbursable contract, most of the risk lies with the buyer. Unit-rate contracts are based on a fixed price per unit of work completed and are typical for recurring work of a standardized character, of which it is difficult to estimate the width. A summary of the different contract types can be seen in Table 3.4.

Table 3.4 Contract types in outsourcing adapted from van Weele (2014)

Contract type	**Price mechanism**
Fixed-price	Total price is fixed and pre-determined and completion date of outsourced activities is pre-determined
Cost-reimbursable	Combination of a fixed-rate and pre-determined percentage covering overhead costs and profit margin. Material is payed by the buyer
Unit-rate	Fixed-price per unit

3.4.2 Supply chain collaboration and incentive alignment

Supply chain collaboration is receiving increasing attention (Ellram and Cooper, 1990) and is used broadly in both practice and the literature with varying definitions (Anthony, 2000). Simatupang and Sridharan (2002, p. 19) define a collaborative supply chain as “two or more independent companies work jointly to plan and execute supply chain operations with greater success than when acting in isolation” while Anthony (2000, p. 41) defines it as something that “occurs when two or more companies share the responsibility of exchanging common planning, management execution, and performance measurement information.” Lambert et al. (1999) argue that most definitions of supply chain collaboration in literature lack a component of customization and, as a consequence, define partnerships as “a tailored business relationship based upon mutual trust, openness, shared risk, and shared rewards that yields a competitive advantage, resulting in business performance greater than would be achieved by the firms individually” (Lambert et al., 1999, p. 166). Meanwhile, strategic partnerships can be defined as “a type of channel relationship where the intent of the relationship is to yield differentiated and intermediate or long-term benefit to the parties involved in the relationship. This relationship is forward looking, takes place over an extended time period, and involves trust and the associated sharing of information, risks and rewards” (Ellram and Cooper, 1990, p.4). Given the definitions, it is evident that supply chain collaboration may include many aspects. However, mutual trust, sharing of risk, rewards and information, and joint planning and execution are commonly mentioned with an ultimate goal to perform better together than as single entities. A summary of supply chain collaboration definitions can be seen in Table 3.5.

Table 3.5 Summary of supply chain collaboration definitions from the literature

Definition	Author(s)
”Two or more independent companies work jointly to plan and execute supply chain operations with greater success than when acting in isolation”	Simatupang and Sridharan (2002, p. 19)
“Occurs when two or more companies share the responsibility of exchanging common planning, management execution and performance measurement information”	Anthony (2000, p. 41)
“A tailored business relationship based upon mutual trust, openness, shared risk and rewards that yields a competitive advantage, resulting in business performance greater than would be achieved by the firms individually”	Lambert et al. (1999, p. 166)
“A type of channel relationship where the intent of the relationship is to yield differentiated and intermediate or long-term benefit to the parties involved in the relationship. This relationship is forward looking, takes place over an extended time period, and involves trust and the associated sharing of information, risks and rewards”	Ellram and Cooper (1990, p. 4)

In today’s business environment marked by increasing globalization, competition has shifted, and no longer is the competition between individual firms but rather between entire supply chains (Horvath, 2001). Collaboration is the enabler for effective and successful implementation of supply chain management (Ellram and Cooper, 1990; Horvath, 2001; Mentzer et al., 2001), and better business performance comes from companies’ ability to leverage their supply chain networks (Barratt, 2004; Horvath, 2001; Sanders and Premus, 2005; Simatupang and Sridharan, 2002, 2005). The benefits of supply chain collaboration mentioned in the literature are increased efficiency and effectiveness (Anthony, 2000; Ellram and Cooper, 1990; Mentzer et al., 2001; Min et al., 2005; Sanders and Premus, 2005), competitive advantage (Horvath, 2001; Mentzer et al., 2001; Min et al., 2005), improved profitability (Min et al., 2005) and increased performance (Barratt, 2004; Sanders and Premus, 2005; Simatupang and Sridharan, 2002, 2005). Despite researchers praising the importance of supply chain collaboration in academics for decades, Norrman and Näslund (2019) identified that most supply chain management work is still limited in terms of partnerships and rarely focuses on the extended supply chain.

Although many benefits can be attributed to supply chain collaboration, it is essential to understand the difficulties and challenges involved (Lambert and Knemeyer, 2004; Narayanan and Raman, 2004; Simatupang and Sridharan, 2005). First, the implementation of partnerships is often costly and requires communication, coordination, and risk-sharing (Lambert and Knemeyer, 2004). Second, partnerships can often be interpreted differently by the chain members involved; thus, the expectations must align (Lambert et al., 1999; Lambert and Knemeyer, 2004). Narayanan and Raman (2004) argue that despite collaboration, most companies behave in their own best interest. They incorrectly assume that these actions will lead to maximized supply chain performance, although that is rarely the case in reality. These sorts of conflicting interests, such as misaligned incentives, cause supply chain discontent, leading to inefficiencies in the supply chains, including excessive inventory, markdowns, and stockouts (Simatupang and Sridharan, 2005). Supply chains perform best when incentives are aligned, and risk, reward, and costs are shared between supply chain partners (Narayanan and Raman, 2004). Thus, aligning the incentives can play a crucial part in counteracting supply chain discontents and inducing better behavior in supply chain partners (Narayanan and Raman, 2004; Simatupang and Sridharan, 2005).

Norrman and Näslund (2019) argue that incentive alignment is one of the keys to successfully implementing supply chain management. While incentive alignment is widely discussed in the literature, little is done in practice, and it is strictly limited to second-tier relationships. According to Narayanan and Raman (2004), there are three causes for misaligned incentives: hidden actions, hidden information, and badly designed incentive schemes. These can be addressed by accepting that the problem exists, diagnosing the cause and creating or redesigning the incentives through contracts, information sharing, and building relationships. Norrman (2008) identified that contract mechanisms could be a good tool for addressing misaligned incentives. They can help structure and improve relationships between supply chain partners and improve both internal and supply chain information. In reality, mechanisms for aligning incentives are simple regardless of the importance of the relationship. Although sophisticated mechanisms have the potential to strengthen risk and reward sharing and improve supply chain integration, they are rarely applied (Norrman and Näslund, 2019).

3.5 Analytical framework

Based on the literature review, we developed an analytical framework to guide the research and analysis (Miles and Huberman, 1994). Figure 3.23 shows the analytical framework, which explains the main entities we have chosen to study and how these will be analyzed to reach our conclusions.

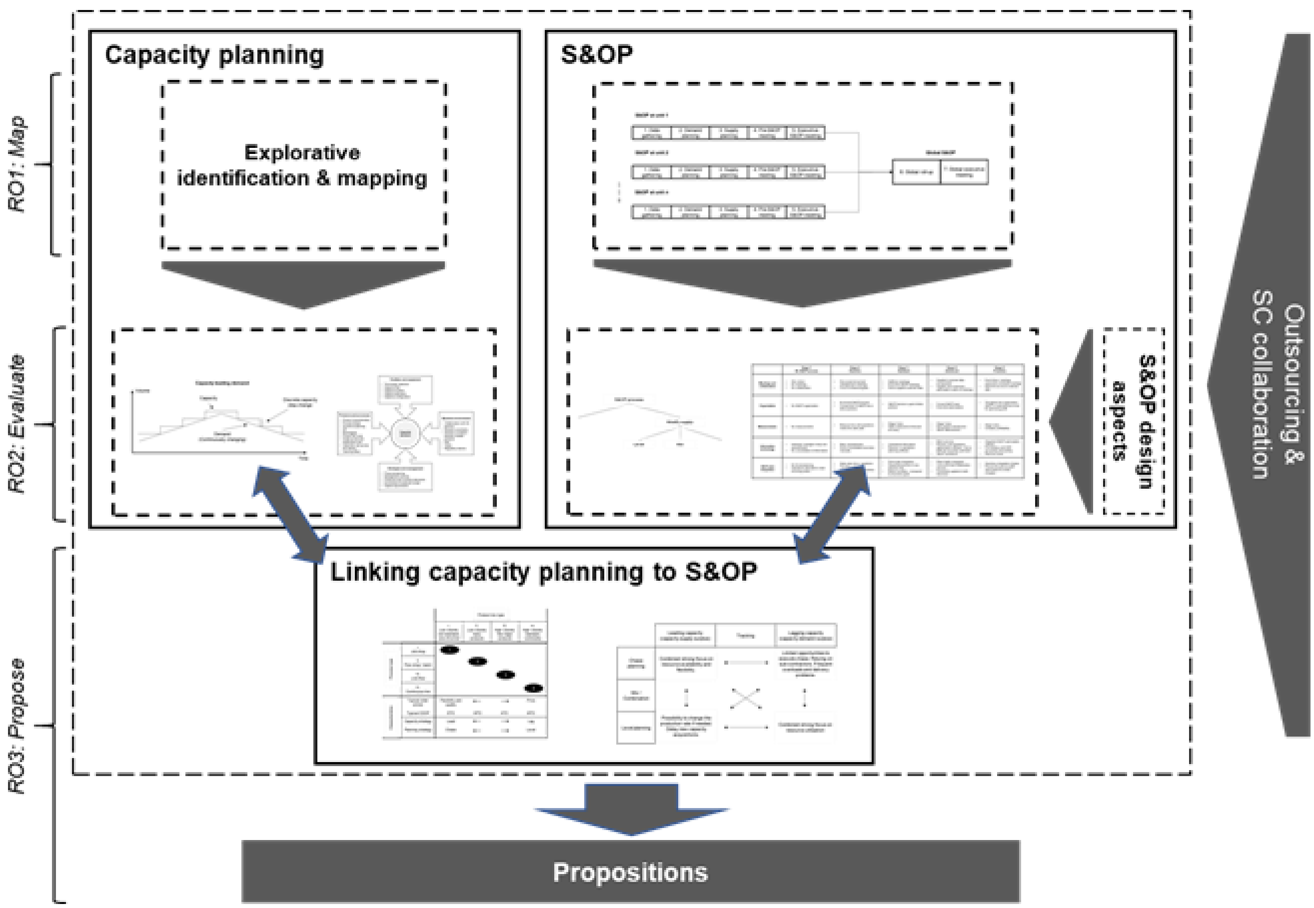

Figure 3.23 Analytical framework

To address RO1, we will map both the embedded units of analysis, the capacity planning process, and the S&OP process. The capacity planning process will be exploratively mapped as there is a lack of frameworks and tools to achieve this. The S&OP process will be mapped according to the extended generic S&OP process adopted by Seeling et al. (2021) and, e.g., Jacobs et al. (2011). RO2 will be addressed by evaluating the two embedded units of analysis: the capacity planning and S&OP processes. The capacity planning process will be evaluated by using the capacity strategy framework by Olhager et al. (2001) and by identification of what factors influence the capacity planning process at Axis based on the framework synthesized from, e.g., Wu et al. (2005), Martinez-Costa et al. (2014) and Kiran (2019). The S&OP process will be evaluated against the maturity framework by Grimson and Pyke (2007), the planning strategies by Olhager et al. (2001), and the S&OP design framework by Kristensen and Jonsson (2018). Finally, RO3 will be addressed through the main unit of analysis, the link between the capacity planning process and S&OP, by applying the frameworks from Olhager et al. (2001). Relevant literature relating to outsourcing and supply chain collaboration will be treated as contextual factors to the entire process.

Chapter 4 – Empirical data

The empirical study will deliver the findings of the conducted data collection in a structured and descriptive way. First, we will present the supply chain set up at Axis. Second, we will describe how capacity planning is currently carried out at the EMS sites. Last, the study will present Axis' current sales and operations planning process. The empirical research is based on data gathered through interviews, archival data, and observations. The findings from the frame of reference chapter will serve as guidance, see Figure 4.1.

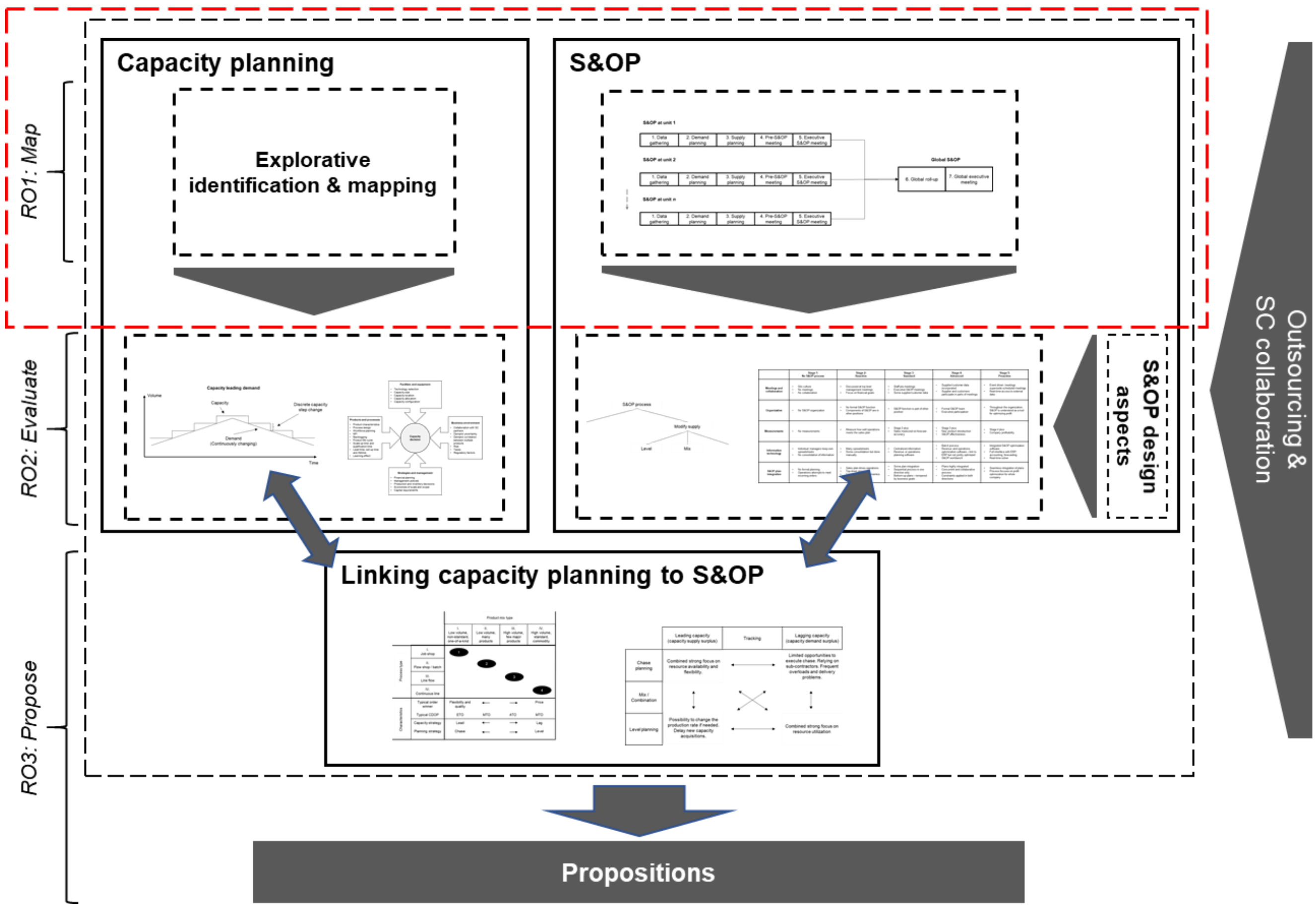

Figure 4.1 Focus area for Chapter 4

4.1 Axis' business model and corporate strategy

Axis does not operate a traditional business model because the company does not sell its products directly to the end customers. Instead, Axis relies on a network of intermediaries to reach the end customers of its products. Axis sells its products to distributors, who sell to resellers and system integrators that sell to the end-users. Axis' business model and the flow of goods are illustrated in Figure 4.2.

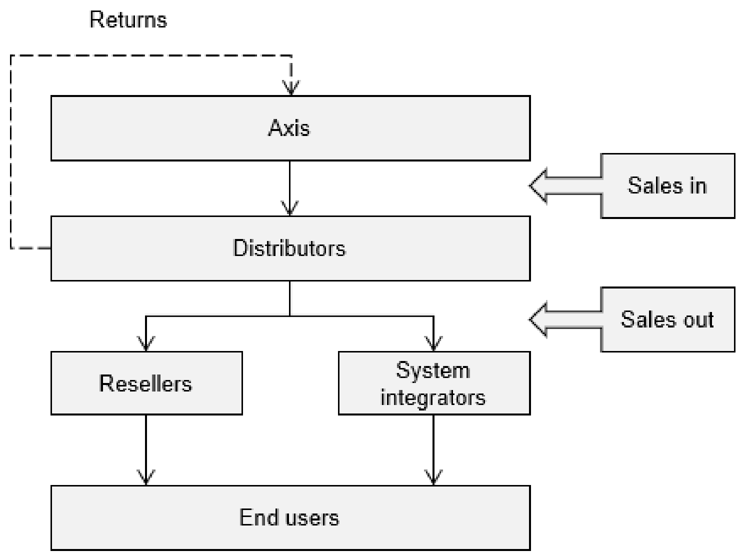

Figure 4.2 Axis' business model

There is a clear distinction in the sales between each layer of intermediaries: *sales in* and *sales out*. The financial flow between Axis and distributors is termed sales in; this is the sales that Axis can realize as revenue as this is what can be invoiced. Further, sales out are the financial flow between distributors, resellers, and system integrators, reflecting the actual market demand for Axis' products. To further complicate the situation, there is also a return flow of goods between distributors and Axis, where distributors can return purchased products if they cannot sell them to resellers and system integrators. If distributors no longer desire their placed orders, they are also allowed to cancel orders at any time.

Axis supply chain set-up is also built upon using strategic supply chain partners, where Axis acts mainly as the coordinating entity, see Figure 4.3. The manufacturing operations are outsourced in their entirety to a few strategic electronics manufacturing services (EMS) partners spread out across the globe who manufactures the products. Axis develops and owns all manufacturing equipment used in the manufacturing process, but the EMS sites are responsible, e.g., for their production planning, including scheduling and workforce planning. EMS sites are also responsible for sourcing most of the material used to manufacture Axis' products through their respective suppliers, although 90 % of suppliers are pre-determined by Axis. A few components of strategic value are sourced in-house by Axis to secure availability. The main reason behind the outsourcing strategy is a fundamental belief in long-term partner collaborations combined with good competition to achieve continuous improvement. Consequently, if an activity cannot be fully outsourced, supply chain partners should still be involved and take part as much as proven valuable. Activities should not remain in-house only due to supply chain relationships being complicated.

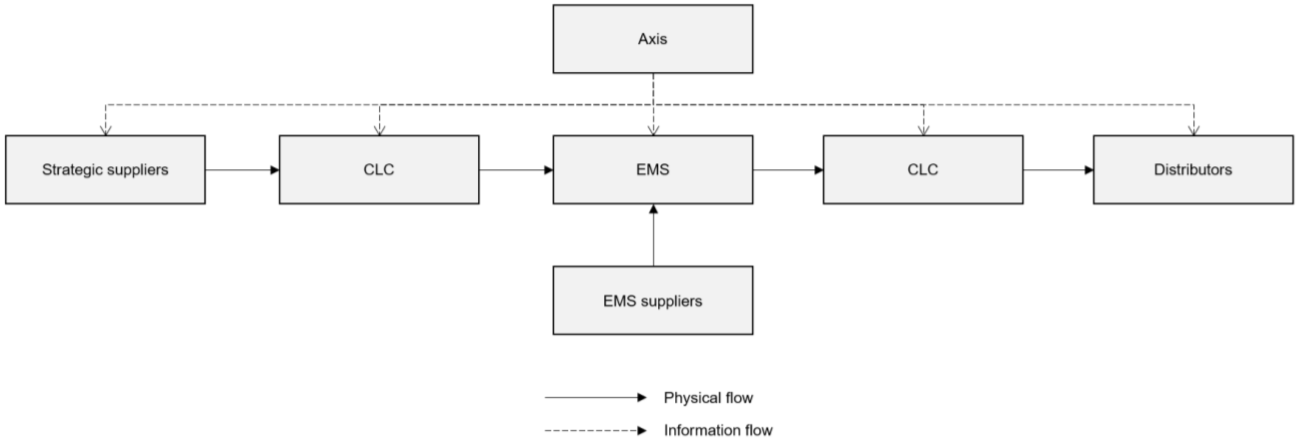

Figure 4.3 Axis' supply chain set-up

The configuration and logistics centers (CLC) act as an intermediary between Axis' strategic suppliers, the EMS sites, and the distributors. The CLCs serve two purposes in Axis' supply chain. First, they act as regular warehouses as they store both strategic components and finished goods shipped to either EMS sites or customers. Second, they act as configuration centers, an important and unique feature. All manufactured products arriving from EMS sites are generic and come in bulk packaging. The last part of the value-adding process is thus to configure each camera to specific customer orders in terms of, e.g., software and accessories, and place each product in individual packaging and labeling. Thus, the CODP from the production perspective is MTS, while it is more oriented towards ATO against end customers. All but one CLC is fully outsourced and thus not owned or operated directly by Axis. All EMS sites ship products to all CLCs, and there are no geographical limitations in that sense. The overarching corporate strategy of Axis is focused on growth and innovation, and Axis has three distinct business regions: Europe, Middle East and Africa (EMEA), Asia-Pacific (APAC), and Americas. A summary of the key takeaways from Section 4.1 can be seen in Table 4.1.

Table 4.1 Key takeaways from Axis' business model and corporate strategy

Business model and corporate strategy takeaways
Indirect sales model
Outsourced manufacturing to EMS sites
Supply chain collaboration is key to success
Corporate strategy focuses on growth and innovation

4.2 Capacity planning at Axis

4.2.1 The capacity planning process

The current planning of capacity at EMS sites follows a primitive process. During the industrialization phase of a new product, all relevant functions meet regularly in a project group where different aspects of the new product project are discussed, including capacity decisions. This forum is called the ramp-up meeting. Important members of this project group are representatives from Material Supply, Demand Planning, Industrial Lead, and outside of Operations, both the Product Owner and Project Manager. The

Industrial Lead is responsible for the pre-builds of products to try the designs, production and test equipment, production instructions, and quality assurance until reaching full-scale industrialization at the EMS. The Industrial Lead also serves as the coordinating entity of the ramp-up meeting and facilitates most of the communication between the involved functions.

The most important part of the capacity planning process is the demand forecast. The forecasting process varies depending on a few factors, most notably the chosen launch strategy and whether the product is a roll-over product or an entirely new product (a roll-over product is an updated version of an old product). When choosing a launch strategy, the main concerns are risk-taking and market demand characteristics, leading to determining two parameters: the importance of product launch as soon as the product is ready and the importance of the availability of the new product's precursor. These parameters result in three main strategies: launch as soon as possible (ASAP) with a short overlap, launch ASAP with a long overlap, and ramp up with postponement and no excess inventory. Figure 4.4 shows the launch strategy matrix.

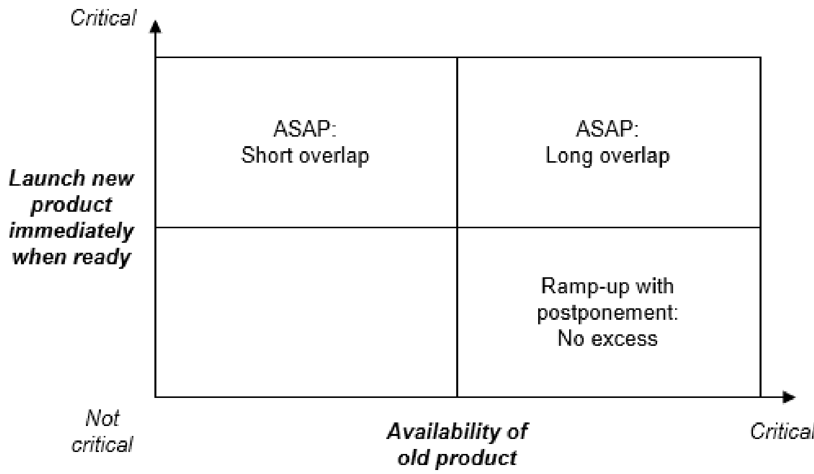

Figure 4.4 Launch strategy matrix

Applying the ASAP with a short overlap strategy leads to risks of a gap in availability between existing products and new products in case of delays in the project. Before launching, key discussion areas are risks in the product development project and if the demand for the existing product needs to be prolonged. The ASAP with long overlap strategy has three key risks: that forecast accuracy is not correct (leading to over-production at EMS), that products that the customers do not request are produced, and if the new product is not sold as expected, there is no demand of producing quantity at the EMS, which can affect the possibility for yield work, leading to risk for over-stock. The critical risk for the ramp-up with postponement strategy is that the launch of the new product will be delayed.

The demand forecast is heavily impacted by whether the new product is a roll-over or new business. For roll-over products, the Demand Planning team has historical data to base forecasts on; meanwhile, entirely new products are more complicated and require more market research input. In both cases, the demand forecast further gathers inputs from the Product Owner, who presents their view on the market demand for the product. Although being very valuable, the input from the Product Owner generally seems to be very optimistic and Demand Planning almost always uses a more modest forecast. Concerning performance measurements, forecast accuracy is generally not used at this stage. In some instances, the seasonal demand is also considered since there are apparent demand patterns connected to when the product will be launched during the financial year for certain sales regions.

Since Axis follows a growth strategy, the forecast should always be higher than the market demand to accommodate this expected and desired growth. Demand Planning finalizes a forecast that is presented and discussed in the project group forum, usually with no further input. After that, production capacity at the chosen EMS sites is planned based on the finalized forecast and an added margin of 30 %. From the data collection, there was no clarity on why Axis chose 30 % instead of e.g. 20 or 40 %. The current capacity planning process is illustrated in Figure 4.5.

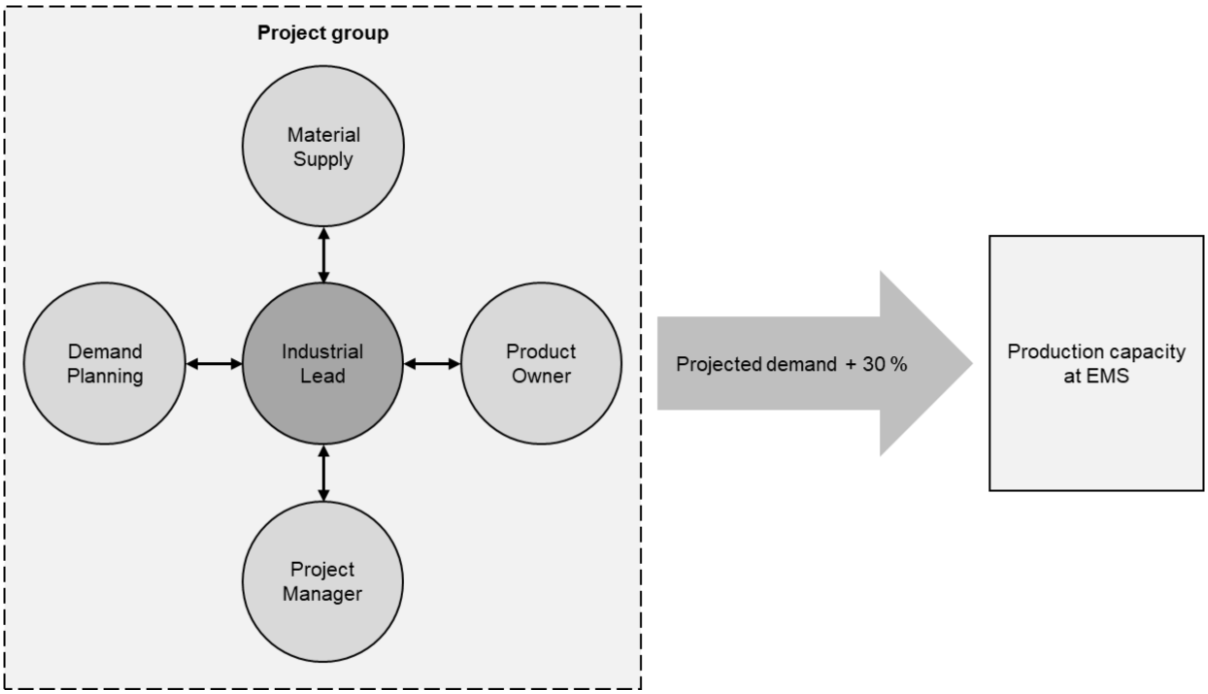

Figure 4.5 Current production capacity planning process

The added margin to the capacity remains static throughout the product's entire lifecycle. An important note is that the production capacity instantly is scaled up to 30 % above the expected maximum demand during the product lifecycle and thus not gradually increased during the ramp-up phase. Further, there is currently no segmentation of this 30 % margin, i.e., all products are subject to the same margin no matter their complexity or predicted volume. An illustrative example can be seen in Figure 2.5. Note that all numbers are indicative and do not reflect an actual situation.

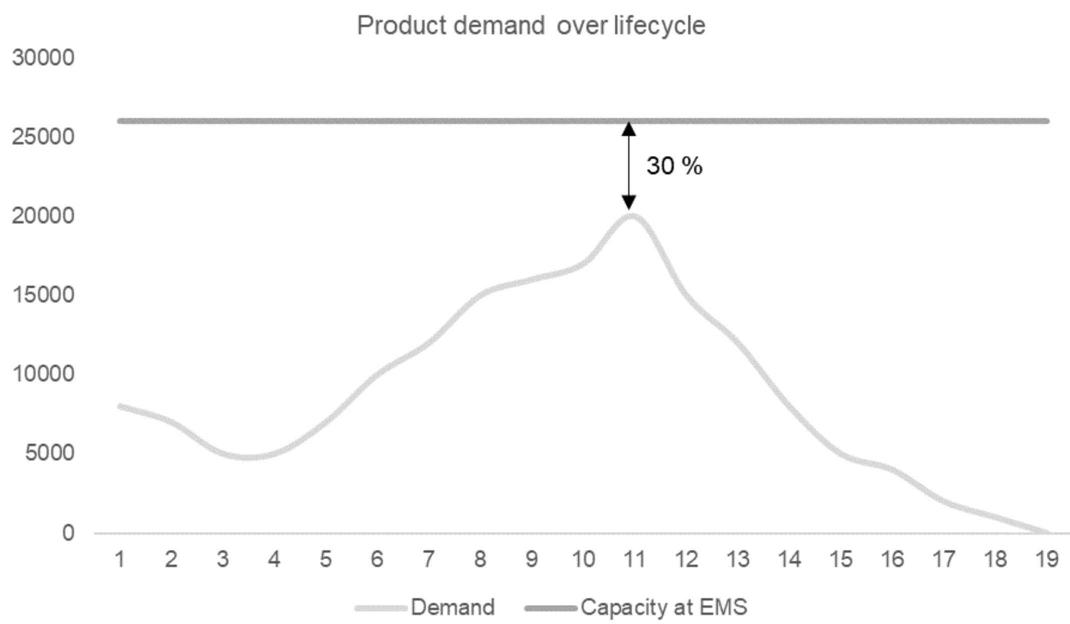

Figure 4.6 Relation between demand and capacity during a product's lifecycle

Axis has a broad product portfolio of approximately 1,500 SKUs, of which some are sold in higher volumes (10's of thousands of units per month) while some are sold in lower volumes (a few hundreds of units per month). Further, some SKUs are heavily ESP-based, meaning that the demand is relatively lumpy as demand one month can be close to zero while another month can be several thousand units.

4.2.2 Production equipment

The equipment used for production is managed by the Production Engineering and Technology (PET) function. Equipment can be divided into two categories: generic equipment and product-specific equipment. Generic equipment includes computers, test equipment, and production equipment needed for manufacturing. The common denominator is that it can be used for multiple product categories. As the name implies, product-specific equipment can only be used for one specific product or product category. Most equipment is developed in-house by Axis and lent out to the EMS sites to operate the production lines. Recently, a decision was made to move towards more generic equipment to create more flexible production lines that different products and new product generations can utilize. An example of a generic production line design is illustrated in Figure 4.7. It typically involves several different assemblies, test stations, and so-called "clean rooms" (a sterile environment where the camera lenses are prepared). Cycle times and throughput rate varies between different stations, which may cause certain stations to become bottlenecks. Thus, in some cases, additional capacity can be added simply through an additional station, while in other cases, a capacity increase might require an entirely new production line. EMS sites are supposed to flag to Axis when extra capacity in the current equipment is needed, but this is rarely the case in practice.

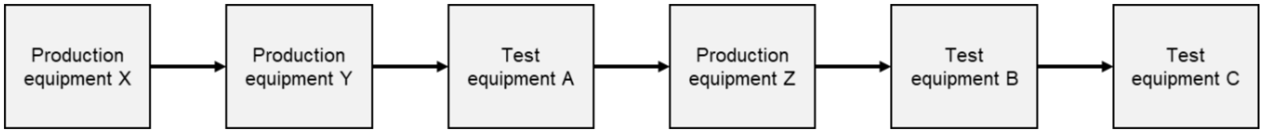

Figure 4.7 Example of production line layout at an EMS site

Theoretically, EMS sites have an infinite capacity if Axis pays for it. The contracts are designed so that Axis pays a fixed price per finished unit shipped to an Axis CLC, i.e., unit rate (van Weele, 2014). The fixed price per product includes costs incurred by the EMS, such as employees, space utilization within the EMS, and overhead costs. Requests for quotation/proposal (RFX) rarely seem to be questioned and further negotiated. Further, the contracts do not stipulate any volume commitment against a particular EMS site; there is no payment if no specific product units are needed. However, the price decided upon in the contracts is based on the projected production volume, i.e., the demand forecast. A summary of the key takeaways from Section 4.2 can be seen in Table 4.2.

Table 4.2 Key takeaways from capacity planning at Axis

Capacity takeaways
Arbitrary process
The chosen launch strategy impacts the demand forecast
Static 30 % margin
The same margin for all products
The product mix consists of both high- and low-volume products
A mix of generic and product-specific equipment
No use of performance measures

4.3 Sales and operations planning at Axis

4.3.1 Process overview

Axis performs the S&OP process at two levels: regional and global. The regional level is divided into three different processes parsed along with Axis' three sales regions: Americas, EMEA, and APAC. Each region conducts its S&OP process, which is coordinated from the headquarters in Lund by one Sales and Operations Planner responsible for that specific region. The regional S&OP processes start with data gathering, where the regions gather all necessary data primarily related to demand forecasts. Each region has demand planning meetings following the data gathering, where the regional forecast is discussed and established with relevant stakeholders. Once determining the demand forecasts for each region, they have their separate S&OP meetings where the forecasts are reviewed. Axis' S&OP process does not include two separate meetings for pre-S&OP and executive S&OP; instead, both have been combined into single S&OP meetings on regional and global levels.

Succeeding the regional S&OP meetings is a global S&OP meeting, the Forecast handshake meeting, where each region's S&OP plan is discussed, established, and after that consolidated into a global demand forecast. Following the Forecast handshake meeting, there is a supply planning review meeting. The supply planning is done globally and thus not parsed along with the three business units. Americas is the most mature region in S&OP, with the other regions far behind. Consequently, the empirics are primarily based on the Americas S&OP as it is an outspoken desire from Axis to reach the same maturity for the EMEA and APAC regions. The entire S&OP process cycle ends with a presentation of the S&OP plan open to all interested parties at Axis. However, representatives from Demand Planning, Material Supply, and Sourcing generally attend. A high-level overview of the S&OP process can be seen in Figure 4.8, while the following sections will dive deeper into the different parts of the S&OP process.

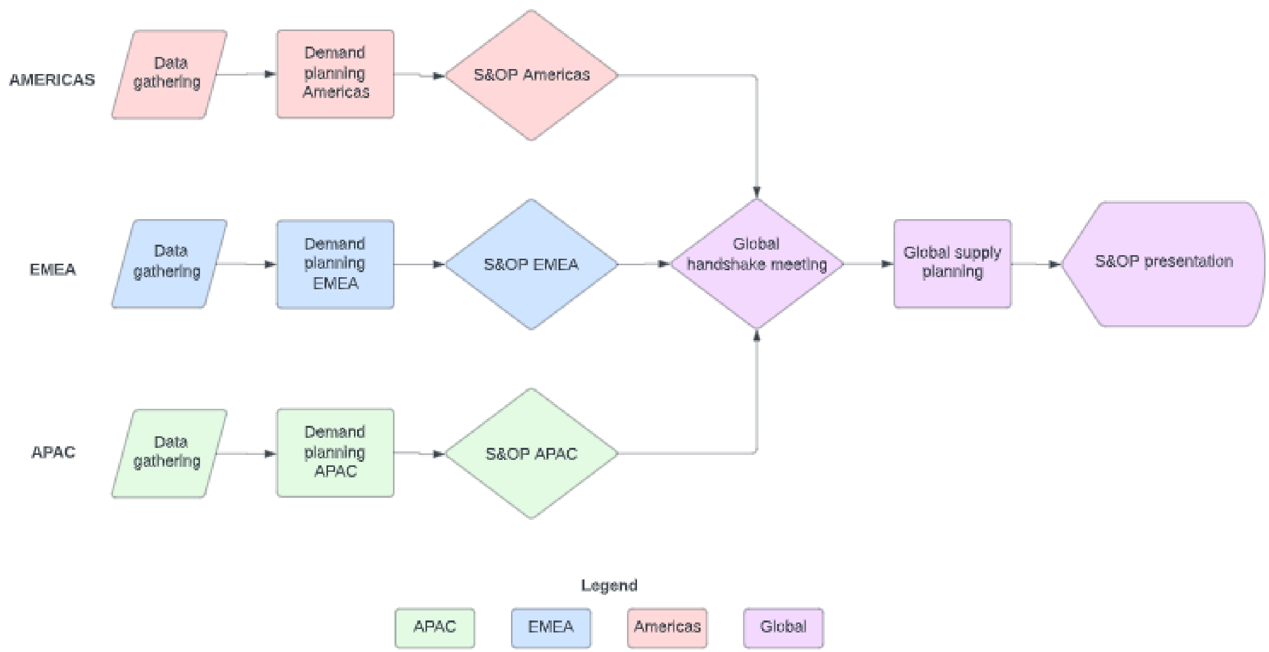

Figure 4.8 Axis' global S&OP process

4.3.2 Data gathering

The data gathering phase at Axis is not strictly limited to the start of each S&OP cycle but is instead conducted continuously throughout the month. Demand planning receives input from Enterprise Sales Project (ESP) continuously during the month on new customer projects. Sales and finance further add their input to the process through the Annual Financial Plan (AFP), which is updated two times per year and takes, e.g., growth targets into account. Although the AFP is gathered twice per year, a “tracker” is updated once per month. Sales & Operations Planners also have regular meetings with product analysts and product owners to gather input, especially for new product introductions (NPI). Customer data, such as distributors' inventory levels, are updated twice per week. Further, marketing is involved and occasionally provides input to the process and is reactive when, e.g., specific promotions are active but do not actively participate in meetings.

Supply planning does not collect much data. As for customer data, supplier data is gathered and updated twice per week, but there is no structured process to make use of it. There are no clear-cut responsibilities regarding who should analyze it. Data collection on equipment capacity utilization at the EMS sites has recently been initiated. However, it is still in its infancy and does not add much value at the time. Data is updated infrequently, and there are considerable differences between the different EMS sites in that some EMS sites update their data while others do not.

4.3.3 Demand planning

The demand planning process at Axis (see Figure 4.9) is conducted by the Demand Planning function consisting of two parts: Sales and Operations Planning and Enterprise Sales Projects. The demand planning is carried out by Sales & Operations Planners responsible for forecasting the demand of Axis' entire hardware product portfolio, consisting of approximately 1,500 SKUs. Each Sales & Operations Planner is responsible for forecasting one or multiple product categories with a planning horizon of 18 months. Forecasts are created using statistical methods, often Bayesian inference, which considers what happens close in time, and forecasts are generally unconstrained. However, recent supply disruptions have forced forecasts to consider constraints already in the forecasting stage. Three different scenarios are always generated: high, expected, and low. A forecasting module for the Enterprise resource planning (ERP) system is used to support the generation of forecasts. This ERP module is primitive as it cannot always be trusted and cannot handle any other input data than historical sales-out data (sales to distributors).

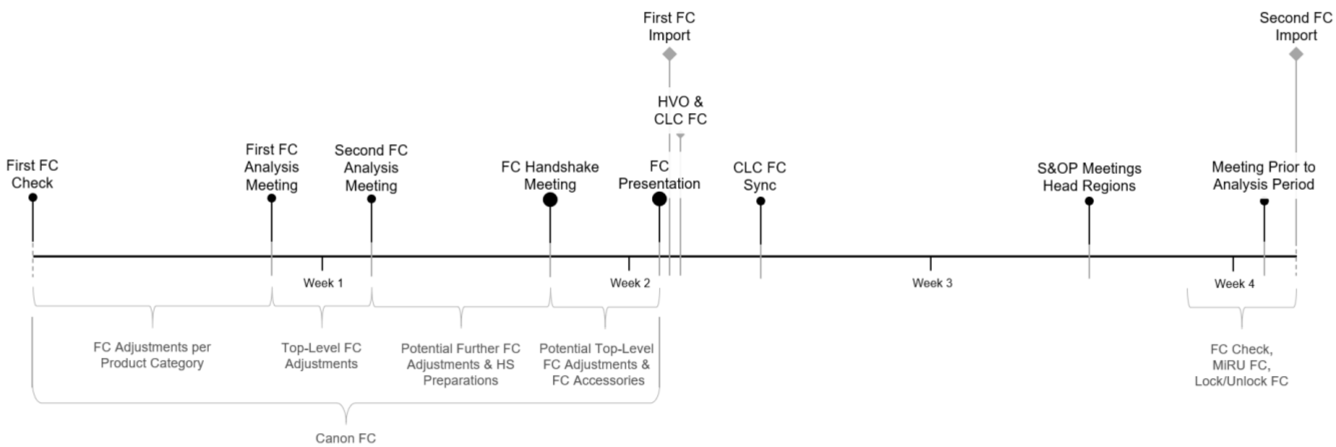

Figure 4.9 Monthly Demand planning process at Axis

To counteract the weakness of the ERP module and be able to use other sources of data as input, each Sales & Operations Planner have their spreadsheets where they perform various calculations and necessary data analysis. All demand forecasts are expressed in quantity and compared against an AFP expressed in monetary value once per month. At the various meetings throughout the S&OP process, all forecasts discussed are expressed in monetary value, which means that the generated demand forecasts need to be translated from quantity to monetary value. This translation is not straightforward since the demand for many products is very heavily project-driven. Thus, there is a distinction between run-rate sales (regular sales) and enterprise project sales which usually get various discounts.

Forecasts are generally done bottom-up by each Sales & Operations Planner, and all forecasts are then aggregated upwards. Individual product-level forecasts are rarely reviewed and validated since each Sales & Operations Planner has different focus areas. Instead, any potential adjustments are made on an aggregate level which the system then breaks down and distributes across all SKUs based on historical data. The expected forecast scenario is loaded into the ERP system twice a month: one preliminary draft in the middle of the month and one final at the end of the month. The forecast that is imported excludes inventories and safety stock policies. Sales collect data of distributors inventories and Americas are doing well while EMEA and APAC are lagging.

In terms of performance measurements, forecast accuracy has been added recently and is part of the meeting agenda, although time limitations frequently restrict the discussions. Further, since forecast accuracy is a new addition, no actions are taken, and currently, it is simply something that is measured, but it does not generate any actions. For instance, Demand Planning is not held accountable for forecast accuracy. Forecasts are generally very optimistic, and there is often a positive bias. Axis's previous analysis on new product introduction ramp-up identified that, on average, forecasts are approximately 50 % off in the first month and 20 % off in month six. Forecast accuracy varies across the three business regions; Americas has significantly better forecast accuracy than EMEA and APAC.

The second part of the Demand Planning function is Enterprise Sales Projects (ESP), the sole sales representative in the S&OP process. It serves two specific purposes: to enable close contact with key end customers and protect the run-rate sales from large project sales. Axis' indirect sales model is still valid for ESP, and therefore it can be seen as another information flow and source of input to the regular forecasts. ESP orders generally follow a strong seasonality pattern, and peaks in demand often appear when distributors want to "burn their budgets" ahead of the new fiscal year. The ESP orders are usually added directly to the forecast by ESP if there is at least a 75-80 % probability that a customer will place the order. The ESP team manages the deliveries to the largest end-customer accounts. The team works together with Axis's end-customer, distributor, and internal functions to spread out the deliveries over a more extended period of time. These major accounts consist of large companies that are recurring customers that once they order, they order large quantities. The split between run-rate sales and ESP is approximately 50/50. Since these ESP sales generally are of large quantities, there is a risk that orders are large enough to "wipe out" the entire inventory, thus prohibiting other customers from purchasing products since orders are served on a first-in, first-out (FIFO) basis.

Further, the end customers are frequently unable to install all cameras ordered during a given period. Consequently, it makes sense to spread out the deliveries for customers. This additional flow of information provides a win-win situation for all parties involved, and, in its essence, ESP is a tool to manage peaks in the actual demand. ESP works with a planning horizon of six months until goods are supposed to be in the distributors' warehouse. Not all products in Axis' product portfolio are subject to project-driven demand, and it is significantly centered among a few different products.

The demand review meetings are conducted on a regional level, and the discussed aspects differ significantly between the regions. Overall, Axis strives to discuss the holistic perspective in the demand review meetings, and forecasts are discussed on an aggregate level in EMEA and APAC. At the same time, Americas occasionally goes into more detail, such as reviewing certain product families and categories if deemed necessary. In APAC, further complications often occur, as the region has difficulties relating to the numbers presented in the demand review meetings. Another wish for the meetings is to bring up and discuss potential risks. No customers or suppliers are participating in the demand review meetings.

4.3.4 Regional S&OP meeting

Regional S&OP meetings are held once per month with each head region. The primary purpose of these meetings is to achieve good input from the business regions to the Global S&OP meeting, and the overall perspective is holistic. The focus of the regional S&OP meetings is to bring up potential risks and discuss how to mitigate these. Although risk management is a big part of the agenda of the Regional S&OP meetings, there are no formal processes in place for working with risks and acting on what is discussed during meetings. The demand forecasts are presented and discussed on an aggregate level in all regions.

The Americas S&OP has recently started to break down forecasts occasionally to analyze specific product categories individually.

The Sales & Operations Planner responsible for the specific region sends out a clear and structured agenda a few days before the meeting to allow participants to prepare. Participants seem to differ from time to time, and there is no formal S&OP team. A few people continually participate in the Regional S&OP meetings, and the rest of the invitees occasionally participate. The Americas S&OP team consists of the following persons: the responsible Sales & Operations Planner, Director Finance and Operations Americas, Demand Planning team lead, S&OP and Material Supply EMS Manager and Manager Demand Planning and Enterprise Sales Projects. Table 4.3 presents a participation list for the March meeting. There are no suppliers or customers featured at the meetings, nor are manufacturing in terms of EMS representatives.

Table 4.3 S&OP Americas participants

Role	**Function**	**Participation**
Sales & Operations Planner	Demand Planning	Yes
Director Finance and Operations, Americas	Finance and Operations, Americas	Yes
Demand Planning Team Lead	Demand Planning, Americas	Yes
S&OP and Material Supply EMS Manager	Material Supply	Yes
Manager Demand Planning and Enterprise Sales Projects	Demand Planning	Yes
Global Supply Chain Director	Operations Management	No
Business Controller Sales 1	Business Navigation Global Sales	No
Operations Manager	Finance and Operations, Americas	No
Business Controller Sales 2	Business Navigation Global Sales	No

Meetings are hybrid and feature a structured PowerPoint presentation sent out before the meeting. The Sales & Operations Planner responsible for the specific region acts as the meeting leader and facilitates the discussion. Although the meeting leader encourages all the participants to engage and interact, a few people provide most of the input. The meeting leader writes down all decisions taken, and afterward, a summary is sent out to all participants. Most of the discussion is focused on reviewing demand forecasts, and very little time is put into discussing and aligning the supply to demand. There is no discussion regarding capacity at EMS sites, and the supply discussion is focused on the material supply and some brief discussion of potential risks.

Regarding performance measures, forecast accuracy and bias are discussed briefly, although this is a rare occurrence; generally, there is no time to discuss forecast accuracy. No other performance measures are discussed. Considering the big picture, it is clear that S&OP Americas is much more mature than the corresponding meetings in EMEA and APAC.

4.3.5 Forecast handshake meeting

Once a month, there is a Forecast handshake meeting, which can be seen as a global S&OP meeting, as input in terms of forecasts is gathered from all three head regions: Americas, EMEA, and APAC. These meetings aim to discuss and agree on the forecast on a total level. The focus is on a global level with a time horizon of six to 15 months. The meeting is arranged by the Demand Planning team in Lund and is of a hybrid structure, where some people participate on-site and others virtually via Microsoft Teams.

The meeting agenda or other material is neither distributed to participants ahead of nor after the meeting. While all participants seemed to take individual notes, there was not anyone documenting meeting outcomes. Stakeholders from several functions, primarily within Operations, are invited to bring different perspectives to discussions and reach a cross-functional consensus on the forecast. A list of the invited attendees and their participation in the April 2022 meeting can be seen in Table 4.4. The authors were told that participants from the CLCs sometimes attend; however, they are not officially invited and did not attend the meeting. Even though specific people are invited, it was highlighted that everyone within Axis is allowed to participate in the meetings. An important note is that no one working directly with the EMS sites regularly participates in the meetings, and neither are any participants from other suppliers, distributors, or customers.

Table 4.4 Invited participants to the Forecast handshake meeting

Role	**Function**	**Participation**
VP Operations	Operations Management	No
Director, Global Industrialization & Sourcing	Operations Management	Yes
Global Supply Chain Director	Operations Management	Yes
Director Product Management	Products and CTO	Yes
S&OP and Material Supply EMS Manager	Material Supply	Yes
Manager, Demand Planning and Enterprise Sales Projects	Demand Planning	Yes
Sales & Operations Planner 1	Demand Planning	Yes
Sales & Operations Planner 2	Demand Planning	Yes
Sales & Operations Planner 3	Demand Planning	Yes
Sales & Operations Planner 4	Demand Planning	Yes
Sales & Operations Planner 5	Demand Planning	No
Sales & Operations Planner 6	Demand Planning	No
Business Controller Sales 1	Business Navigation Global Sales	Yes
Business Controller Sales 2	Business Navigation Global Sales	Yes
Manager Business Navigation HQ	Business Finance	No

The nine-month forecast from the previous month's meeting is compared to the preliminary forecast for the upcoming month. The demand forecast is presented as graphs at an aggregate and product category level. Moreover, there seems to be confusion among the participants on what the demand forecast numbers presented represent. Discussions usually concern the demand planning team's input since last month, changes to the new forecast relative to the previous one, and reasons behind these changes. Other frequent discussion points include considering potential future scenarios and what strategic actions might need to be taken if a scenario is realized. Discussions on balancing risks and the aggressiveness level of plans also occur. The supply perspective is discussed briefly in terms of component shortage.

Meanwhile, there is no discussion on the expected output from the EMS sites, and in general, supply seems to be limited to the component availability. There was no concrete supply plan presented in the meeting, leading to scarce supply and demand plan integration. Discussions were not supported by tangible KPIs, even though past sales in, sales out, and actual demand were linked to the future demand forecast on an aggregate level.

The global market situation is also discussed, and how different order management strategies for the head regions have impacted both the regional and global demand forecast. Representatives from sales were present at the meeting; however, their engagement was limited besides contributing with explanations of how the Sales department interprets and handles specific numbers. There was no representation from either Finance or senior management. Overall, there is a friendly atmosphere in the meetings, and participants are not afraid to ask clarifying questions leading to discussions.

A goal of the meeting is to gather a forum to align operations planning with strategic growth targets; however, there currently are no performance measurements linking the two to support this. The target output of the Forecast handshake meeting is an agreed-upon forecast that Sales & Operations Planners from the Demand Planning team later import into the ERP. However, no distinct decisions were made in the meeting that the authors attended. Instead, the character of the meeting was more of a presentation that included cross-functional discussions.

4.3.6 Supply planning

The supply planning at Axis is performed by the Material Supply team, which consists of approximately 30 people placed at the headquarters in Lund. The team consists of purchasers of materials for EMS sites, accessories and sourced products, packaging and labels, and electronics. Other roles include process developers, purchasing analysts, coordinators, and two managers. Other than managing part of the Material Supply team, one of the managers is the owner of the S&OP process. Being the S&OP process owner includes coordinating, assessing, and developing the S&OP process within Axis. The Material Supply team is responsible for securing and planning material availability, capacity planning at EMS sites, planning of ramp-up/down transitions of old and new products, material component visibility, supplier collaboration and evaluation, inventory management, and more. Input to supply is gathered from the perspectives of the three sales regions; however, the supply planning execution is done on a global level.

The Material Supply team collaborates with several other functions within Axis to achieve its responsibilities. These functions primarily include Industrial Lead, Demand Planning, Sourcing, Production Preparation, CLC, and Finance, see Figure 4.10. Material Supply receives input on the bill of materials, product specifications, opinions on supplier selection, and project time plans from the Industrial Lead team. The outputs towards Industrial Lead include handing over confirmation, securing material for production, and escalating production issues. The main inputs are forecasts and project information from the Demand Planning team. Material Supply is to provide Demand Planning with information on material availability, which might impact the demand forecasts. The Purchasers buy material based on the aggregate level forecast loaded into the ERP system twice per month by the Demand Planning team, plus an extra margin to account for safety stock for the EMS sites and CLCs based on pre-determined policies.

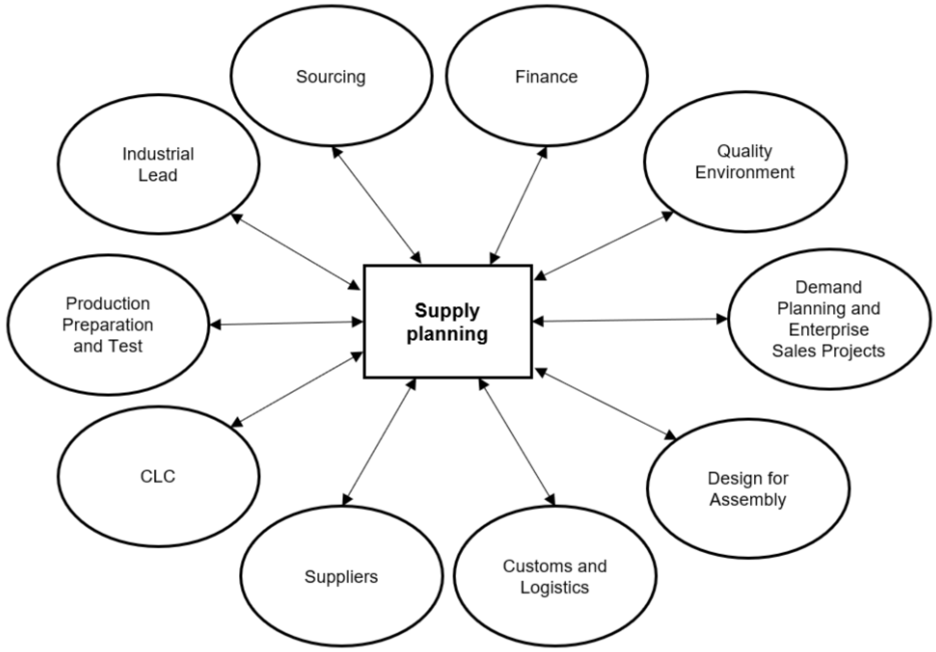

Figure 4.10 Collaborating partners to the Material Supply team

Within the Material Supply team lies responsibilities related to the EMS decisions. For example, questions regarding what EMS site to produce, what products, and how much to allocate at each EMS. By considering contextual factors such as if an EMS site has produced a similar product before, if the product is a roll-over replacing an old product, how are competencies spread out across different EMS sites, price, and target markets. However, the Material Supply team is not solely responsible for this. Together with the Commodity team, which consists of different representatives bringing different perspectives, including, e.g., Quality Environment, Finance, and Production Engineering and Technology (PET).

In terms of EMS collaboration, EMS sites share data on inventory levels with Material supply twice a week. Material supply has initiated a project aiming to improve the visibility upstream in the supply chain by, e.g., having real-time access to inventory levels at the EMS sites. However, it is still in its early stages. The main issue with these initiatives is that the organization is not always set up to handle this new type of information since it is unclear who should analyze the data and how it should be used. The primary key performance indicator (KPI) used within Material Supply is the delivery precision from the EMS sites, i.e., the service level. Currently, there is no measurement evaluating the capacity utilization at the EMS sites, and people involved have indicated that there is no plan to introduce such a KPI.

The role of supply planning within the S&OP process is relatively new. The purpose is to provide the process with information from the materials availability perspective. There is a monthly Supply planning review meeting in the S&OP process where the main focal point is to identify if there are any obstacles that prohibit Axis from delivering against demand. Obstacles, e.g., supply disruptions, restricted component availability, and information technology issues, appear. The Supply planning review meeting considers supply from a global perspective; however, it gathers input from all sales regions. The time horizon discussed is generally three to six months.

Attendees are invited from several functions to the Supply planning review meetings, including Material Supply, Sourcing, Industrial Lead, Logistics, CLC, Order Fulfillment, PET, and Customs Compliance, see Table 4.5. Meanwhile, participation from the Demand Planning team is optional. The meeting has grown to a large meeting with several stakeholders participating. Representatives from neither suppliers nor the EMS sites are invited to the Supply planning review meetings. As the meetings are currently structured, there seldom are discussions concerning capacity issues or decisions at the EMS sites during the meetings.

Table 4.5 Invitees and participants in April's Supply planning review meeting

Role	**Function**	**Participation**
VP Operations	Operations Management	No
Director, Global Industrialization & Sourcing	Operations Management	No
Global Supply Chain Director	Operations Management	Yes
Manager Industrial Lead	Industrial Lead	Yes
S&OP and Material Supply EMS Manager	Material Supply	No
Material Supply Manager	Material Supply	Yes
EMS Supply Lead	Material Supply	Yes
Manager, Demand Planning and Enterprise Sales Projects	Demand Planning	Yes
Sourcing Manager	Sourcing	Yes
Sourcing Manager, Electronics and Manufacturing	Sourcing	Yes
Manager Production Systems High Volume	Production Engineering and Technology (PET)	Yes
Customs Compliance Manager	Customs Compliance	Yes
Order Fulfillment Director	Order Fulfillment	No
Global Order Manager	Order Fulfillment	No
Process Development Manager	Order Fulfillment	Yes

4.3.7 Forecast presentation

The final step of the S&OP process is a Forecast presentation usually scheduled for the middle of the month. This meeting aims to inform the organization about the forecast plans from both a demand and supply perspective established in the S&OP process. Representatives of the Demand Planning team lead the meeting, but Material Supply also plays a key role. Since the meeting is informative, it is open to everyone who wants to attend; however, only ESP, Material Supply, Sourcing, and a few representatives from the Demand Planning team are invited. The Global Supply Chain Director also attends the meetings to bring input and answer questions from the rest of the organization.

Since the meeting is a presentation, there is not much discussion. Instead, attendees ask questions when clarification is needed. The future demand forecast is first presented on an aggregate level measured in value. The past actual demand is compared to sales in and sales out; however, there is no comparison to the previous demand forecast. Another discussion area is the open order stock, which is broken down on a regional level and into product categories measured in quantity.

Moreover, the supply forecast at the EMS sites is presented on an aggregate level measured in value. The total supply and demand, actual purchase orders, and supply forecasts are compared to the plan of the previous month. The perspective of the EMS sites and their reactions to the updated forecasts is brought up in the meeting the authors attended; however, it is not a focus area. The demand and supply plans are presented separately but not compared. A summary of the key takeaways from Section 4.3 can be seen in Table 4.6.

Table 4.6 Key takeaways from sales and operations planning at Axis

S&OP takeaways
Does not follow the generic S&OP process
Global S&OP set-up • Regional demand review meetings for each sales region • Global supply review meeting with all regions • Global S&OP meeting with all sales regions
Enterprise sales project
The planning horizon is 18 months Bottom-up forecasting
Demand planning is the most mature "function" of the S&OP process, while the supply planning is lagging
The Supply planning review meeting is after the demand Forecast handshake meeting
One person acting as S&OP process owner alongside other responsibilities
Little to no performance measures associated with the S&OP process
Participants are almost exclusively from the Operations function
No top management participation No formal S&OP team(s)

Chapter 5 – Analysis and findings

The analysis and findings chapter will present our findings and analysis of Axis' capacity planning and S&OP processes. We will apply the theoretical models from our analytical framework, which will guide the analysis. Each section will be summarized through one or more propositions, as illustrated in Figure 5.1. *The chapter starts with the capacity planning process, followed by the S&OP process. Last, we will present a proposition linking the capacity planning and S&OP processes together*.

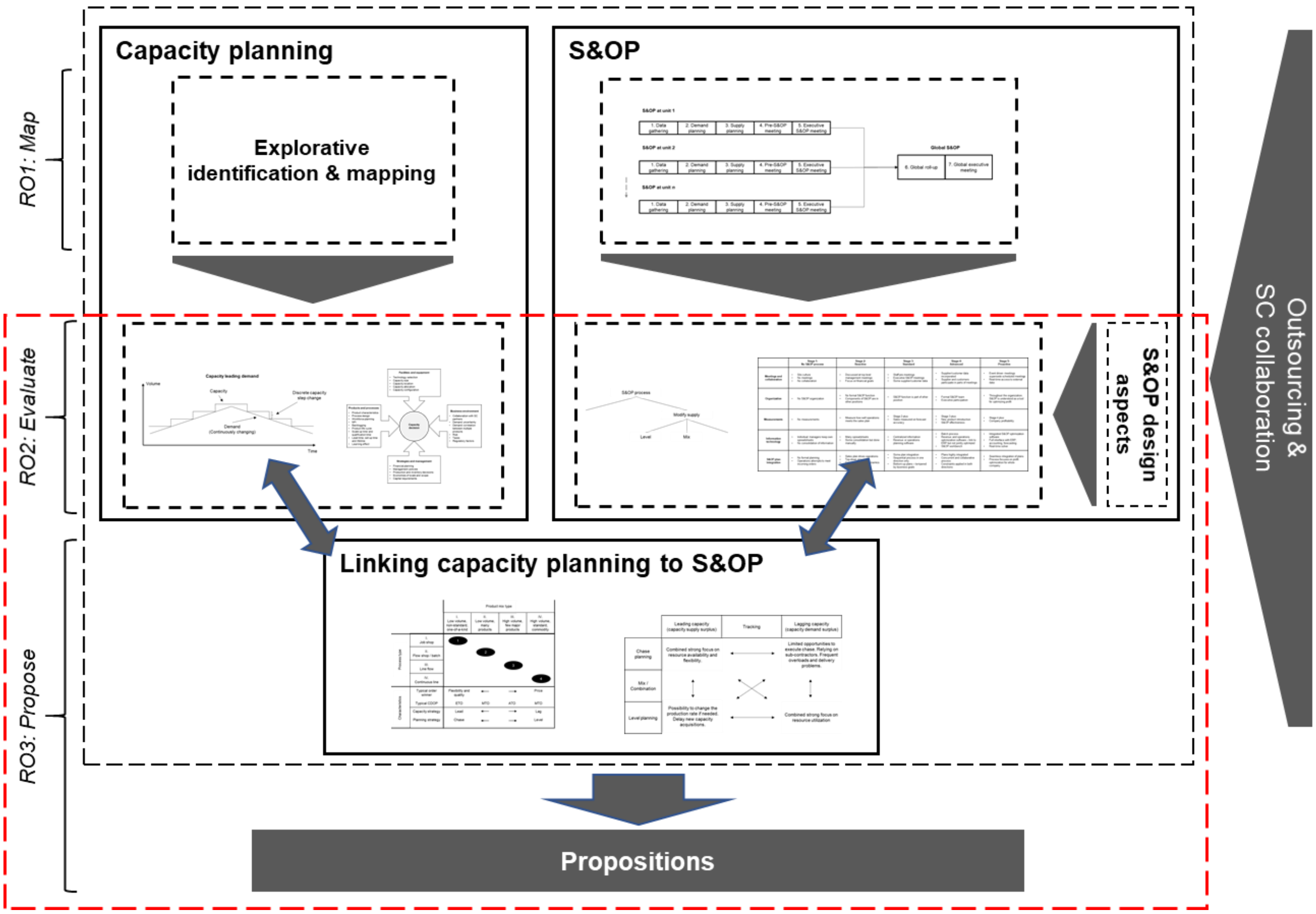

Figure 5.1 Focus of analysis and findings

5.1 Capacity and planning strategy

Axis is pursuing a lead capacity strategy (Figure 5.2), as the company consistently strives to achieve a capacity surplus relative to the demand (Olhager et al., 2001). In Axis' case, there is a set goal of consistently achieving a 30 % capacity surplus, regardless of product characteristics. Our interviews made clear that Axis strongly emphasizes product availability above all and that the culture at Axis reflects this. There is very little concern regarding costs due to a corporate strategy focusing heavily on growth, high contribution margins, and a history of long-term business success. The mantra is always to have extra of everything to ensure high service levels. A lead strategy establishes a higher cost profile; however, it leads to better service levels and increased flexibility (Olhager et al., 2001). Adopting a lead strategy aligns well with what Axis wants to accomplish. Thus we argue that a lead capacity strategy is an excellent strategic fit (Chopra and Meindl, 2007). Another argument for pursuing a lead capacity strategy is that the production equipment is relatively cheap. The pay-back time for product projects is only a few months on average which implies that the trade-off between a lead or lag strategy is not as significant as usual (Olhager et al., 2001) since the opportunity cost of failing to deliver to customers is greater than the investments in equipment.

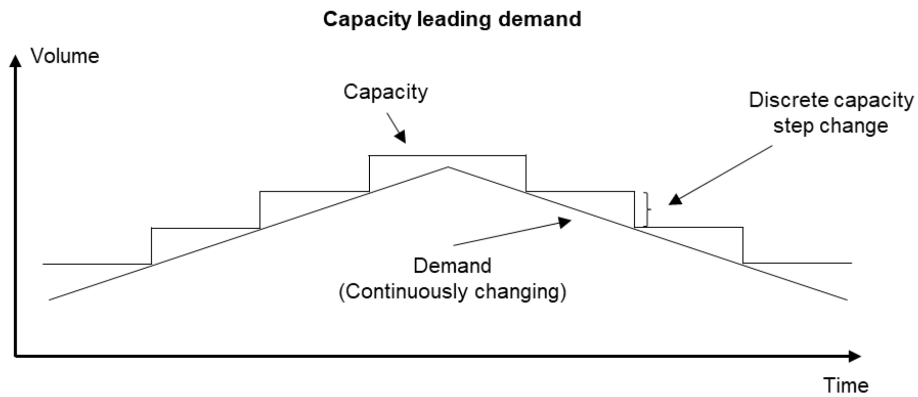

Figure 5.2 Axis' capacity strategy, adapted from Olhager et al. (2001)

The EMS sites themselves carry out the production planning at the EMS sites, and our interviews indicated that the EMS sites are pursuing a mix planning strategy (Olhager et al., 2001). The planning strategy is level since the EMS sites are concerned about achieving a high and steady production output with minimal changes to production plans (Olhager et al., 2001). Our interviews indicated that the EMS sites are most often unwilling to change production plans once the plan is set, effectively decoupling supply from demand for a given period of time. On the other hand, the EMS sites are pursuing a chase planning strategy since the production plans are based on forecasts, meaning that supply is matched to the forecasted demand. Additionally, the EMS sites can change employment levels and add extra shifts, which are common ways of adopting a chase planning strategy. Consequently, the planning strategy involves elements of both a chase and level planning strategy equivalent to a mix planning strategy (Olhager et al., 2001).

The combination of a lead capacity strategy and a mixed planning strategy is a viable option (Olhager et al., 2001); see Figure 5.3. Using a combination of a leading capacity strategy and a chase planning strategy is mutually supportive and results in a strong focus on resource availability and flexibility. In comparison, combining a leading capacity strategy and a level planning strategy is neither supportive nor conflicting. A leading capacity strategy and a mix planning strategy is considered an intermediate option that is neither mutually supportive nor conflicting, resulting in a viable option.

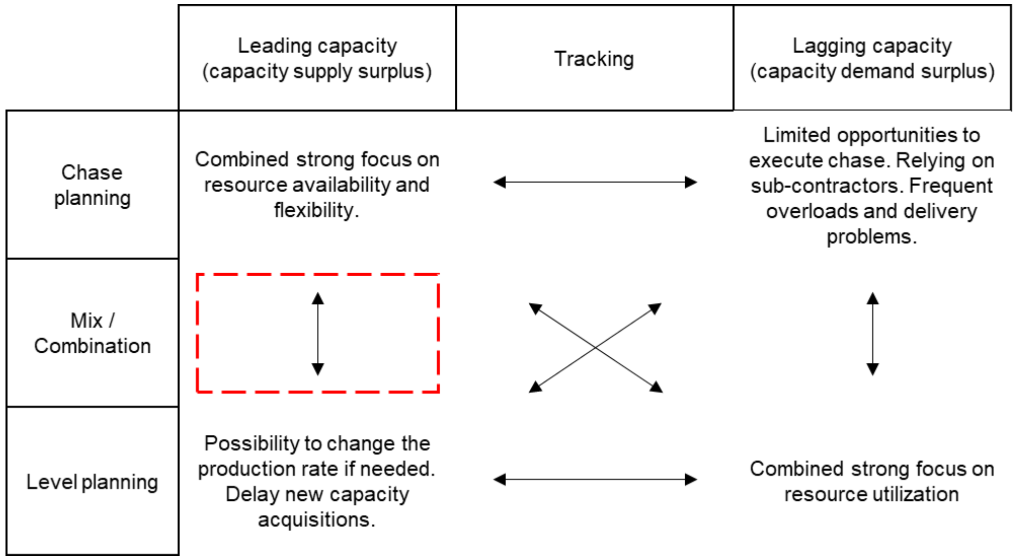

Figure 5.3 Axis and EMS sites' combined capacity and planning strategies

We consider a leading capacity strategy an excellent strategic fit for Axis, given the strong emphasis on product availability, high contribution margins, a corporate strategy focused on growth, and the mantra of always having extra. Meanwhile, the EMS sites pursue a mix planning strategy. They aim to achieve high and steady production rates with minimal changes to production planes while still matching production to demand forecasts. This combination of a leading capacity strategy and a mix planning strategy is a good option that seems to fit Axis well, resulting in our proposition that Axis should stick to this combination. Based on this analysis, we submit the following proposition:

P1. To maintain a strategic fit between capacity and planning strategies, Axis should keep a leading capacity strategy, and the EMS sites should keep their mixed planning strategy.

5.2 Factors influencing the capacity planning process

The interviews revealed that all four identified dimensions in the literature review play a role in Axis' current capacity planning process: business environment, facilities and equipment, product and process, and strategy and management. The interviews were coded using the Gioia methodology (Corley and Gioia, 2004), and the result can be seen in Figure 5.4. In this section, we will deep-dive into each of the four dimensions.

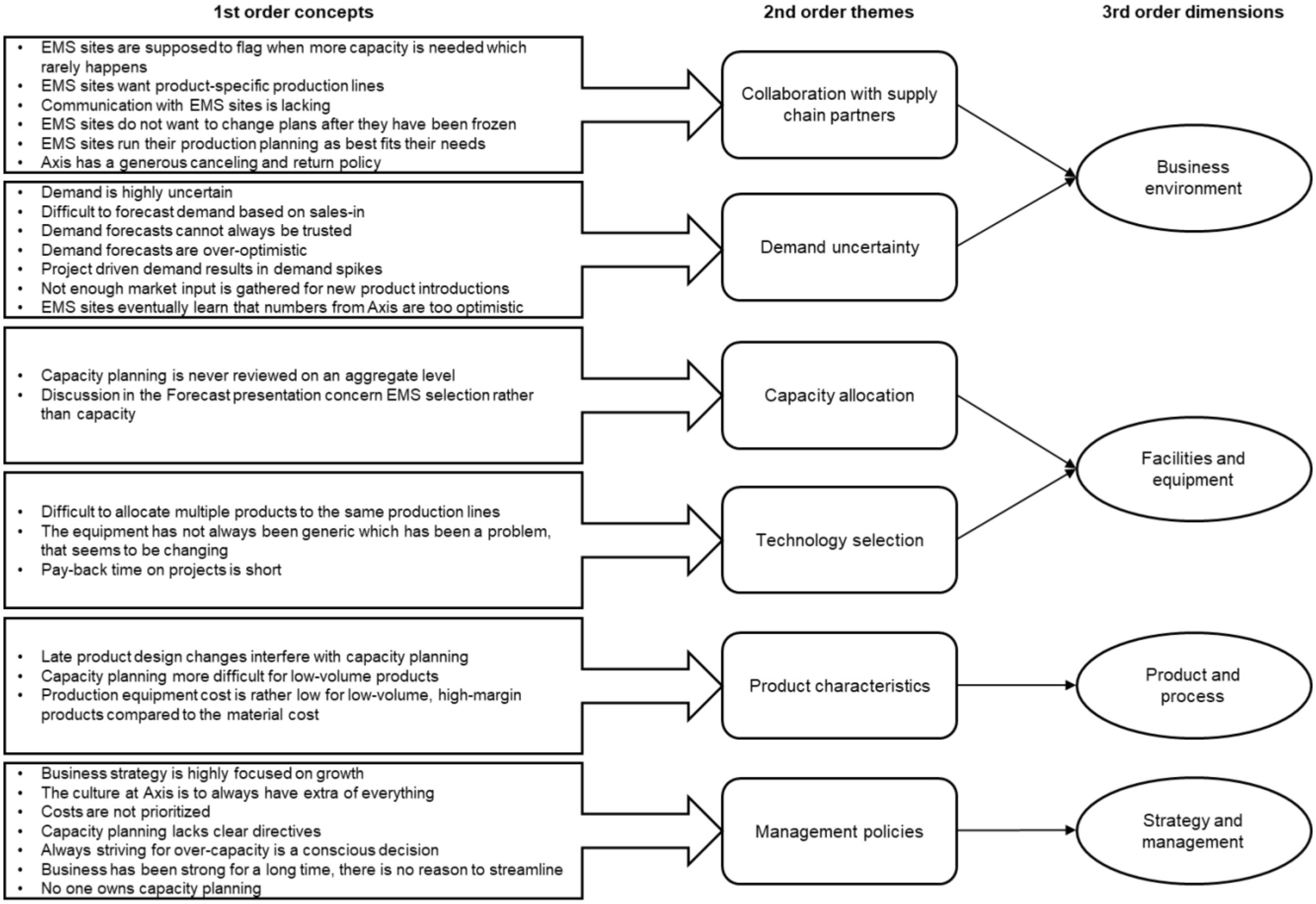

Figure 5.4 Identified factors influencing capacity planning at Axis

5.2.1 Business environment

Within Axis' business environment, we identified demand uncertainty and collaboration with supply chain partners as the two factors that play the most significant role in the capacity decision, see Figure 5.5. Capacity planning decisions result from the input from the demand forecasts, which make the capacity highly dependent on the quality of the forecasts in the first place and thus a strong influencing factor. Demand forecasts are known throughout Axis to be over-optimistic, motivated by the demand uncertainty and the overarching growth focus of the corporate strategy. Over-forecasting is thus a way to accommodate and hedge for both. Many products are subject to heavy project-driven demand, which consistently add peaks to the demand. Demand spikes must be accounted for somehow, and for Axis, this is done by pursuing a leading capacity strategy. To further complicate the capacity planning decision, Axis has an indirect sales model. Consequently, forecasts are based on sales in, i.e., what Axis sells to distributors, rather than sales out, which represents the actual demand from end customers. Our interviews revealed that the EMS sites know the over-optimistic purchasing behavior, and consequently, they account for this in their planning.

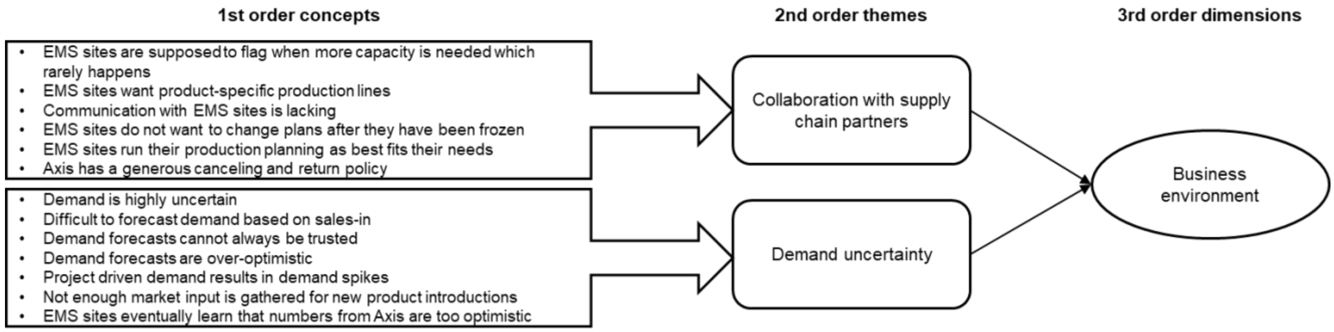

Figure 5.5 Identified concepts and themes for the business environment dimension

The second theme we identified is the collaboration with supply chain partners (the EMS sites), which strongly seems to influence capacity planning decisions. Since Axis has opted for turnkey outsourcing of the manufacturing function, i.e., both execution and coordination of the manufacturing lie with the EMS sites (van Weele, 2014), Axis has little control of the EMS sites. The EMS sites are responsible for production planning, control, and purchasing of most components which causes friction in the capacity planning process. They run their production planning as they see fit their needs best, which means it is difficult for Axis to change plans after the EMS sites have frozen them. Although much of the production equipment is generic and many products can share production lines, it is easier for the EMS sites to have product-specific production lines rather than sharing production lines between multiple products.

Another aspect that enhances the disconnect between Axis and the EMS sites is the contracts currently structured as unit rate contracts (van Weele, 2014) with no associated incentives. Narayanan and Raman (2004) state that poorly designed incentive schemes are one leading cause of supply chain discontent, which is the case for the contracts between Axis and the EMS sites. Norrman and Näslund (2019) argue that aligning incentives is critical for successful supply chain management. EMS sites are supposed to alert Axis when more capacity in the production lines is needed; however, this rarely happens, although capacity shortages often can be addressed by simply adding a few extra test stations with little effort and investment.

Our interviews indicate an overall lack of visibility and communication with the EMS sites, inhibiting the overall supply chain performance. According to van Weele (2014), disadvantages of turnkey outsourcing include limited influence and insight into cost structure and employees, technology and materials used, and significant dependence on the supplier, resulting in increased risks. Axis has an extensive insight into what technologies and equipment are used since they choose and own the equipment; still, it is clear that all other disadvantages are present. Outsourcing, in general, requires trust, communication, and continuous management of the partnership (van Weele, 2014), which is currently lacking at Axis in terms of capacity planning, of which there is little collaboration.

Another complicating factor is that Axis has a generous canceling and return policy. Distributors can place orders ahead of time, and if they no longer want them, they can simply cancel the order later without any consequences. All products the distributor purchase can be returned to Axis if not sold. This lack of visibility and control along the intermediary layers of Axis' indirect business model has implications on demand. First, the lack of upstream visibility cause distortions in the demand since it is difficult to know the actual demand from customers. Second, the return and canceling policies result in opportunistic purchasing behavior from distributors, which has become even more evident in the current situation with global supply disruptions and shortage of components. The opportunistic purchasing behavior from distributors adds to the demand variations. According to several interviews, the use of forecast accuracy on an aggregate level has recently been implemented. However, our observations and some interviews show that it is still not used and instead merely measured as a formality. Forecast bias on SKU level is occasionally used as a parameter when determining capacity but not according to a structured process.

5.2.2 Facilities and equipment

We identified capacity allocation and technology selection as the two moderately influencing factors for capacity planning within facilities and equipment, see Figure 5.6. First, capacity allocation influences the capacity planning decision. Our interviews revealed that there never are reviews of the capacity plans on an aggregate level, which leads to a lack of a holistic view. However, as much of the production equipment moves toward being generic, increased attention has been directed to manufacturing multiple products on the same production lines. Thus, planning what products to allocate to what EMS site needs to consider the existing production line capacity and how the capacity will be changed in the future.

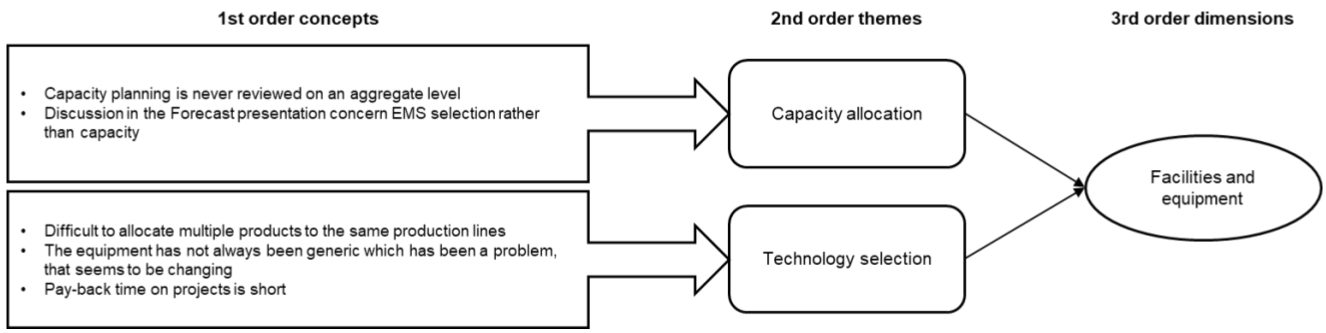

Figure 5.6 Identified concepts and themes for the facilities and equipment dimension

Second, technology selection seems to influence the capacity planning process. Although some of the equipment is already generic, there is still plenty of product-specific production equipment, making it challenging to allocate multiple products to the same production lines and thus optimize the production. A significant part of the production process also involves "clean rooms" where the camera lenses are prepared in a sterile environment. Specific product mixes that could share the same production line are not always compatible with the same "clean rooms," resulting in the need for different production lines.

5.2.3 Product and process

Within the product and process category, we identified product characteristics as the sole influencing factor in the capacity planning process, see Figure 5.7. First, our interviews revealed that late changes in product specifications from the product development project within R&D are common. The delays in product development project plans interfere with capacity planning and consequently impede optimal capacity planning. It was highlighted that the more product development projects are delayed, the worse it gets in terms of capacity planning since the plans usually are made at an earlier stage.

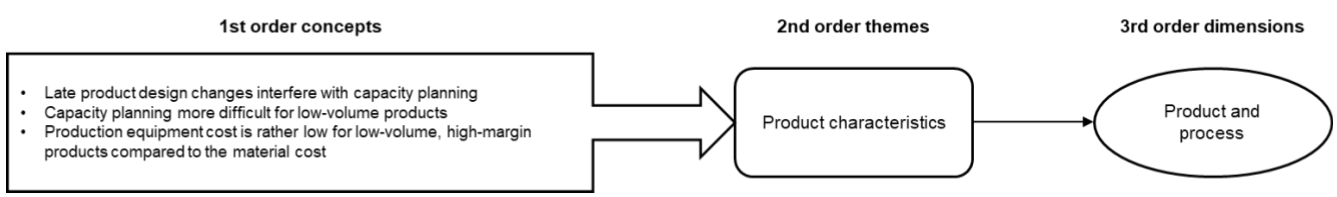

Figure 5.7 Identified concepts and themes for the product and process dimension

Second, the difficulty of capacity planning varies heavily, whether it is a product manufactured in low or high volumes. High-volume products generally have a more stable run-rate and project sales which, in some cases, makes it easier to forecast and consequently plan the capacity accurately. Products of low volume are subject to more errors in forecasts and lumpy demand, making capacity planning for these products more difficult.

5.2.4 Strategy and management

Within strategy and management, we identified management policies as the sole factor influencing capacity planning decisions at Axis, see Figure 5.8. The overarching corporate strategy is highly focused on growth which can be seen throughout the organization, especially with capacity planning. The growth mindset is deeply rooted in Axis' corporate culture, and generally, little attention is paid to costs. Instead, the common practice is always to have extra of everything. This mindset is motivated by the fact that business performance has been solid for a long time, generating few reasons to streamline processes. Consequently, the decision to persistently strive for over-capacity is a conscious decision to accommodate for growth. A lack of supply should not limit Axis, and products should always be available, no matter the cost.

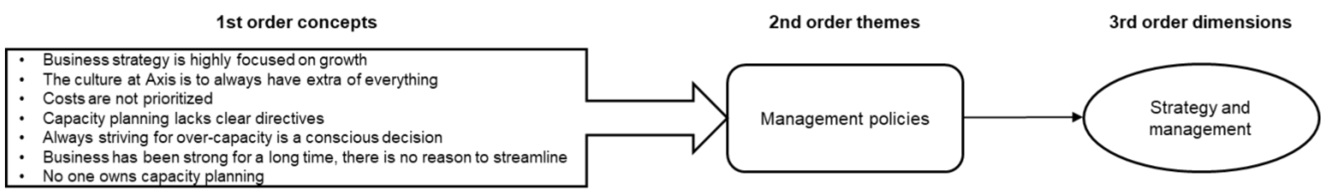

Figure 5.8 Identified concepts and themes for the strategy and management dimension

Currently, there is no sole owner of the capacity planning process. Instead, the responsibility is spread out over several functions, and no one sits on the complete picture, leaving several gaps. The existing capacity planning process is not structured, and specific directives are lacking. Apart from the pronounced target of 30 % overcapacity and availability of demand forecasts, there is no straightforward process to follow when determining capacity at EMS sites. The lack of directives leaves the process very much up to individuals who are not held accountable for the varying outcomes. The analysis indicates that business environment and strategy and management are the two dimensions having the most impact on the capacity planning process at Axis, as illustrated in Figure 5.9. Thus, we submit the following proposition:

P2. To achieve a more mature capacity planning process, Industrial Lead should direct focus on the *business environment* and *strategy and management* dimensions when planning capacity at the EMS sites, as these factors seem to have the strongest influence on the capacity planning process at Axis.

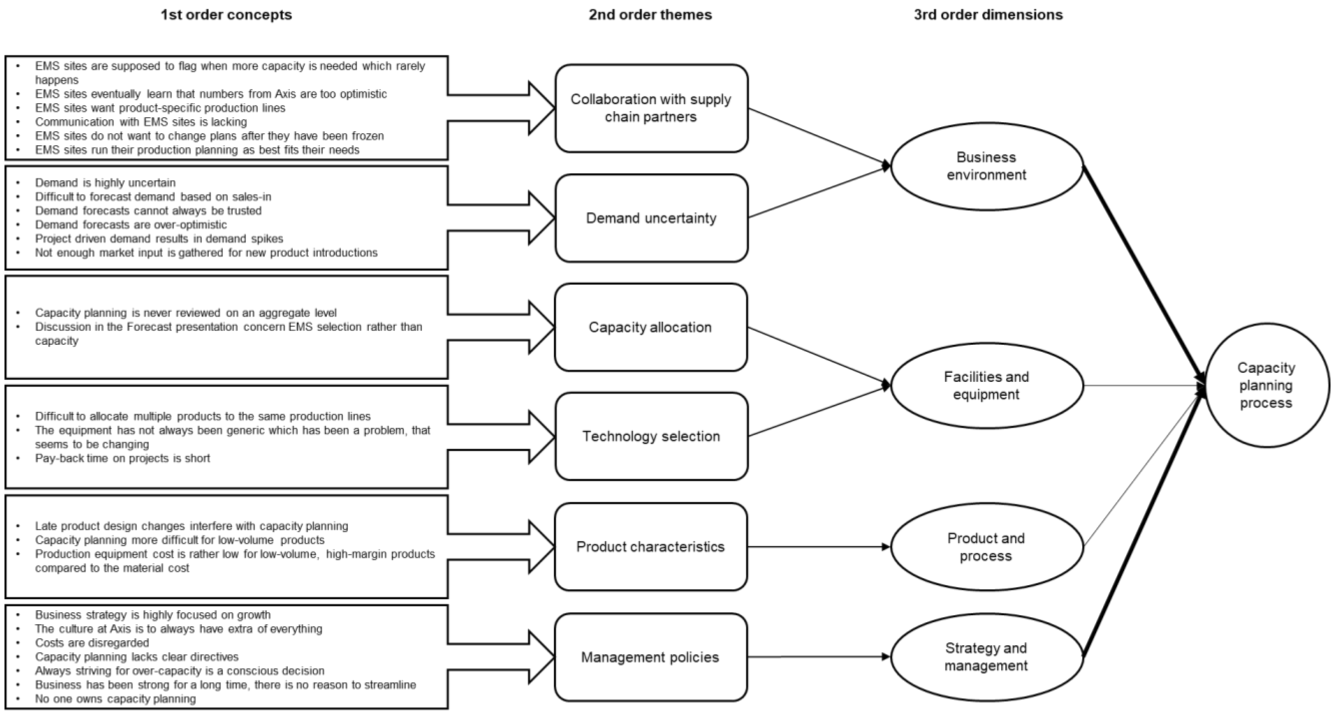

Figure 5.9 Illustration of correlation between identified dimensions and the capacity planning process at Axis

5.3 Capacity, planning, and manufacturing and strategy

The product mix at Axis is broad and includes both high- and low-volume products, while the process type at the EMS sites is of a line flow character. Thus, we argue that Axis has a stage 3 positioning in the matrix by Olhager et al. (2001), considering it from an aggregate perspective. In terms of order winners, Axis typically competes on product availability, design, and quality rather than on price, which places Axis at the very far left. Production is MTS as Axis aims to keep inventory at CLCs. However, the CODP towards distributors is oriented toward ATO since the final part of the value-adding process is to package, label, and configure (e.g., accessories, software, and manuals) cameras individually to match each specific customer preferences. Since production is in the spotlight, we argue that the relevant CODP is MTS, thus placing Axis on the very far right of the matrix. The capacity and planning strategies are lead and mix, as established in P1. Axis' placement can be seen in Figure 5.10 and highlights a discrepancy between the product-process mix, CODP, capacity strategy, and planning strategy.

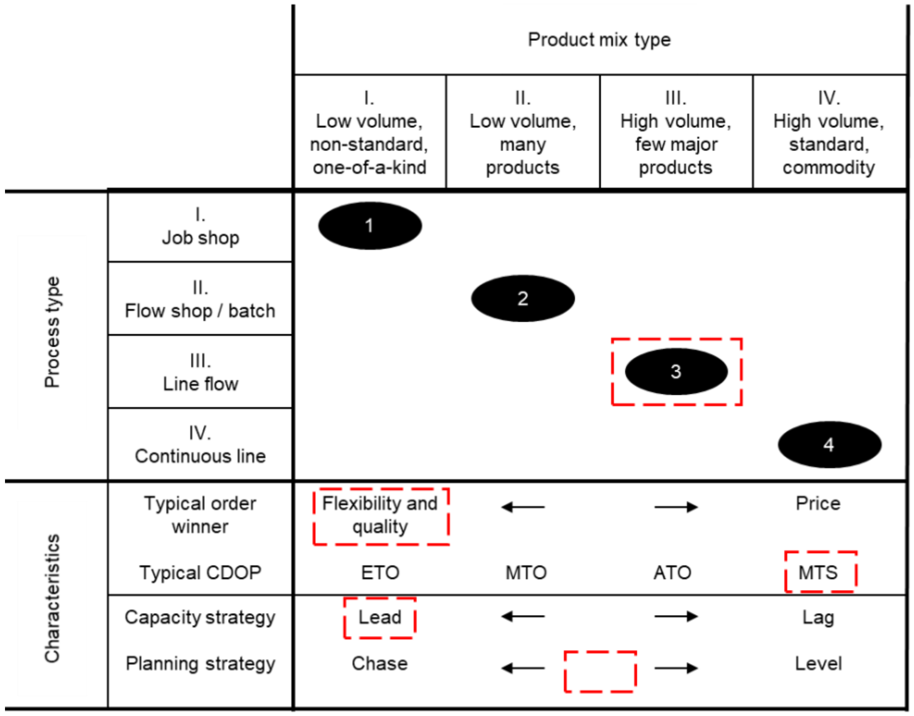

Figure 5.10 Axis position in the matrix by Olhager et al. (2001)

Axis' placement in the matrix by Olhager et al. (2001) has two implications. First, the product-process mix is in stage 3, which suggests that Axis should compete on price as the order winner and pursue an ATO CODP, which is not the case as Axis competes on product availability, design, and quality rather than price. At the same time, EMS sites produce MTS against CLCs. Second, Axis' current combination of a leading capacity strategy and mix planning strategy, which P1 proposes to maintain, is not aligned with the matrix as it suggests a lag capacity strategy and a level planning strategy as the best fit (Olhager et al., 2001). The placement in the matrix leaves Axis with two options: change the CODP towards ETO, or change the capacity strategy towards lag. The complication of the first option is that the product-process mix would need to change and move towards stage 1 as stage 3 positioning does not align with the flexibility required to achieve an ETO market environment. The second option is somewhat more appealing as it would "simply" require Axis to switch its capacity strategy from lead to lag which would have fewer complications than changing the product-process mix and CODP.

However, Axis' wide product range characterized by a few significant products selling in high volumes relative to the rest of the product portfolio selling in low volumes presents exciting opportunities. As we identified, demand uncertainty and management policies strongly influence the capacity planning process, and demand uncertainty seemingly affects products selling in low volume more than high-volume products. Considering the two different categories of products (high- and low-volume) separately in the matrix by Olhager et al. (2001), we argue that high-volume products are in stage 3 while low-volume products are in stage 2. The process type remains the same for both, meaning low-volume products would get a positioning off the diagonal, which may work but is more challenging to manage (Hayes and Wheelwright, 1979), see Figure 5.11.

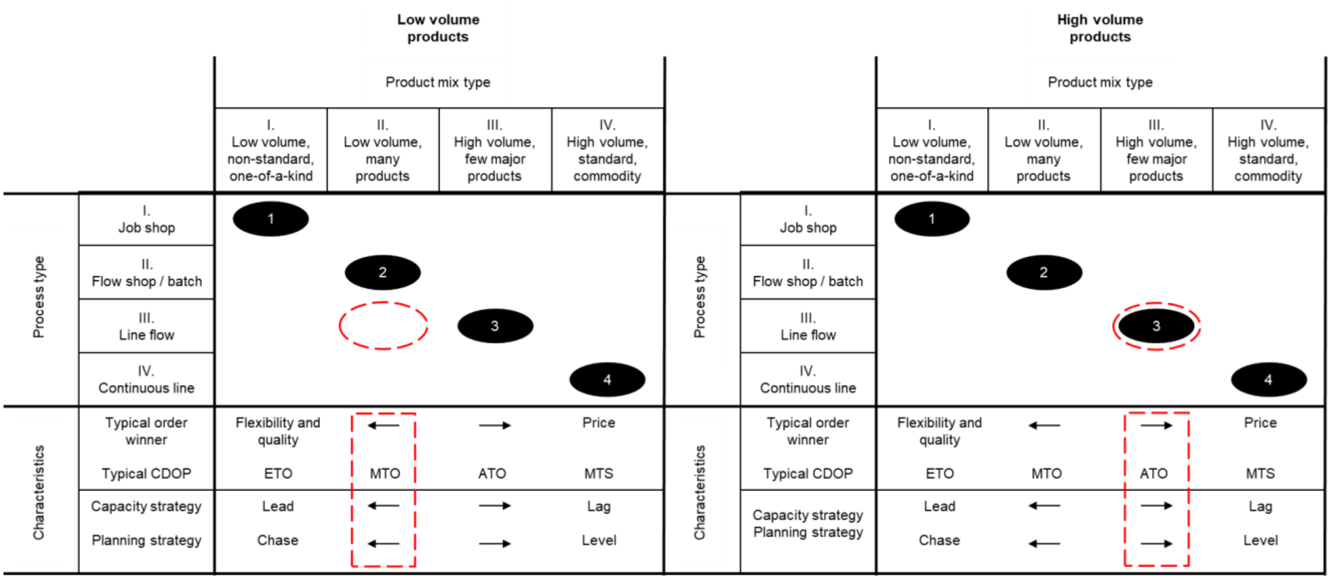

Figure 5.11 Positioning of low- and high-volume products, respectively

Such a differentiated positioning implies that high-volume products lean towards MTS while low-volume products lean towards MTO. In terms of the capacity planning process, this positioning implies that high-volume products should pursue a lag capacity strategy while low-volume products should pursue a lead capacity strategy. P1 established that Axis should continue to pursue a lead strategy according to the current management policy, and we argue this still holds considering the strategic fit. Instead, we argue that high-volume products may benefit from pursuing a lag capacity strategy relative to the lead capacity strategy for low-volume products. We call these *low-lead* and *high-lead*, respectively.

The low-lead strategy for high-volume products would maintain MTS as the CODP, while low-volume products would shift towards MTO. Choosing an MTO strategy for low-volume products may seem odd, but we think there is a good reason. Our interviews indicated that low-volume products are generally more complex, have a more significant contribution margin, and frequently have larger forecast errors with lumpy demand character. Considering these aspects, we argue that the low-volume products can be classified as innovative products with unpredictable demand (Fisher, 1997), which further adds to the argument that the CODP should be changed. On the contrary, our interviews indicate that high-volume products have a far more predictable demand than low-volume products. The project-driven demand characteristics that significantly impact the demand for low-volume products are not seen as much since projects almost have become regular "run-rate sales." Fisher (1997) further states that products with a predictable demand can be seen as functional products and requires a physically efficient supply chain configuration that motivates an MTS environment. This analysis leads us to our following proposition:

P3. To achieve better capacity utilization, Axis should differentiate the capacity strategies based on product volumes and forecast accuracy.

In practice, we propose the following ideas to achieve product differentiation. Using the current guideline of achieving a 30 % capacity surplus as the basis for the two different strategies, we propose that high-volume products pursue a low-lead strategy of less than a 30 % capacity surplus. In comparison, low-volume products should pursue a higher-lead strategy greater than a 30 % capacity surplus. To increase the reliability of this concept, we further propose that the forecast accuracy is considered as it can be used as another variable to determine better how to classify individual products (Fisher, 1997).

Since roll-over products are updated versions of their predecessor, we assume that demand patterns are similar. Consequently, we should be able to make accurate approximations of the demand pattern for roll-over products by analyzing the predecessor. E.g., suppose we have a roll-over product with a forecast accuracy greater than 90 % for the predecessor. In that case, we can be reasonably confident that the required capacity surplus would be lower than a product with 50 % forecast accuracy. The issue is more complex for new business products as there is no historical data to base decisions. However, since the allocation is approximately 80/20 roll-over and new business, we argue that getting roll-over products right is enough improvement for now. Due to the lack of quantitative data, it is not easy to pinpoint precise numbers that can be used, although we can draw upon theory for indications. Fisher (1997) classifies, e.g., functional products as products with 10 % or less in forecast error while innovative products have a forecast error of 40-100 %, which can initially serve as indicative numbers. The two proposed capacity strategies can be seen in Table 5.1.

Table 5.1 The proposed capacity strategies

	High volume products	**Low volume products**
Strategy	Low lead	High lead
CODP	MTS	MTO
Capacity strategy	Lag (relative to high lead)	Lead (relative to low lead)
Capacity surplus	-	+
Planning strategy	Mix	Mix
Forecast accuracy	> 90 %	< 60 %

5.4 Capacity planning process

Since Axis' role in the capacity planning process is of a more long-term character due to relying on turnkey outsourcing for manufacturing activities (van Weele, 2014), we define these decisions as strategic (Hopp and Spearman, 2008). Forecasting is conducted strictly by Axis, with marketing serving as an input to the forecasting process, which is also done by Axis independently of the EMS sites. Axis mostly does capacity and facility planning, although EMS sites have some input to the process. Axis chooses the facility where each product is manufactured and allocated between different EMS sites according to internal policies. Axis decides capacity based on the current capacity planning process, where 30% is added to the forecast. Since Axis develops both the equipment used in the manufacturing process and the products to be manufactured, we consider Axis to have complete control of product and process parameters that serve as an input to the capacity and facility planning. Based on the product and process parameters and capacity and facility plan, Axis creates a capacity plan in collaboration with the EMS sites, determining cost and throughput time. Figure 5.12 highlights the MPC activities conducted by Axis.

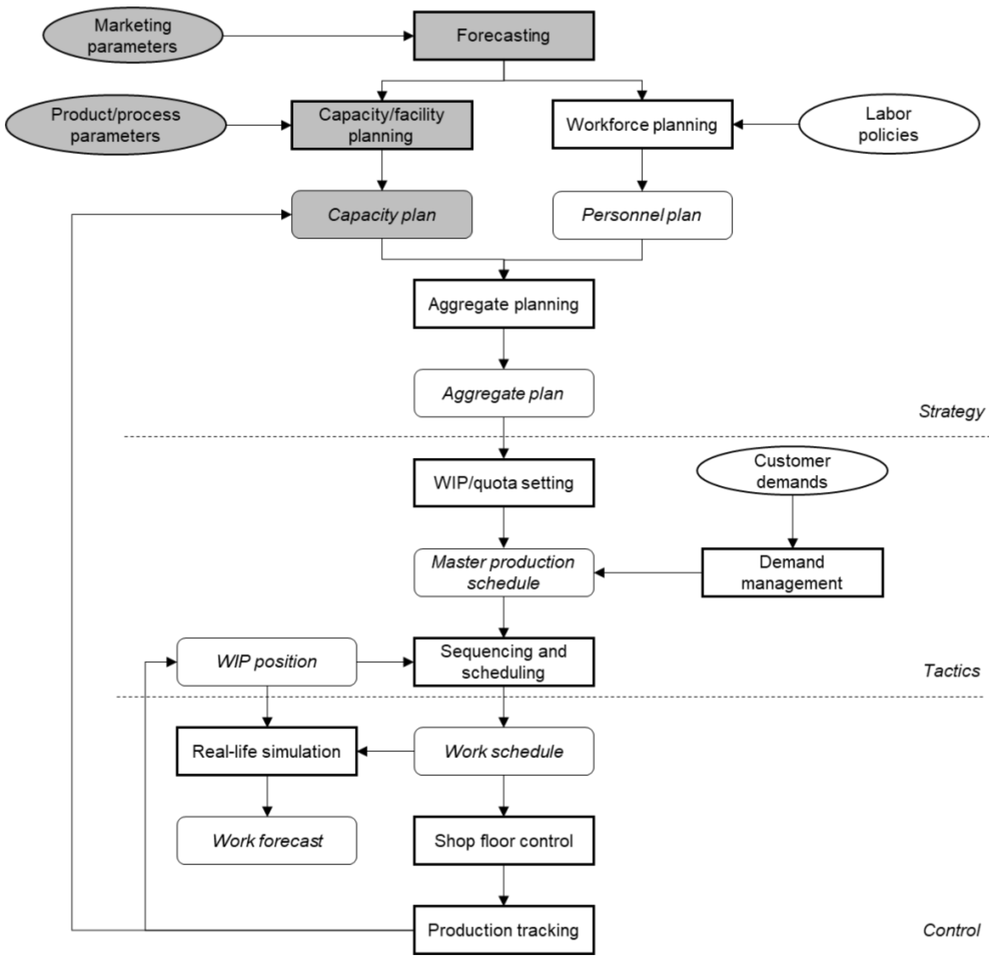

Figure 5.12 MPC activities conducted by Axis highlighted in grey (Hopp and Spearman, 2008)

As illustrated in Figure 5.12, Axis can only influence certain activities within the MPC, including forecasting, capacity and facility planning, and the capacity plan. Consequently, those are the activities where there is room for improvement in the current capacity planning process. P1 established that Axis should maintain a leading capacity strategy combined with a mixed planning strategy. P2 established that the business environment, strategy, and management seem to strongly influence the capacity planning process, while P3 lays the foundation for connecting forecasting and product parameters to achieve better capacity and facility planning. Although these propositions serve as a good starting point, our interviews indicated that the number one issue with the current capacity planning process is that there is no process owner. Thus, no one has a holistic perspective, and no clear directives exist.

We see a few things as especially important to include in both the capacity planning process and the role description of the process owner. First, the capacity planning process owner needs to own, develop and enforce the capacity planning process. In practice, this includes full responsibility for the capacity planning process in terms of performance and making sure, e.g., the leading capacity strategy and mix planning strategy is applied from P1, and attention is given to the influencing factors from P2. We argue that IL should still execute the decisions, but this needs to be done closely with the capacity planning process owner.

Second, there is a need to establish relevant performance measures to monitor the capacity planning process performance and continuously improve it over time. Precisely what performance measure to establish is challenging to pinpoint due to the lack of quantitative data, but potential measures from the literature include, e.g., capacity utilization, production capacity shortages, actual versus planned production, and actual quantities shipped versus quantities ordered (Thomé et al., 2012a). We further propose to closely monitor the availability of capacity in terms of equipment at EMS sites since our interviews indicated that there currently is a lack of visibility in terms of available equipment, and there is no one who knows the situation to a full extent. These measurements need to exist on both product and an aggregate level to allow for complete visibility of the capacity planning process.

Third, the capacity planning process owner should be in frequent contact with the EMS sites, and we suggest frequent site visits, at least initially, to follow up, improve, and build the relationship. P2 identified that collaboration with supply chain partners is one factor that strongly influences the capacity planning process and where there is room for much improvement for Axis. Literature suggests supply chain collaboration is crucial for successful supply chain management (Ellram and Cooper, 1990; Horvath, 2001; Mentzer et al., 2001). However, our interviews indicate discontent regarding different expectations of the partnership between Axis and EMS sites (Lambert et al., 1999; Lambert and Knemeyer, 2004) which leads to inefficiencies in the manufacturing (Simatupang and Sridharan, 2005). This supply chain discontent needs to be addressed. Narayanan and Raman (2004) state that information sharing and building relationships with supply chain partners effectively align incentives and improve overall supply chain performance.

Successful outsourcing relationships require open lines for communication (van Weele, 2014). Our interviews indicated this is one issue today, and outsourcing, in general, requires trust, communication, and continuous management of the partnership (van Weele, 2014), which is currently lacking at Axis. Our interviews indicated that the capacity plan is difficult to change after being set. Increased communication with EMS sites should help facilitate changes to capacity plans and allow Axis to allocate production differently if demand is not realized. Consequently, the capacity planning process owner needs to pay great attention to improving the relationship with EMS sites and increasing the information flow. The main reason for this is that the relationship is not working as efficiently as possible as Axis needs to be more actively involved in the manufacturing process than before. A process map illustrating the current capacity planning process and our redesigned process can be seen in Figure 5.13. Given this analysis, we submit the following proposition:

P4. Axis needs to re-engineer the capacity planning process and allocate one employee as a full-time process owner to improve the overall capacity planning process, gain a holistic view of it, and establish and follow up on performance measurements related to capacity planning.

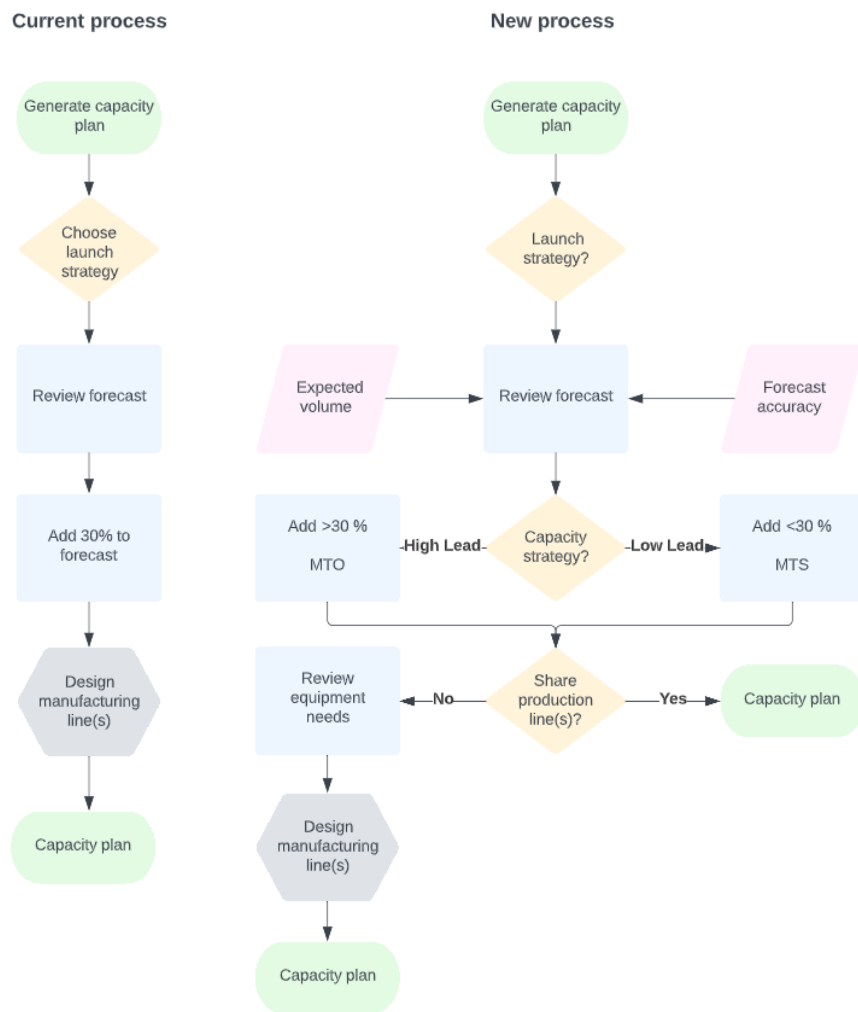

Figure 5.13 Redesigned capacity planning process proposition

5.5 Sales and operations planning maturity level

Applying the S&OP maturity framework by Grimson and Pyke (2007) to Axis generates a current average maturity level of 2.5 out of 5.0, see Figure 5.14. The position in the framework has been reviewed and validated by the S&OP and Material Supply EMS Manager, who is the S&OP process owner. This section will further explain and motivate the S&OP maturity positioning and submit propositions to improve the S&OP process. To guide the development of propositions, we used the factors proposed by Kristensen and Jonsson (2018) to evaluate the S&OP process design, see Figure 5.15.

	Stage 1: No S&OP process	Stage 2: Reactive	Stage 3: Standard	Stage 4: Advanced	Stage 5: Proactive
Meetings and collaboration	• Silo culture • No meetings • No collaboration	• Discussed at top level management meetings • Focus on financial goals	• Staff pre-meetings • Executive S&OP meetings • Some supplier/customer data	• Supplier/customer data incorporated • Supplier and customers participate in parts of meetings	• Event driven meetings supersede scheduled meetings • Real-time access to external data
Organization	• No S&OP organization	• No formal S&OP function • Components of S&OP are in other positions	• S&OP function is part of other position	• Formal S&OP team • Executive participation	• Throughout the organization, S&OP is understood as a tool for optimizing profit
Measurements	• No measurements	• Measure how well operations meets the sales plan	• Stage 2 plus: • Sales measured on forecast accuracy	• Stage 3 plus: • New product introduction • S&OP effectiveness	• Stage 4 plus: • Company profitability
Information technology	• Individual managers keep own spreadsheets • No consolidation of information	• Many spreadsheets • Some consolidation but done manually	• Centralized information • Revenue or operations planning software	• Batch process • Revenue and operations optimization software – link to ERP but not jointly optimized • S&OP workbench	• Integrated S&OP optimization software • Full interface with ERP, accounting, forecasting • Real-time solver
S&OP plan integration	• No formal planning • Operations attempts to meet incoming orders	• Sales plan drives operations • Top-down process • Capacity utilization dynamics ignored	• Some plan integration • Sequential process in one direction only • Bottom-up plans – tempered by business goals	• Plans highly integrated • Concurrent and collaborative process • Constraints applied in both directions	• Seamless integration of plans • Process focuses on profit optimization for whole company

Figure 5.14 Axis' position in the S&OP maturity framework by Grimson and Pyke (2007)

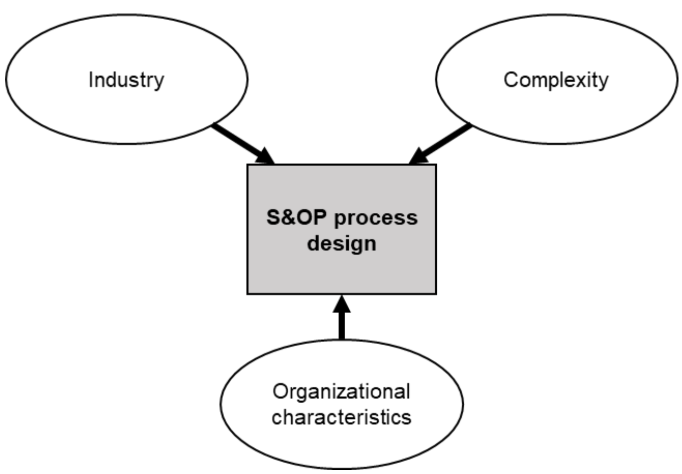

Figure 5.15 Factors to evaluate S&OP process design (Kristensen and Jonsson (2018)

5.5.1 Meetings and collaboration

Axis is currently between Stage 2 and Stage 3 in the meetings and collaboration category (Grimson and Pyke, 2007); see Figure 5.16. There is indeed an S&OP process in place, although a certain amount of silo culture still exists. The S&OP process at Axis is mature enough to fulfill all the requirements of Stage 1. The focus of the S&OP process at Axis is to reach a consensus on the demand forecast, although it is not clearly stated that is the case. We argue that the current S&OP process at Axis is heavily focused on financial goals. The demand and supply functions have pre-meetings before the formal S&OP meetings, where plans are discussed, and input to the S&OP meetings is generated. Considering these two central functions, it is clear that the demand function is much more mature than the supply function. Consequently, the demand planning process is more structured than the supply planning process. Data is collected from suppliers and customers twice a week for supply and demand planning. Both teams use the data to some extent. However, there are no processes and responsibilities regarding the external data regarding who should analyze it and what it is supposed to result.

	Stage 1: No S&OP process	Stage 2: Reactive	Stage 3: Standard	Stage 4: Advanced	Stage 5: Proactive
Meetings and collaboration	• Silo culture • No meetings • No collaboration	• Discussed at top level management meetings • Focus on financial goals	• Staff pre-meetings • Executive S&OP meetings • Some supplier/customer data	• Supplier/customer data incorporated • Supplier and customers participate in parts of meetings	• Event driven meetings supersede scheduled meetings • Real-time access to external data

Figure 5.16 S&OP maturity level: Meetings and collaboration

Concerning the existing S&OP meetings at Axis, we identified that the Global supply meeting takes place at the end of the monthly S&OP cycle. This placement differentiates from the literature (Jacobs et al., 2011), which has the supply planning directly following the demand planning. This discrepancy could explain the imbalance between supply and demand within the company. It could also explain the lack of presentations of concrete demand and supply plans during the S&OP meetings, highlighted as crucial in the literature (e.g., Grimson and Pyke, 2007; Jacobs et al., 2011; Lapide, 2004). As the target of the S&OP meetings is to raise, discuss, and resolve issues and risks concerning the plans, the presentation of plans must be distinct and direct. The lack of concrete plans precludes the comparison of the supply and demand plans and, later, the decision-making of a joint plan moving forward.

There are no defined executive S&OP meetings in the process. However, we still argue that they exist since Axis has combined the pre-S&OP and executive meetings into one S&OP meeting (the Forecast handshake meeting). Consequently, Axis has some parts of Stage 2 and Stage 3 in place, but none of the stages are fulfilled entirely. Axis has yet to reach stage 4 because neither suppliers nor customers participate in the S&OP meetings, and Axis has yet to fully incorporate supplier and customer data into the S&OP process. The overall maturity level is 2.5 in the meetings and collaboration category, as some parts of both Stage 2 and Stage 3 are in place.

Our interviews indicated that R&D and Sales "rule within the company," as indicated by the commonly occurring delay in product development projects. Consequently, Operations must align with actions made by R&D which highlights the lack of internal integration within Axis, and cross-functional integration is highlighted as a CSF (Jacobs et al., 2011; Pedroso et al., 2016; Swaim et al., 2016). Again, Axis leverages external data and collaborates throughout the supply chain, implying a certain degree of external integration. ESP work close with key end customers and intermediaries to plan sales and deliveries, while some large distributors share their inventory levels. A joint discussion with certain distributors is initiated to better plan inventories, and there is a certain amount of collaboration and information exchange with EMS sites. However, Axis does not leverage, e.g., VMI, CPFR, or PoS data as inputs to the S&OP process (Lapide, 2004), which highlights a gap in the external integration and collaboration. Neither does Axis employ any supplier integration shown by Goh and Eldridge (2015) to significantly improve forecast accuracy and reduce inventory levels for a case company using contract manufacturing like Axis.

P5. The Global supply meeting should be held before the Regional S&OP to improve the balance between supply and demand plans and further favor the comparison of plans in the Regional S&OP and Forecast handshake meetings.

P6. To increase internal integration and avoid disconnects and delays in product development project plans, Operations should involve R&D to a greater extent in the S&OP process.

P7. To strengthen external integration, Axis should involve suppliers and customers in the S&OP meetings and focus on improving the relationships.

5.5.2 Organization

Axis is currently at Stage 3 in the organization category (Grimson and Pyke, 2007); see Figure 5.17. No formal S&OP team exists, but there is still an established S&OP organization. However, it is not widely known throughout the organization; even within the operations functions, few people are aware of its existence. Even within the Demand Planning team, members seem to lack awareness and understanding of S&OP and the key drivers and reasons for the process (apart from the few actively participating people). Outside of Demand Planning, most Axis employees interviewed confuse S&OP with the daily work of Demand Planning, which is one of the most common pitfalls when implementing S&OP (Bower, 2005). Goh and Eldridge (2019) identified that it is less critical for technology companies to pursue formal S&OP processes than companies in, e.g., the automotive industry. As a company, Axis is heavily focused on innovation, and thus too many cross-functional, formal processes may inhibit innovation capabilities.

	Stage 1: No S&OP process	**Stage 2: Reactive**	**Stage 3: Standard**	**Stage 4: Advanced**	**Stage 5: Proactive**
Organization	• No S&OP organization	• No formal S&OP function • Components of S&OP are in other positions	• S&OP function is part of other position	• Formal S&OP team • Executive participation	• Throughout the organization, S&OP is understood as a tool for optimizing profit

Figure 5.17 S&OP maturity level: Organization

Axis has highly uncertain demand, which is typical for innovative companies. We identified the main reasons behind Axis' demand uncertainty: the heavily project-driven sales for some of its products and the indirect sales model, which is a dynamic complexity (Kristensen and Jonsson, 2018). Kristensen and Jonsson (2018) argue that companies subject to a large degree of dynamic complexity need more cross-functional integration and horizontal coordination in their S&OP processes. That said, Axis' S&OP process cannot be seen as cross-functional and horizontally coordinated since most participants are from different departments within the Operations department. Consequently, involving different departments within Axis to a greater extent could potentially be a way to overcome the dynamic complexity. Scenario planning is currently experiencing minimal use. It is a tool mentioned by Kristensen and Jonsson (2018) that can be used to a greater extent to manage risk and dynamic complexity. However, Axis is not at the maturity stage where Grimson and Pyke (2007) argue it is used. Considering detail complexity, Dittfeld et al. (2020) state that risk management is not limited to scenario planning and that S&OP design plays a significant role through, e.g., multi-level design and temporary design changes. Axis has achieved a multi-level design by parsing the S&OP process along the three business regions according to the multiple shared sourcing scenario described by Lapide (2012), which addresses both detail and dynamic complexity.

All components of S&OP are part of other positions, and no role is 100 % focused on S&OP. Nevertheless, Axis still fulfills Stage 1 and Stage 2 in the maturity framework (Grimson and Pyke, 2007). The responsibility of the S&OP function lies with the S&OP and Material Supply EMS Manager, who is the process owner and the sole employee that works with designing and developing the S&OP process. The S&OP and Material Supply EMS Manager is also the only person to have S&OP included in the job description. Even though being the one person responsible for the S&OP process, the S&OP and Material Supply EMS Manager has limited time allocated to work with S&OP process improvement due to the recent global supply disruptions. Instead, much focus has been directed toward managing the supply situation. As a result, much of the S&OP process improvement work has been outsourced to other project groups. Another disconnect identified is that the employees who formally plan demand are called Sales & Operations Planners, a title that does not accurately reflect the job description since all but three (who are responsible for a sales region) are not directly involved in the S&OP process. The Sales & Operations Planners are part of the Demand Planning team; simultaneously, the S&OP process owner is part of the supply planning side of Operation, causing an apparent misalignment in the organizational set-up.

Our observations and interviews revealed that the S&OP process lacks top management participation, although VP Operations (part of the executive management team) is invited to the S&OP meetings. Meanwhile, VP Sales is not participating in the process at all. During our study, we observed no top management participation in the S&OP process, while in interviews, Axis' flat organization motivated the lack of top management involvement. Since much decision-making is left to lower management levels, top-level participation is seen as unnecessary, although literature suggests top management support is critical (Jacobs et al., 2011; Thomé et al., 2012a; Pedroso et al., 2016).

We argue that the absence of top management involvement can be seen through the S&OP process in several ways. First, the S&OP meetings lack the decision-making that theory suggests as critical (Grimson and Pyke, 2007; Jacobs et al., 2011). Småros and Falck (2013) argue that "if the S&OP process does not directly result in improved decision making then, to put it bluntly, you're wasting your time" (Småros and Falck, 2013, paragraph 12). This lack of decision-making stresses the importance of increased decision-making in the S&OP process, of which it is very little currently. Another way the absence of top management involvement is seen is that there is little awareness and knowledge of S&OP within the organization (Grimson and Pyke, 2007; Tuomikangas and Kaipia, 2014) and the owner of the S&OP process has limited time allocated to work with process improvement. The interviews clearly stated that there is a desire to develop and improve the S&OP process, but the lack of top management support seems to fail, which does not enable much progress. We still argue that Axis fulfills Stage 3 of the maturity model despite this. However, when considering Stage 4, Axis has not yet reached that maturity level. There is no formal S&OP team, executive participation is lacking, and S&OP is far from being understood throughout the organization.

P8. To enable S&OP process development, the role of the S&OP process owner should be separated from the Material Supply Manager role and instead shift complete focus towards managing and developing the S&OP process.

P9. The S&OP process needs more top management support and participation to increase awareness and decision-making.

P10. Rename the position *Sales & Operations Planner* to *Demand Planner* to avoid confusion concerning the purpose of the position and the S&OP process and create transparency about the S&OP process throughout the organization.

5.5.3 Measurements

Axis is currently between Stage 2 and Stage 3 in the measurements category (Grimson and Pyke, 2007); see Figure 5.18. Performance measurement is widely emphasized as a critical aspect of S&OP in literature (e.g., Bower, 2005; Grimson and Pyke, 2007; Jacobs et al., 2011; Lapide, 2004; Pedroso et al., 2016; Thomé et al., 2012a; Tuomikangas and Kaipia, 2014). Although performance measurements are critical, Axis severely lacks performance measurements in S&OP and in general. Few things are measured, and even fewer generate actions. Despite this fact, Axis does have measurements in place, and thus they fulfill Stage 1, although our interviews indicated that the measurements do not result in any actions. Axis measures how many deliveries are delivered to customers within the promised lead time, i.e., delivery precision, which can be seen as one way to measure how well the Operations organization meets the sales plan.

	Stage 1: No S&OP process	**Stage 2: Reactive**	**Stage 3: Standard**	**Stage 4: Advanced**	**Stage 5: Proactive**
Measurements	• No measurements	• Measure how well operations meets the sales plan	• Stage 2 plus: • Sales measured on forecast accuracy	• Stage 3 plus: • New product introduction • S&OP effectiveness	• Stage 4 plus: • Company profitability

Figure 5.18 S&OP maturity level: Measurements

Since sales plan heavily drive Operations, there is minimal opportunity for any feedback from the supply function. The interviews indicate that no one is held accountable for this performance measurement and that it rarely generates any concrete actions. Either way, we argue Axis fulfills Stage 2. For example, forecast accuracy and forecast bias are measured, but the same theme applies here, the Demand Planning team is not held accountable, and the measurements are not followed up. During the S&OP meetings, there is usually not enough time to review forecast accuracy and forecast bias. There are no performance measures relating to either NPI or S&OP effectiveness either. Consequently, Axis fulfills Stage 3 but does not act upon the metrics collected, leaving them at maturity level 2.5. Axis is not yet near reaching Stage 4 and has plenty of room to improve its performance measurements within the S&OP process and within Operations in general.

P11. To achieve better capacity planning, focus on measuring and acting on forecast accuracy rather than hedging with over-optimistic forecasts.

P12. To increase the S&OP process efficiency and effectiveness, establish specific performance measures inspired by the integrative framework by Hulthén et al. (2016) and allocate time to review performance measures during S&OP meetings.

5.5.4 Information technology

Axis is currently at Stage 2 in the information technology category (Grimson and Pyke, 2007); see Figure 5.19. Kristensen and Jonsson (2018) mention IT integration as a critical component of S&OP design, while information systems and information sharing are commonly mentioned as CSF (Lapide, 2004;

Pedroso et al., 2016; Thomé et al., 2012a). Axis currently has limited IT integration as there are no information systems specifically used to support the S&OP process. Individual people own spreadsheets that are not directly shared, but there are certain amounts of data consolidation, and thus Axis fulfills Stage 1 requirements. Consolidation of data is done manually among various spreadsheets and not shared in real-time. No information is centralized and easily accessible since no software exists to support the S&OP process.

Consequently, Axis fulfills the requirements for Stage 2, but not Stage 3, as IT integration of the S&OP process is lacking. Information systems have no direct impact on firm performance, although appropriate supply chain process integration fully mediates the impact of IT integration on firm performance hence emphasizing information systems as a prerequisite for increased firm performance (Rai et al., 2006). Consequently, Axis has much to benefit from improving the IT integration and investing in information systems, although it is essential to keep in mind that process integration must follow.

	Stage 1: No S&OP process	**Stage 2: Reactive**	**Stage 3: Standard**	**Stage 4: Advanced**	**Stage 5: Proactive**
Information technology	• Individual managers keep own spreadsheets • No consolidation of information	• Many spreadsheets • Some consolidation but done manually	• Centralized information • Revenue or operations planning software	• Batch process • Revenue and operations optimization software – link to ERP but not jointly optimized • S&OP workbench	• Integrated S&OP optimization software • Full interface with ERP, accounting, forecasting • Real-time solver

Figure 5.19 S&OP maturity level: Information technology

P13. Axis needs to improve the IT integration to facilitate a more robust S&OP process integration.

5.5.5 Sales and operations planning plan integration

Axis is currently in-between Stage 2 and Stage 3 in the S&OP plan integration category (Grimson and Pyke, 2007); see Figure 5.20. Formal planning exists, and Operations attempt to meet incoming orders which fulfill the requirements of Stage 1. The sales plan drives the operations, and operations must always align with the demand side; there is little communication and feedback from the supply side, which is not enough to be counted as plan integration. The lack of plan integration highlights a lack of internal integration. There is no joint balance between demand and supply, which is crucial for successful S&OP and a common pitfall (Bower; 2005; Lapide, 2004). The S&OP process is currently very focused on the demand side, and thus supply needs to get more attention to achieve a joint balance. Considering that the S&OP process at Axis is still in its relative infancy, Axis' focus on growth and recent supply disruptions are potentially natural explanations for why the S&OP process is demand-focused. Despite this, there are reasons to increase the attention given to the supply side.

	Stage 1: No S&OP process	**Stage 2: Reactive**	**Stage 3: Standard**	**Stage 4: Advanced**	**Stage 5: Proactive**
S&OP plan integration	• No formal planning • Operations attempts to meet incoming orders	• Sales plan drives operations • Top-down process • Capacity utilization dynamics ignored	• Some plan integration • Sequential process in one direction only • Bottom-up plans – tempered by business goals	• Plans highly integrated • Concurrent and collaborative process • Constraints applied in both directions	• Seamless integration of plans • Process focuses on profit optimization for whole company

Figure 5.20 S&OP maturity level: S&OP plan integration

Forecasting is done in a bottom-up fashion with a planning horizon of 18 months which is at the end of the spectrum suggested by Thomé et al. (2012a), while reviews and potential adjustments are made on an aggregate level which means that forecasting is predominantly done bottom-up. Previously, the planning horizon used to be shorter, and the shift in horizon length is due to increased lead times resulting from global component shortages. This change in planning horizon is in line with Grimson and Pyke (2007), who argue that industries with long lead times and high seasonality typically aim toward longer planning horizons than industries with short lead times and low seasonality. Under normal circumstances, 18 months is likely too long as the planning horizon considering lead times are typically shorter and the short life cycle of Axis products. As the planning horizon was recently changed, it can be characterized as temporary design changes.

Since Axis' business model is heavily driven by innovation and new product introductions, establishing a separate S&OP process to address new product introductions may be viable (Bagni et al., 2022). It would further add another level to the multi-level design proposed by Dittfeld et al. (2020). Capacity at the EMS sites is rarely discussed in the process, which is another example of lacking plan integration. At Stage 4, plans should be highly integrated, the S&OP process collaborative, and constraints should go both ways. Our interviews do not indicate any signs of that, which means that Axis has yet to reach Stage 4 and is somewhere between Stage 2 and Stage 3.

5.5.6 The link between capacity planning and S&OP processes

As part of the responsibilities presented in P4, the capacity planning process owner should also participate actively in the S&OP process as part of the supply review meeting to facilitate a better capacity and S&OP plan integration. Jointly balancing supply and demand is imperative (Bower, 2005; Lapide, 2004). It is essential to discuss material availability in the S&OP forums and the capacity available at the EMS sites to balance supply and demand. Consequently, the capacity planning process owner should present a holistic perspective of available production capacity at the EMS sites at the supply review meetings to allow decisions aligned with the capacity strategy, planning strategy, demand forecasts, and potential risks. Presenting an aggregate perspective is essential, but individual product families and products too if necessary. Grimson and Pyke (2007) propose that implementation of S&OP is conducted in multiple stages, starting with a pilot project which we believe is an excellent strategy to pursue when trying the following proposition:

P14. To facilitate an improved capacity planning process through the existing S&OP process, the capacity planning process owner should participate actively in the S&OP process.

5.6 Proposition summary

The analysis and findings chapter has resulted in the authors submitting 14 propositions to Axis. First, P1 through P4 address the capacity planning process and how it can be improved. Second, P5 through P13 address the S&OP process and deliver propositions that we believe can improve the cross-functional practices within Operations as a whole. Some of the propositions concerning S&OP are relatively minor changes compared to those concerning capacity planning, and thus, a more significant number of S&OP propositions are submitted. Last, P14 provides a link between capacity planning and S&OP processes.

P14 requires support from all other propositions to reach the desired results. Most importantly, there must be assigned a capacity planning process owner (P4), while presentations of plans within the S&OP

process (P5) are critical to facilitate for P4 and P14 fulfilling their potential. Meanwhile, differentiation of the capacity strategy (P3) gathers much input from the capacity planning process owner taking part in the S&OP process (P14). Likewise, the lack of decision-making and top management participation in the S&OP process (P9) is improved through P14, bringing an additional aspect to the S&OP forum. To summarize, P1 through P13 support the realization of P14 and facilitate an improved capacity planning process through S&OP. Inspired by Kembro et al. (2022), we developed Figure 5.21, which gives an overview of the submitted propositions.

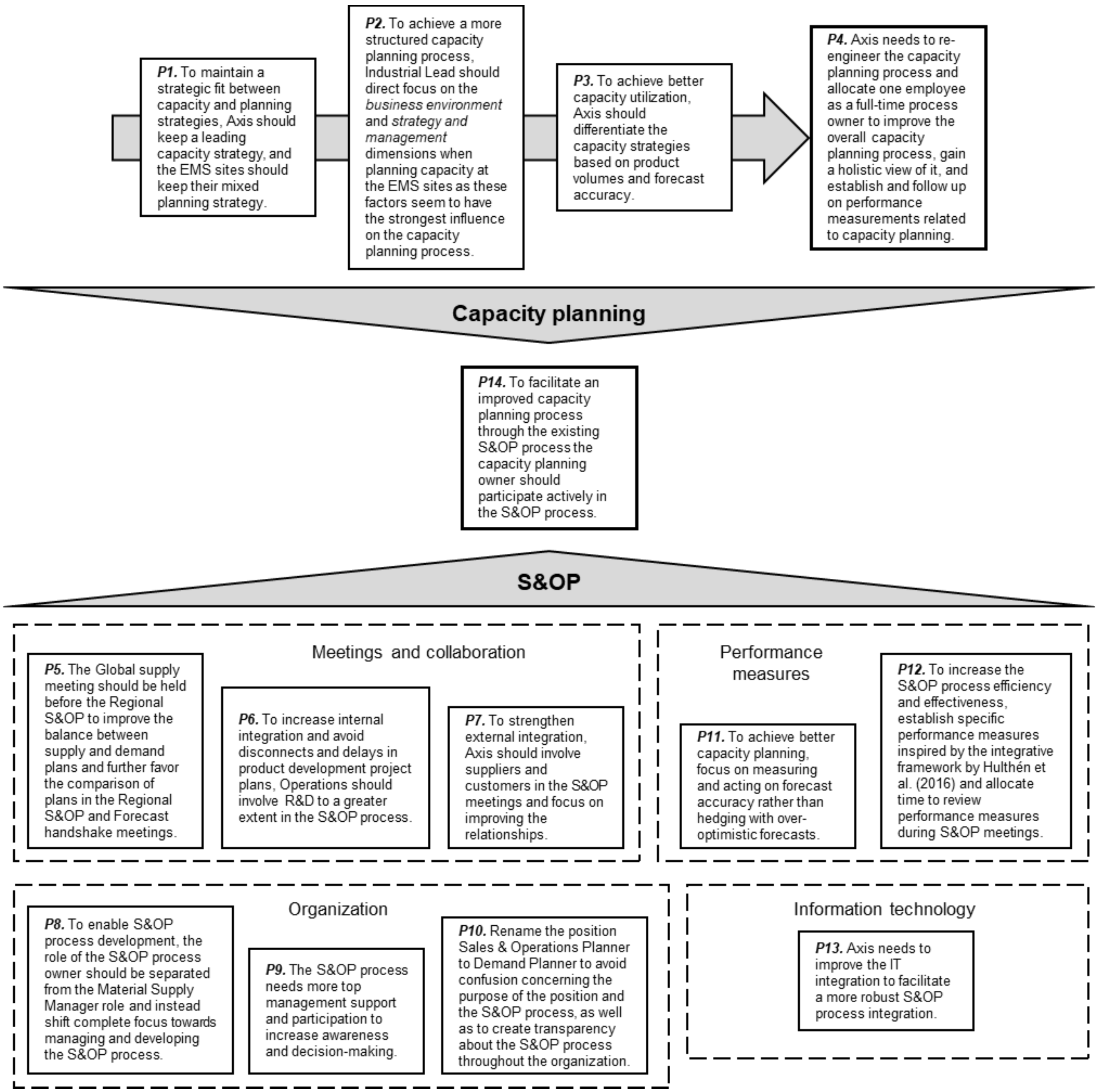

Figure 5.21 Overview of the submitted propositions, inspired by Kembro et al. (2022)

Chapter 6 – Conclusions, limitations, and future research

The conclusions and future research propositions chapter will summarize our findings and analysis of Axis' capacity planning and S&OP processes. First, we will revisit the purpose and answer our research objectives. Second, the implications of this master's thesis from a managerial and theoretical perspective will be discussed. Last, we will spotlight the limitations of this master's thesis and submit a future research agenda.

6.1 Revisiting purpose and research objectives

The purpose of this master's thesis was to improve the process of capacity planning for manufacturing at EMS sites and investigate how S&OP can facilitate these improvements at the case company. We addressed the purpose through three research objectives (RO). First, we identified and mapped the capacity planning and S&OP processes. Second, we evaluated the opportunities to improve the capacity planning and S&OP processes. Last, we made propositions to facilitate the capacity planning process through the S&OP process.

6.1.1 Research objective 1

RO1: Identify and map the processes for capacity planning and S&OP.

We identified and mapped both the capacity planning and S&OP process. Our findings indicate that the capacity planning process at Axis is currently highly arbitrary, and there exists no "real" process. Capacity planning is discussed in the project group responsible for industrializing a new product. It involves mainly five functions: Demand Planning, Material Supply, Product Owner, Project Manager, and Industrial Lead. The Industrial Leads are responsible for the capacity plan and gather input from the project group, especially from demand planning, which is responsible for developing a forecast on which the capacity plan is based. Once forecast and launch strategy is agreed upon, a further 30 % is added to the forecast regardless of product characteristics. This plan serves as the final capacity plan against which the design of manufacturing lines is measured. This capacity plan is then used for the rest of the product's life cycle, making it difficult to change the production plan once it is set. We identified that Axis develops and owns all production equipment at the EMS sites, consisting of both generic and product-specific equipment. The product portfolio consists of a wide range of both high- and low-volume products.

The S&OP process does not follow the generic five-step S&OP process standard in literature but rather a combination of the generic five-step S&OP process and the global S&OP process. Axis' current S&OP process involves six significant steps: data gathering, regional demand planning, global supply planning, regional S&OP, global handshake meeting, and S&OP presentation. The planning horizon used is 18 months which is at the end of the interval suggested by the literature, and forecasting is mostly done bottom-up. One person is acting as the S&OP process owner and is the sole employee that has any S&OP-related responsibilities included in the job description alongside other responsibilities. There is no formal S&OP team, and the S&OP function is part of other positions, mainly the Operations functions, as there is little involvement of other functions. Although forecast accuracy and service level are measured, little to no performance measures associated with the S&OP process and its effectiveness or efficiency were identified. Top management support is limited as our findings present no evidence of top management involvement in the S&OP process.

6.1.2 Research objective 2

RO2: Evaluate opportunities to improve the capacity planning and S&OP processes.

We evaluated opportunities to improve Axis's capacity planning and S&OP processes. First, our findings indicate that the current lead capacity strategy is an excellent strategic fit for Axis. A leading capacity strategy aligns well with Axis' corporate strategy focusing on product availability and growth and Axis' order winners: design, quality, and flexibility. Second, a leading strategy can be differentiated depending on the product characteristics, which differ within Axis' product mix. Some products have more stable demand characteristics than others, indicating a possibility for capacity strategy differentiation. Thus, some products should have more capacity cushion than others. Third, there are no performance measurements associated with the capacity planning process, which is critical according to the literature. Fourth, there is a gap in collaboration with the EMS sites, which is another area of improvement. The main disconnect identified is the different planning strategies as Axis wants to chase demand while EMS sites instead want to pursue level production. Last, we evaluated the factors influencing capacity planning and identified business environment and strategy and management as the dimensions most critical for Axis to address.

Concerning Axis' S&OP process, our findings indicate that it is still in its infancy and thus has room to be improved in several areas. First, Axis needs to increase the flexibility in planning and improve the internal cross-functional collaboration due to the current demand uncertainty. Second, the S&OP process gets too little attention within Axis, which is shown through the lack of top management participation in the process, which the literature highlights as a CSF for S&OP. Third, a symptom of the lacking top management participation is the absence of decision-making within the process. According to the literature, a key advantage of S&OP is its ability to align different functions and enable joint decision-making in the process forums. Fourth, since the decision-making is not a clear outcome of S&OP, there are few incentives to create and present concrete supply and demand plans in the meetings, resulting in the absence of plans. Likewise, it is not easy to make decisions when the groundwork is not in place. Fifth, our findings indicate that the presence and use of performance measurements in the S&OP process can be enhanced. The number of KPIs is limited, but the more significant problem is that those existing does not lead to any actions. Last, the integration of IT systems has room to improve, illustrated by the absence of a specific IT system for S&OP.

6.1.3 Research objective 3

RO3: Propose changes to facilitate the capacity planning process through the S&OP process.

To address RO3, we submitted a list of 14 propositions to Axis that facilitates the capacity planning process through the S&OP process. A table of the submitted propositions can be seen in Figure 5.21. The propositions are specific to the case company, but some takeaways may be applicable in other cases and highlight important aspects. First, this case study highlights the importance of supply chain collaboration in cases when activities are turnkey outsourced. Although execution and coordination responsibilities of the activities lie with a provider, we believe there is still a need to participate in the process to achieve a successful outcome actively. Second, this case study highlights the importance of differentiating product strategies and that there is no "one size fits all" solution. We believe this is especially true in cases where the product portfolio is broad and diverse. Third, this case study highlights the importance of jointly balancing demand and supply and top management involvement to allow decision-making in S&OP, which is stressed by literature. Failure to jointly balance supply and demand and involve top management leads to inefficiencies in the S&OP process. Fourth, this case study highlights the need for performance measures which is another area that is heavily discussed in the literature as critical but underdeveloped in practice.

6.2 Managerial implications

The findings presented in this master's thesis are relevant for managers, and the managerial implications of the thesis are threefold. First, managers can review a synthesis of different factors from the literature that influence the capacity planning process in general and our findings on which generic influencing factors seem to play a part in a high-tech context with outsourced manufacturing. Hopefully, this review can give managers some insights into what factors are required to address when dealing with capacity planning issues both for in-house and outsourced manufacturing contexts.

Second, we explain how S&OP is applied in a high-tech company focused on innovation where manufacturing is outsourced. Different design aspects of S&OP are covered and explained while applying the maturity framework by Grimson and Pyke (2007), which managers can use to benchmark their own S&OP process against the case company's S&OP process.

Third, we provide propositions of how S&OP can facilitate an improved capacity planning process, hopefully inspiring managers to consider using S&OP to coordinate strategic capacity planning decisions in manufacturing. Further, we also show an application of the framework by Olhager et al. (2001), which we hope can inspire managers to review their capacity strategies and planning strategies to improve further and achieve a better strategic fit.

6.3 Theoretical contributions

The findings presented in this master's thesis are relevant for researchers, and the theoretical contributions of this master's thesis are threefold. First, we provided an example of aspects to consider when addressing capacity planning in outsourced manufacturing. Previous research by Wu et al. (2005) and Martinez-Costa et al. (2014) emphasizes the lack of research for capacity planning in a high-tech context. Most research has focused on mathematical models to address strategic capacity planning rather than qualitative frameworks. We provided a foundation for developing approaches of a qualitative nature to address capacity planning in manufacturing that researchers may further develop and generalize. Further, we have yet to find any research addressing strategic capacity planning in outsourced manufacturing, and thus, our findings should be of interest to researchers.

Second, much of the S&OP literature emphasizes the need to adapt the S&OP design (Kristensen and Jonsson, 2018; Goh and Eldridge, 2019; Dittfeld et al., 2020), but despite this, most academic research does not address this (Thomé et al., 2012a; Kristensen and Jonsson, 2018). We highlighted design aspects and provided insights on how the case company's S&OP design is affected by the contextual factors suggested by Kristensen and Jonsson (2018), which should be of interest to researchers.

Third, we provided a proposal linking the capacity planning process to the S&OP process. There is little research conducted within this area besides Olhager et al. (2001), and we showed how to apply their research and framework in the case company's context. Although the framework is developed with in-house manufacturing in mind, we believe it may be used in an outsourced manufacturing context to provide insights on how to structure the collaboration with supply chain partners and guide future research.

6.4 Limitations and future research

As with all research, our master's thesis has some limitations. First, the external validity, i.e., the generalizability of the research, is limited, which always is the case with single-case studies (Eisenhardt and Graebner, 2007; Voss et al., 2002; Yin, 2018) and qualitative research in general (Denscombe, 2010). However, this master's thesis aims not to generalize findings but rather to showcase the application of S&OP to improve the capacity planning process for the chosen case company. Since we present the case context, it allows for certain generalizability to similar contexts. However, we would like to be transparent and request caution when generalizing to similar contexts as the results may not be similar. Second, the internal validity is limited since it is difficult to achieve for case study research in general and single-case studies (Yin, 2018). There are limited causal relationships established, which are difficult to prove; thus, we strived to be as specific and transparent as possible to explain the logic we used to arrive at our conclusions (Ketokivi and Choi, 2014). Third, the lack of quantitative data has limited us from verifying the experienced issue or quantifying its size. This lack of quantitative data has also had implications for our propositions. Qualitative data only allowed us to pinpoint issues but provided a limited basis to make many propositions concrete enough to be as valuable as possible. Fourth, the scope of our study was, in hindsight, potentially a bit too broad, and we believe further delimitations in terms of focusing on, e.g., a specific product category would allow us to deliver more in-depth propositions. Fifth, our initial hypothesis that S&OP would facilitate an improved capacity planning process was limited by the lack of research addressing capacity planning and S&OP for outsourced manufacturing and especially how to combine the different concepts. This lack of literature made it challenging to make in-depth propositions based on literature. Instead, it left us to explore, leading us to our future research agenda.

To validate, challenge, and further develop the knowledge of capacity planning processes both on its own and in combination with S&OP, we suggest a research agenda for this critical area. First, we identified limited research on capacity planning, considering the perspective of outsourced manufacturing. Since electronics is a large business and many original equipment manufacturers use outsourcing, there is a need to research this area. We propose a multiple-case study benchmarking different original equipment manufacturers' capacity planning processes to understand better how contextual factors influence the process and identify best practices. Such a multiple-case study would ideally include both qualitative and quantitative data to capture the contextual factors and quantify the potential cost savings more efficient capacity planning processes can achieve. Second, we identified limited research addressing the link between capacity planning and S&OP since Olhager et al. (2001) published their article more than 20 years ago. Consequently, we propose future research exploring this link both in general and when companies outsource manufacturing. Third, S&OP literature generally only considers manufacturing that is still in-house, and to our knowledge, there is no research on how to design S&OP processes when manufacturing is outsourced. Due to the increasing popularity of outsourcing, this is an exciting research area for future research. We hope this master's thesis can inspire further research and exploration of both capacity planning and S&OP processes.

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Appendix

Appendix A – Interview guide S&OP

General

What is your role with Axis? Please describe.

- How long have you had this role?
- How long have you been at Axis?

Are you familiar with the concept of S&OP?

S&OP organization

What is your role in the S&OP process?

How would you describe the current S&OP process?

- Which functions are involved?
- Which steps are conducted?
- What activities are coordinated? E.g., NPI, demand/supply planning, etc.
- What are the key drivers/goals for S&OP?
- How do you think the S&OP process is performing related to the goals?

How is S&OP generally perceived within the company? What is your perception?

Demand planning

Who is involved in forecasting and how?

What tools are used to generate the forecast?

Are the forecasts unconstrained?

What factors are considered in the forecasts?

How are customers involved in the process?

How long is the planning horizon?

On what level are the forecasts generated? I.e., aggregated, SKU, etc.

Supply planning

How do you define supply in the context of S&OP?

Who is involved and most importantly how?

How are suppliers and/or EMS sites involved?

What are the inputs to the supply planning? Any inputs from demand planning?

How are the demand and supply plans linked and integrated?

EMS/IL

How is capacity planning captured in the S&OP process?

How are you working to align incentives with the EMS sites?

Are you using a single S&OP process for all EMS sites and business units?

Meetings and collaboration

What kind of meetings do you have related to balancing supply and demand?

Who is participating in the meetings?

- Number of participants
- Full time/part-time
- Functions?
- Top management?
- Customers?
- Suppliers?
- EMS sites?

How are the meetings structured?

- Structure
- Level of formality
- Discussion topics

How often do you have meetings and of what character?

- Regularly scheduled?
- Event-driven meetings?

Measurements

How are performance measurements used to evaluate S&OP effectiveness?

- Financial?
- Operational?
- Process?
- New product introduction?

How is the S&OP process evaluated and improved?

In your opinion are there things you think should be measured that are not?

Information technology

What tools do you use? Spreadsheets and/or other software?

Is data consolidated? If so, how and by whom?

Are the tools used for S&OP connected to the ERP system?

How are you working with scenario planning?

How are you working with data-driven supply chain management in the S&OP process?

- E.g., big data analytics, machine learning, and AI?

How are you leveraging external data as inputs to the S&OP process? E.g., VMI, CPFR, PoS, etc.

- Is there real-time access to external data?
- Who has access to this data?

Appendix B – Interview guide industrialization

General

What is your role with Axis? Describe.

- How long have you had this role?
- How long have you been at Axis?

Axis' supply chain

Can you describe the fundamentals of Axis' supply chain setup?

What is the supply chain strategy?

- Responsive/efficient?
- CODP?

Industrialization

Can you describe the current industrialization process at Axis?

- Explain the main steps?
- Who is involved?
- How are they involved?
- Project duration?

How are meetings conducted?

- Regularly scheduled?
- Event-driven?
- Structure?
- Participants?
- Functions?

How are supply and demand planning involved in the process?

- What sort of information is shared?

What tools are you using?

- Spreadsheets?
- Other software?
- Scenario planning?

From your perspective, what works well and not?

- Potential for improvement?

How do you account for potential risks and disruptions?

What sort of measurements are you using to evaluate the industrialization process?

- How are you evaluating performance?

- How do you act upon it?

Are you familiar with the concept of S&OP?

Appendix C – Observation schedule

Observation schedule			
Date: Meeting: Format: Duration:			
Category	Characteristics	Answer	Notes
Forecast	• Is the forecast discussed unbiased? • What level is discussed (aggregate/product family/SKU)? • How long is the planning horizon?		
Participants	• Who leads the meeting? • Top management participation? • What functions are represented? • Suppliers and customers?		
Performance measures	• Are PMs discussed? • What PMs are used?		
Context	• Is everybody there who is supposed to be there? • How is the atmosphere? • Are all participants engaged? • PowerPoint? • Are decisions summarized before the end of the meeting? • Do participants express opinions?		
General	• How much data is shown/discussed? • Is supplier/customer data incorporated? • Go around the table and bring up potential risks? • Is capacity planning mentioned? • Prepared agenda? • Agenda sent out on time?		