Study of the Impact of Digitalization on Sales and Operations Planning and Its Influence on Supply Chain Performance.

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Abstract

This research examines the impact of digitalization on Sales and Operations Planning (S&OP) and its broader influence on supply chain performance. By adopting digital technologies, companies can streamline decision-making processes, reduce manual efforts, and enhance operational efficiency. The study aims to address the insufficient understanding of how the integration of digital technologies into S&OP practices affects key performance indicators (KPIs) and the overall dynamics of the supply chain. The research methodology involves an extensive literature review and interviews with companies, providing both theoretical and practical insights.

The study makes notable contributions to improving organizational efficiency, filling academic gaps, and exploring the role of digitalization in promoting sustainability in supply chain practices. This research provides valuable insights into the practical implications of digitalization in business, fostering critical analytical and research skills for future roles in industries undergoing digital transformation. Overall, the research aims to guide companies in navigating the digital landscape to improve their performance in the supply chain and adapt to the ever-evolving business environment.

Key words

Supply chain performance; digitalization; critical success factors; KPI; Sales and Operations Planning; S&OP

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List of Abbreviations

AC - Alternating current

AI - Artificial Intelligence

ANN - Artificial Neural Network

AR - Augmented Reality

BI - Business Intelligence

BOM - Bill-of-material

CEO - Chief executive officer

DC - Direct current

DOT - Delivery on time

DOT - Supplier delivery on time

DSL - Delivery service levels

ERP - Enterprise resource planner

GPS - Global positioning systems

HR - Human resources

HVDC - High Voltage Direct Current

IDS - Inventory days of supply

IoT - Internet of Things

KPIs - Key performance indicators

ML - Machine Learning

MPS - Master production schedule

MRP - Manufacturing resources planning

MRP - Material requirement planning

NASA - National Aeronautics and Space Administration

NC - Numerically controlled (machines)

NPI - New Product Introduction

R&D - Research and development

RCCP - Rough Cut Capacity Analysis

RFID - Radio Frequency identification

ROC - Return on capital

S&OP - Sales and Operational Planning

SC - Supply Chain

SCD - Supply chain digitalization

SCI - Supply chain Integration

SCM - Supply Chain Management

SCP - Supply Chain Performance

SCR - Supply Chain Resilience

VR - Virtual Reality

WIP - Work-in-process

1 Introduction

In this initial chapter of the thesis, the background and the problem that serves as the focal point of the study are presented. The purpose of the thesis is also outlined, along with the questions it aims to address and its inherent limitations. Towards the end of the chapter, a concise summary is provided outlining how the thesis is organized.

1.1 Background

The Impact of Digitalization on Sales and Operations Planning and Its Influence on Supply Chain Performance is a pivotal research topic for companies across industries. By embracing digitalization, businesses can streamline decision- making processes, reducing manual efforts, and enhancing overall operational efficiency. Real time visibility into supply chain activities enables companies to swiftly respond to changes in demand or supply, a crucial factor for maintaining competitiveness in dynamic markets. Data-driven decision-making, facilitated by analytics, not only improves the quality of strategic planning but also contributes to continuous operational improvement within the supply chain. (Özceylan el al. 2022).

Furthermore, enhanced supply chain performance achieved through digitalization directly influences customer satisfaction. Timely and accurate deliveries, optimized inventory, and responsive customer service contribute to positive customer experiences. Beyond immediate benefits, the implementation of digitalized sales and operations planning provides a competitive advantage by enabling faster responses to market changes and optimizing supply chains for improved overall performance. The commitment to innovation and future readiness ensures that companies can adapt seamlessly to emerging trends, technologies, and market demands, positioning themselves for long-term success in a rapidly evolving business landscape. (Hallikas et al 2021).

1.2 Problem Formulation

The increasing prevalence of digitalization in business operations presents both opportunities and challenges for companies aiming to optimize their supply chain performance. While digital technologies offer the potential to streamline sales and operations planning (S&OP) processes, there exists a critical need to understand the specific mechanisms through which digitalization influences supply chain dynamics. The problem area lies in the insufficient understanding of how the effective integration of digital technologies into S&OP practices impacts key performance indicators and overall supply chain performance.

This research aims to address this gap by investigating the role of digitalization in addressing challenges, leveraging opportunities, and influencing the sustainability and effectiveness of sales and operations planning within diverse industry contexts.

The goal is to provide valuable insights that will guide companies in navigating the digital landscape to enhance their supply chain performance.

This problem formulation outlines the core issue – the need to understand the impact of digitalization on S&OP and subsequent effects on supply chain performance. It sets the stage for a comprehensive investigation into the role of digital technologies, addressing challenges, and identifying opportunities in the context of sales and operations planning.

When we look at digitized Sales and Operations Planning (S&OP), we see some significant challenges, especially when it comes to expediting orders. Rushing orders often means using faster transportation methods, which can lead to higher gas emissions. This not only harms the environment but also clashes with our sustainability goals. Additionally, this rush puts a strain on our workers, who may have to endure longer hours to meet these urgent deadlines, affecting their health and job satisfaction. On the financial side, the costs of speeding up orders can take a big bite out of our profits due to higher transportation expenses and overtime pay.(Azevedo et al .2021).

These issues show the tricky balance we need to maintain between being efficient and staying true to the three pillars of sustainability: environmental care, social responsibility, and economic viability. To tackle these problems, we need to make the most of the advanced technologies available in digitized S&OP. By enhancing our planning and forecasting with better data accuracy, quicker decision-making, and improved collaboration, we can reduce the need to expedite orders. This way, we can foster a more sustainable and balanced approach to our supply chain operations, supporting both our business goals and our commitment to sustainability.(et al Jonsson .2021)

1.3 Purpose

The purpose of this research is to investigate the specific ways in which digitalization in sales and operations planning influences key performance indicators and shapes overall supply chain performance.

1.4 Research questions

This thesis aims to address the following posed questions:

RQ1: What are the enablers of successful digitalization of sales and operations planning?

RQ1 seeks to identify and understand the key elements or factors that play a significant role in ensuring the effective implementation of digitalization in the context of sales and operations planning. It aims to explore the enablers that contribute to a successful digital transformation in this specific area.

RQ2: How does the role of digitalization in enhancing sales and operations planning practices impact overall supply chain performance?

On the other hand, RQ2 delves into the impact of digitalization on sales and operations planning practices and its broader consequences on the overall performance of the supply chain. This question aims to uncover the specific ways in which incorporating digital

technologies influences and enhances the efficiency and effectiveness of the broader supply chain processes.

1.5 Organization of the thesis

The thesis is organised following the structure seen in the following Table 1, where each chapter is briefly described.

Table 1. Organization of the thesis.

Introduction	It provides an introduction and presents the background and problem that is the subject of the thesis. Describes the purpose of the thesis and its limitations.
Methodology	It describes the research approach followed in the thesis and presents the different research strategies, methodologies, and data collection methods.
Theoretical framework	Describes the relevant concepts and their relations.
Conceptual framework	Illustrates the expected relationship between the relevant concepts. It works as a boundary for the data collection and maps out how the authors projected the reviewed literature on the studied companies
Cases studies	Researcher collects data through semi structured interviews
Comparison of cases studies and Literature review	The gained data are compared with themes generated from literature
Conclusions	Research questions are answered, and further work is recommended.

1.6 Limitations

There are different limitations of this research. Firstly, time represents a significant constraint as the project is subject to deadlines that must be met. Additionally, one of our major limitations is the number of companies we can interview, as we have approached companies with whom we have contacts who have agreed to participate in the interviews, as it is difficult for companies to accept these types of interviews where they describe how they work. Furthermore, the information these companies can share may be limited due to confidentiality concerns or the lack of availability of certain data.

Another challenge lies in the dynamic nature of digitization, which is a relatively new and constantly evolving field. The scarcity of updated literature on digitization can also be a

limitation, as some articles may quickly become obsolete or new research and discoveries may emerge, making it difficult to keep up with the state of the art in the field. Additionally, relating it to such a specific field as Sales and Operational Planning has been difficult to find in the literature, as most articles and studies are more general and focus more broadly on the supply chain.

2 Methodology

This chapter describes the research approach followed in the thesis. It presents the different research strategies, methodologies, and data collection methods.

2.1 Literature review

The literature review is the first part of the work. It will involve an in-depth examination of scholarly works, academic journals, and industry publications to establish a conceptual framework. This framework aims to comprehend the variables and their interactions related to the phenomenon under investigation. Specifically, the review will focus on exploring the roles and effects of digitalization in Sales and Operations Planning (S&OP) and its impact on supply chain performance.

The literature review represents a crucial phase in the research process, providing support for all subsequent stages. The articles and books examined in this master's thesis have been sourced through various online research article platforms, including Google Scholar, ResearchGate, Web of Science, PoliBuscador (the search engine provided by the Polytechnic University of Valencia) and literature utilized in prior courses during the master's program. The search strategy employed to identify these articles involved using the following keywords, showed in Table 2, categorizing them into different groups.: "digitalization", "sales and operational planning," "S&OP," and "supply chain performance".

Table 2. Search term sample for literature review.

Category	Kew word
Sales and operational planning	Sales and operational planning S&OP
Digitalization	Digitization Digitalization Digital Transformation Industry 4.0 Digital enablers Supply chain digitalization Supply chain Integration Supply Chain Management Supply Chain Performance Key Performance Indicators for Supply Chain

Supply Chain	Supply chain digitalization Supply chain Integration Supply Chain Management Supply Chain Performance Key Performance Indicators for Supply Chain
Methodologies and Approaches	Multiple case study Validity Reliability
Sales and Operation planning	S&OP, Supply Planning , demand planning , Aggregate planning , Supply chain planning scheme

The literature is leveraged in multifaceted ways throughout the thesis, serving as a foundational resource for the development of themes and the establishment of a theoretical framework. Additionally, it plays a crucial role in preparing interview questions. Furthermore, the literature functions as a knowledge-enhancing tool, enriching understanding of the subjects under investigation.

2.2 Multiple case of study

Multiple case study is the second part of the work, it complements and validates the literature findings but also represents the practical part of the study. Multiple case studies were conducted through semi structured interviews (as research instruments) with managers who are working with S&OP and supply chain digitization in general. In the following lines the authors define the case studies, highlight their significance, and argue its suitability as a research method for this study.

A case study involves examining the history of a past or present phenomenon by drawing insights from various tracks of evidence. The approach to exploring the phenomenon is influenced by the nature of the phenomenon under investigation. Various data sources, such as direct observations, systematic interviews, and public and private records analysis, can be employed for investigation (Leonard, 1990). This method significantly impacts research by enabling the study of the phenomenon in its natural environment, facilitating the development of relevant theories through practical observation.

The case study approach is adaptable to different types of research, ranging from exploration to validation and improvement of existing approaches, thereby fostering new ideas and verifying pre-existing theories (Voss et al., 2002). This methodology proves itself valuable in exploratory research by addressing essential questions about the phenomenon (why, what, and how), including its nature and complexity, especially when variables are unknown, and there is limited understanding of the phenomenon (Leonard, 1990; Voss et al., 2002).

While Fisher (2007) in his 2x2 interaction with the world matrix, claims that case study is a descriptive and less structured research method as seen in Figure 1

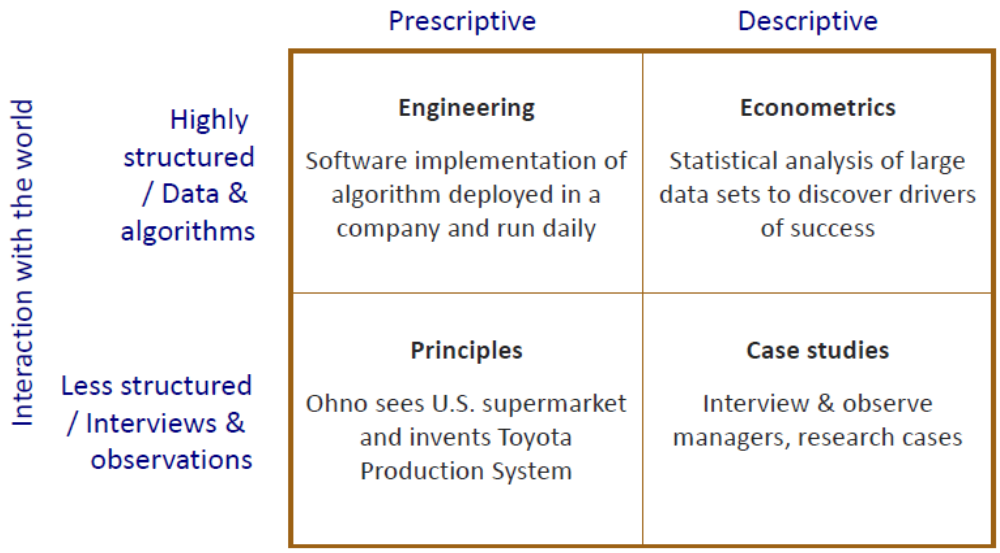

Figure 1. Interaction with the world (Fisher 2007).

According to Voss et al. (2002), case study research can be carried out for different purposes, as described in Table 3.

Table 3. Purposes of Case Research Methodologies (Source: Voss et al. (2002)).

Purpose	Research Question	Research Structure
Exploration Uncover areas for research and theory development	• Is there something interesting enough to justify research?	• In-depth case studies • Unfocused longitudinal field study
Theory Building Identify key variables, linkages between them and why these relationships exist	• What are the key variables? • What are the patterns? • Why should these relationships exist?	• Few focused case studies • In-depth field studies • Multi-site case studies • Best-in-class case studies
Theory Testing Test the theories developed and predict future outcomes	• Are the theories able to survive the test of empirical data?	• Experiment • Multiple case studies • Large-scale samples
Theory refinement To better structure the theories considering the observed results	• How generalisable is the theory? • Where does the theory apply?	• Experiment • Case studies • Large-scale samples

Still, according to Voss et al. (2002), there are five steps in the case study research process:

2.2.1 Research Framework and Questions

A conceptual framework, whether presented graphically or narratively, describes visually or through text the elements to be studied and the possible relationships between them. Research questions originate directly from the conceptual framework or are derived from it. It is advisable always to approach an organisation with a clearly defined objective.

2.2.2 Choosing Cases

Cases are chosen with the intention of being exemplary rather than representative and following specific criteria, including high levels of experience or extreme situations. The polar types deliberately seek to disconfirm patterns between case studies, also considering high and low performance.

The choice of the number and type of cases, whether single or multiple, retrospective or longitudinal, is an integral part of the selection process and depends on the necessity, available time, or the phenomenon under examination.

In this thesis, two companies, Hitachi Energy and Alfa Laval, will be studied. They have been selected for the study because they are both large companies but differ significantly from each other. Hitachi Energy is a project-based company, scaling up its business by using digitalization to expand its operations. Alfa Laval, on the other hand, is a product-based company with a large supply chain, due to its many companies around the world, and also implements digitalization within its operations.

2.2.3 Research Instrument and Protocol

This step is related to developing the instruments and protocols necessary for data collection. It includes determining the type of data to be collected, the methods of data collection (interviews, observations, documents), and the procedures for ensuring consistency and reliability in data gathering. The research instrument and protocol help maintain a structured and systematic approach.

2.2.4 Data gathering

It involves the actual collection of data from the chosen cases. Researchers implement the research instrument and protocol to gather information through methods like interviews, observations, or document analysis. The goal is to obtain comprehensive and relevant data to address the research questions and provide a holistic understanding of the cases.

The data for this thesis will be collected through semi-structured interviews conducted by the authors, with the presence of the supervisor from LTH. The interviews were conducted online on May 3, 2024, with Hitachi, lasting 30 minutes, and on May 15, 2024, with Alfa Laval, lasting 1 hour. No interview was recorded due to the confidentiality of the information and the interviewees' request, although recording them provides a more accurate account of any interview than taking notes. However, in this study, to ensure no key information is missed, one of the authors conducts the interviews while the other

writes down the responses. This reduces the likelihood of missing any important information.

According to Saunders, Thornhill, and Lewis (2007), an interview is a purposeful discussion between two or more people to help gather valid and reliable data relevant to your research question(s) and objectives.

Interviews can be differentiated according to the level of structure and standardization adopted. Semi-structured interviews may be used to understand the relationships between variables. In semi-structured interviews, a list of themes and open questions is prepared in advance. However, additional questions may be required to explore the research question and objectives, given the nature of events within particular organizations (Saunders, Thornhill, and Lewis 2007). This type of interview has been selected to create some standardization in the questions and allow for comparisons between the interviewed companies, while also providing the interviewees with the freedom to comment on and explain their individual situations thanks to the use of open questions.

The use of open questions will allow participants to define and describe a situation or event. An open question is designed to encourage the interviewee to provide an extensive and developmental answer and may be used to reveal attitudes or obtain facts. It encourages the interviewee to reply as they wish. (Saunders, Thornhill and Lewis 2007)

The questions used in the interviews are provided in Appendix A. Interview questions, at the end of the document.

2.2.5 Analysis

Analyzing the data collected to derive meaningful insights and draw conclusions that might be helpful for the scientific or business community. This often involves organizing, categorizing, and interpreting the data to identify patterns, themes, or trends. The analysis phase aims to address the research questions, uncover relationships between variables, and generate findings that contribute to the overall objectives of the study.

2.3 Validity and reliability

In qualitative research as this thesis, as answers to research questions are explored through multiple methods and procedures which are both flexible and evolving, to ensure standardization of research tools as well as the processes becomes difficult. Data collection can have an effect on the quality of the conclusions taken when carrying out this thesis, therefore, this is something that is important to look into (Kumar, 2011). According to Saunders, Thornhill and Lewis, 2007 the aim of research credibility is to reduce the possibility of getting the research questions wrong. Reducing the possibility of getting the answer wrong means that attention has to be paid to two particular emphases on research design: reliability and validity.

Validity pertains to whether the conclusions accurately reflect what they claim to represent. It involves determining whether the observed relationship between variables truly implies causation. (Saunders, Thornhill, & Lewis, 2007)

Saunders, Thornhill, and Lewis (2007) also discuss the concept of Generalisability, also referred to as external validity. A concern in research design is the extent to which research results can be generalized, meaning whether findings may apply equally to other research settings, such as other organizations. This may be a particular concern when conducting case study research in one organization or a small number of organizations, as in this case. Therefore, as this thesis only gathers data from two companies, the results cannot be generalized. However, attempts have been made using different types of companies and comparing them with the literature review to try to generalize the conclusions further.

Reliability refers to the extent to which your data collection techniques or analysis procedures will yield consistent findings. It can be defined as the ability to allow for your analysis and data collection to be repeatable; in case someone follows the same steps, the results should be consistent (Saunders, Thornhill, & Lewis, 2007)

Saunders, Thornhill and Lewis (2007) state that there are four four threats to reliability in research, these are subject or participant error, subject or participant bias, observer error and observer bias.

The first of these is subject or participant error. This threat arises because the consistency in the results may be influenced by the timing of data collection.

Similarly, there may be subject or participant bias when, for example, interviewees may have been saying what they thought their bosses wanted them to say, rather than expressing their true thoughts due to fear of potential consequences.

One way to alleviate these issues would be to ensure confidentiality and exercise extra scrutiny when analyzing the data and selecting participants in a neutral time.

Observer error, characterized by variations in questioning techniques during interviews, can introduce inconsistencies in participant responses. For example, in studies involving multiple interviewers, each may employ their unique approach, potentially influencing how participants respond. These can be attempted to reduce by adding structure to the interviews. Conversely, observer bias arises from subjective interpretations of participant responses by interviewers, leading to skewed conclusions, especially when divergent interpretations occur among

In this master's thesis, the supervisor from the LTH has been present during the interviews and has reviewed all thesis contents to minimize potential errors and biases. Additionally, there will be two seminars where students will provide opposition, further reviewing the thesis. Finally, both authors will review the gathered data together and individually, aiming to reduce the risk of biases.

3 Theoretical framework

In this part, we explain the important ideas we found in our research and how they're connected. We looked into three main topics: Sales and Operations Planning (S&OP), Digitalization, and Supply Chain Performance, as shown in Figure 2. Each of these themes is described in detail below and subsequently, all their relationships will be described.

Figure 2. Themes relationship.

3.1 Sales and operations planning

The following section describes sales and operations planning (S&OP). It starts by defining S&OP then its significance and role in linking strategic and operational planning in SCM. Finally, the process of S&OP will be described.

3.1.1 Overview of S&OP

Handfield (2019) argues that the practice of creating tactical plans by linking marketing and supply chain management strategies for both new and existing items is known as sales and operations planning (aggregate planning). The procedure combines all of the company's plans including product development, manufacturing, sourcing, sales, marketing, and finance into a single, cohesive set. Management reviews it once a month, looking at the whole (product family) picture.

Sales and operations planning is a set of business practices that maintain the balance between supply and demand. It involves – in one hand- Supply planning which includes enterprise resource planner (ERP), Material requirement planning (MRP), Master production schedule (MPS), Rough Cut Capacity Analysis (RCCP) and shop floor planning. On the other hand, we have the demand planning which includes forecasting and inputs from the sales team. Both supply and demand planning are then grouped into bigger planning that is called Executive S&OP. Executive S&OP is the stage of S&OP where the balancing takes place! (IOMA, 2005, 2004b; Wing and Perry, 2001; Sheldon, 2006)

Wallace (2004) believes that executive S&OP is a process that helps many organizations improve many of their supply chain performance indicators including better customer service, stable production rates, enhanced supplier collaboration, shorter lead times, real management involvement and good harmony between manufacturing, sales and finance people. S&OP helps companies achieve balance, as illustrated in Figure 3, between supply and demand and maintain this balance not only on aggregated volume level but also on detailed mix level.

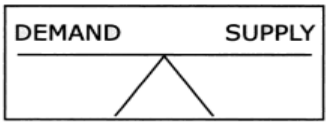

Figure 3. Balancing supply and demand. (Wallace, 2004).

Demand is defined as what the external customer wants while supply is all about the internal company resources allocated toward that demand. (Grimson and Pyke, 2007).

3.1.2 Why is S&OP important?

Bower (2006) believes balancing supply and demand is important for business continuity. If the demand is largely higher than the supply, Customer service becomes poor and backorder cost and penalties comes on, Operation costs including emergency shipping, unplanned overtime and Sudden procurement goes up. Even the Quality is affected as the company might compromise its high standards, dealings with short time contractors also affects the quality and purchasing from emergency suppliers might not give high quality.

When The supply is extremely higher than demand the inventory holding cost increases this affects the cash-to-cash cycle and ultimately the cash flow. Higher production than needed causes sudden production shutdown which causes layoff and loss of skilled workers beside having lower efficiency rates. Profits margins will also be lower than planning due to emergency discounts and promotions to get rid of the accumulated stocks.

3.1.3 S&OP Position in Supply Chain planning scheme

There are three levels of supply chain planning: Strategic, tactical and operational level. The figure below shows different levels of planning along with the carried out activities and planning horizon. The planning horizon considered, the extent of planning intricacy needed, and the managerial leeway to alter capacity are the distinguishing characteristics between the three planning levels, As depicted in Figure 4. (Bozarth and Handfield, 2019 p 321)

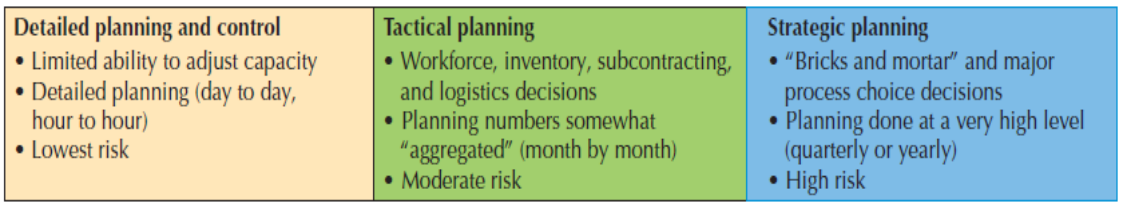

Figure 4. Different planning levels.

Figure 5 illustrates the framework of the resource planning process. The dotted horizontal line signifies that Strategic Planning and Business Planning are not directly embedded within the resource planning process but serve as significant inputs into it. Sales & Operations Planning plays a crucial role in connecting Strategic and Business Plans with the Master Scheduling function. The Master Schedule, in turn, acts as the foundation for customer order commitments and influences all subsequent schedules for plant operations. (Sheldon, 2006).

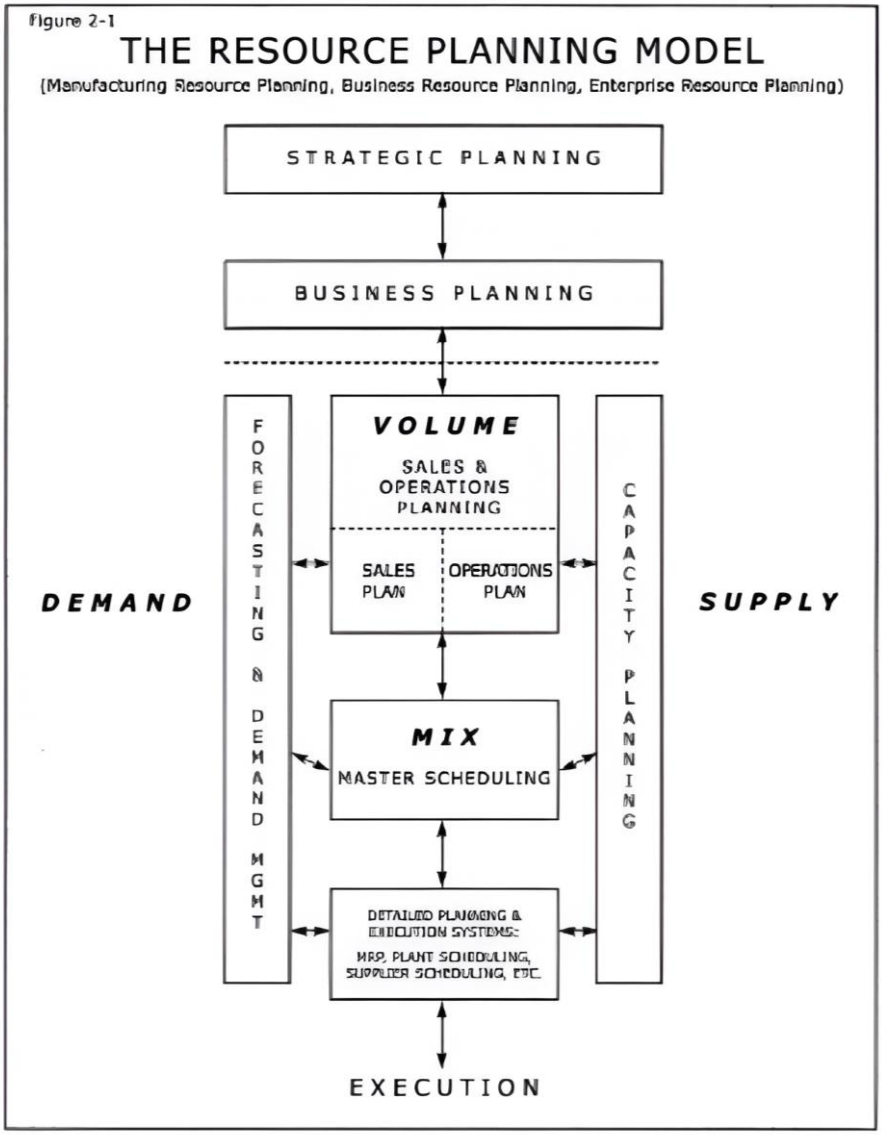

Figure 5. How S&OP fits in Resource planning model (Wallace, 2004).

S&OP comes under tactical planning, and it helps organizations strengthen their tactical planning in many ways. First of all, Sales and Operations Planning (S&OP) outlines how the organization will utilize its tactical capacity resources to fulfil anticipated customer demand. These resources encompass workforce size, inventory levels, shift schedules, and subcontractor availability. Secondly, S&OP achieves a harmonious equilibrium among the diverse requirements and limitations of supply chain collaborators. It not only considers customer demand but also the capabilities of suppliers, production facilities, and logistics service providers involved in delivering the product or service.

Consequently, the plan is not only workable but also harmonizes costs, delivery schedules, quality standards, and adaptability.

Thirdly S&OP acts as a unifying mechanism for the various stakeholders in the supply chain. By the end of the S&OP process, there should be a mutual understanding of the responsibilities of each involved party—be it marketing, operations, finance, key suppliers, or logistics providers—to execute the plan effectively. Effective S&OP clarifies the actions each party should take, fostering alignment and enabling detailed decision-making with confidence in consistency across partners.

Last but not least, S&OP translates the business's strategies into comprehensible terms for all stakeholders. While finance professionals may focus on cash flows and profitability metrics, marketing managers concentrate on sales targets and market segments, and operations and supply chain managers prioritize activities related to specific products or services. S&OP intentionally presents the resulting plans in a format accessible to all parties, facilitating integration into their detailed planning processes. (Hahn et al., 2000; Rooney and Bangert, 2001; Grimson and Pyke, 2007;)

S&OP helps organizations moving from Figure 6 to Figure 7.

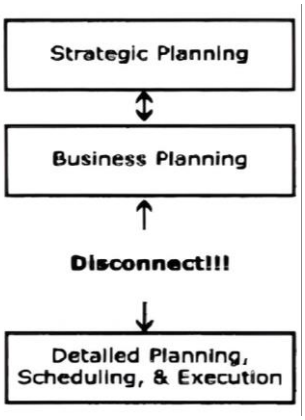

Figure 6. How Business planning levels are disconnected without S&OP (Wallace, 2004).

Figure 7. How S&OP connect Business planning levels (Wallace, 2004).

Top Management involvement in S&OP process is important for two main reasons. Firstly, Top management holds responsibility for the Business Plan, as it impacts financial outcomes and represents stakeholders. Failure to align the Business Plan with Sales & Operations Planning (S&OP) leads to discrepancies between expected financial results and operational plans. Best performance involves using a single set of internal metrics.

Secondly, Active participation by business leaders in S&OP emphasizes its importance in integrating planning and balancing demand. Without top management's leadership, S&OP participation may decline, leading to process erosion or simplification into a shortage-focused meeting. (Wallace, 2004)

3.1.4 The S&OP process

S&OP typically follows a five-step process (Grimson and Pyke, 2007; Wallace, 2004; Kruse, 2004; Lapide, 2002). First, Initially, sales team members convene in either formal or informal preliminary sessions to construct an unrestrained baseline demand prediction, which focuses not on the company's production capacity but on potential customer sales.

This forecast is modified based on expected reactions to marketing strategies like advertising, trade shows, and promotions. Additionally, it encompasses details regarding the introduction of new products and the phasing out of existing ones. The outcome is a consensus-driven, unrestricted demand forecast.

An essential aspect of the forecasting process involves determining the planning horizon. Typically, planning horizons span from 6 months to over 3 years, with the most prevalent range falling between 6 to 18 months. However, the specific horizon varies depending on factors such as industry type, product seasonality, and the timing of Sales and Operations Planning (S&OP). Industries characterized by lengthy production lead times or significant seasonality, such as apparel, pharmaceuticals, and automotive products, tend to favor longer planning horizons. Conversely, shorter horizons are more common in industries with brief lead times and minimal seasonality, such as commodity items. In order to allow the company to fit a full marketing cycle, the horizon for seasonal products, such winter apparel, is typically 12 months when the plan is prepared in December, but 18 months if it is created in July. The organization develops its annual S&OP plans in tandem with the budgeting process for the fiscal year. Some revise their plans and forecasts during their formal S&OP meetings and employ a rolling horizon.

Pre-meetings with the operations team are the second phase. The operations team gets data on inventory strategy (build-up or draw-down), supply chain capacity, and internal capacity while the sales team creates its projections. A time-phased image of future plans and requirements can be created in this process by utilizing modules of manufacturing resources planning (MRP). The operations team then, although while the meeting is still in the pre-meeting stage, uses the consensus demand projection to develop an initial supply plan, also known as a rough-cut capacity plan, that is intended to satisfy the anticipated needs.

Third, in order to create the final operating plan for the upcoming term, the S&OP team convenes formally. The participants and the frequency of the meetings are important factors for these sessions. Before discussing the last two steps in the procedure, we offer our opinions on each of these choices. Representatives from sales and marketing (demand management, forecasting, etc.), operations (buying, inventory management, supply chain operations, master production scheduling, etc.), and finance should be on the cross-functional S&OP team. An S&OP champion significantly increases the efficacy of S&OP. Senior executives should ideally be present at the formal meetings where they evaluate and approve the work from the functional pre-meetings and give the S&OP team

permission to carry out planned decisions. Companies differ in the frequency of their meetings.

The fourth step is Distributing and putting the strategy into action. The operations and sales teams are the main beneficiaries; yet, in nearly every instance that we have seen, the operations team is responsible for achieving the necessary production targets, and the sales team is infrequently called upon to modify sales strategies. When we present our framework, we will go into more detail about this.

The fifth and final stage executives meeting involves assessing the outcomes and efficacy of the Sales and Operations Planning (S&OP) process. Measurement plays a crucial role in both implementation and ongoing enhancement. Literature suggests that the selected metrics should be tailored to fit the specific industry, operational processes, and product lines. Commonly utilized metrics in operations encompass factors such as line fill, inventory levels, obsolete inventory, frequency of expediting, stockouts, variance from standard cost, quality standards, and capacity utilization. In scenarios where new product introduction holds significance, metrics may include development expenses, time taken to enter the market, ramp-up duration, and the number of successful introductions. Sales team metrics could encompass aspects like top-line sales growth, market share, forecast accuracy, and variance from the baseline forecast.

In the following Figure 8, the 5 steps of the S&OP process are shown

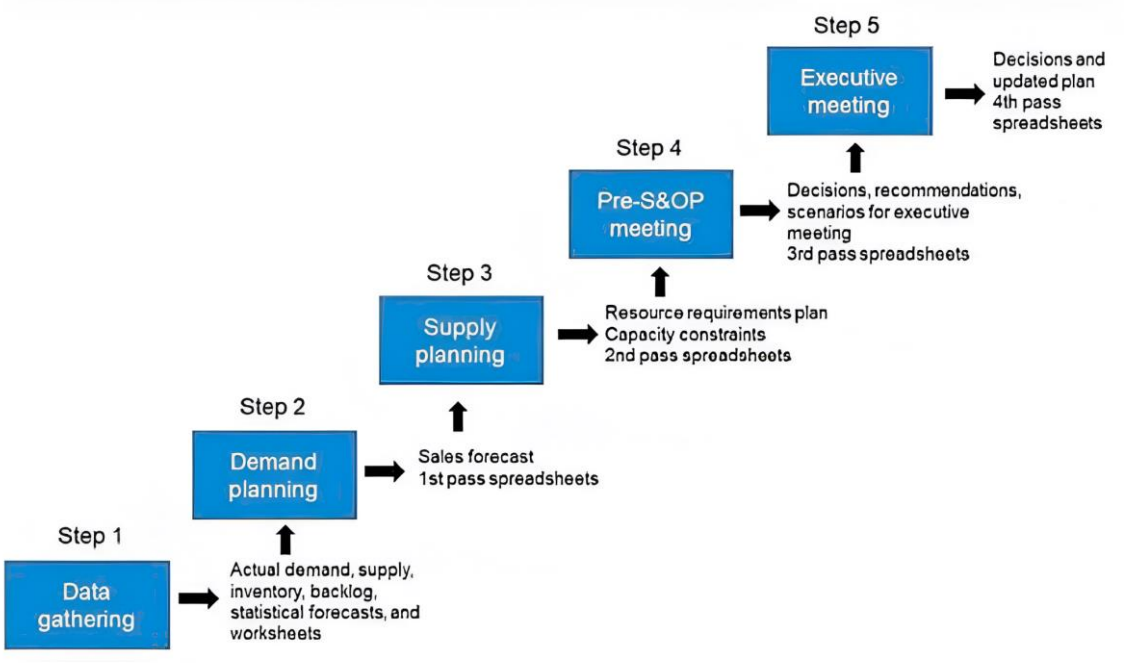

Figure 8. The five steps of S&OP (Grimson and Pyke, 2007)

These five steps capture the common S&OP process, although it is evident from the stages of S&OP maturity in our framework that company experience varies widely. (Grimson and Pyke, 2007)

Finance primarily focuses on business metrics such as market share, sales revenue, stock price, and return on invested capital. These metrics are essential for evaluating the financial health, performance, and value creation of a business from an investor's perspective. (Sheldon, 2006). The authors failed to obtain Measures for S&OP effectiveness.

3.1.5 The S&OP Integration Framework

Grimson & Pyke (2007) created an S&OP integration framework that uses a one-to-five ranking across five dimensions to position companies according to their S&OP maturity level. The five dimensions evaluated are: Meetings and Collaboration, which assesses the effectiveness of the human component in S&OP; Organization, which focuses on the corporate S&OP structure; Measurements, which apply to both company performance and the effectiveness of the S&OP process; Information Technology, which focuses on an information process rather than a business process; and S&OP Plan Integration, which measures how effectively a company builds its sales and operations plans and how well these plans interface. This integration is the ultimate goal of the meetings, measurements, organizational changes, and information technology.

In the following Figure 9, the Grimson & Pyke Matrix can be observed, displaying the characteristics of each dimension at different stages. The ranking starts with a company that has no S&OP practices whatsoever and is thus classified as Stage 1. The top rating, Stage 5, is designated as proactive, considered the ultimate level that a company can achieve in the foreseeable future. This figure can be seen in detail in Appendix B. Grimson and Pyke matrix.

	Stage 1 No S&OP Processes	Stage 2 Reactive	Stage 3 Standard	Stage 4 Advanced	Stage 5 Proactive
Meetings & 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 • Suppliers & 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: Product Manager, Supply Chain Manager	• Formal S&OP team • Executive participation	• Throughout the organization, S&OP is understood as a tool for optimizing company profit.
Measurements	• No measurements	• Measure how well Operations meets the sales plan	• Stage 2 plus: • Sales measured on forecast accuracy	• Stage3 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 & 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 & collaborative process • Constraints applied in both directions	• Seamless integration of plans • Process focuses on profit optimization for whole company

Figure 9. S&OP integration framework (Grimson & Pyke, 2007).

3.2 Digitalization

Digital disruption is a transformative force that changes how people live, socialize and work. Digitalization of products and services is a fast moving, global megatrend that fundamentally changes existing value chains. In response, companies in almost all industries have conducted several initiatives to explore new digital technologies and exploit their benefits. (Tagscherer & Carbon, 2023)

Digitalization can be defined as the use of digital technologies to change a business model and provide new revenue and value-producing opportunities. It represents the process of transitioning toward a digital business (Gartner, n.d.).

Digitalization emerges as a predominant trend, changing both society and business with significant research and practitioners' focus. Despite the current attention on digitalization, related terms are often used interchangeably without commonly accepted definitions. (Tagscherer & Carbon, 2023)

3.2.1 Fundamental concepts

Although, as mentioned earlier, terms related to digitalization are often used interchangeably, to better understand the concept, it is necessary to comprehend the differences between these three fundamental concepts: digitization, digitalization, and digital transformation, and their relationships.

Unfortunately, it is worth mentioning that most languages, like German, Spanish, and Japanese, do not differentiate between digitization and digitalization, even though the digitization and digitalization activities have little in common. The only commonality between the two terms (besides the similarity in notation) is that digitalization requires digitization. (Tagscherer & Carbon, 2023)

3.2.1.1 Digitization:

The term digitization can be defined as converting analog information into digital data. Digitized information can be transferred quickly, cheaply, and accurately. Digitization does not change value-creation activities. This technological shift enabled the creation of digital technologies such as the Internet of Things (IoT), cloud services and mobile applications, artificial intelligence, big data, analytics, social media, and embedded devices. All these means have the potential to change industries and societies fundamentally. (Tagscherer & Carbon, 2023)

Digitization serves as the foundation for the third industrial revolution (Industry 3.0). (Vrana & Singh, 2021)

3.2.1.2 Digitalization:

Digitalization utilizes digitized information to streamline specific operations while digitization focuses just on the conversion from analog to digital, so digitization forms the basis for digitalization, which is more centered on creating value-added applications for convenience, marking the transition from Industry 3.0 to 4.0. (Vrana & Singh, 2021)

Digitalization describes the transformation of existing processes, business models, and revenue streams driven by the integration of digital technologies. Digitalization efforts are often implemented within projects and transform specific business operations. The application of digital technologies can occur in different areas of the company, facilitating the enhancement of customer experiences, the streamlining of operational processes, and the transformation of entire business models. (Tagscherer & Carbon, 2023)

3.2.1.3 Digital Transformation:

Digital transformation takes the idea of digitalization to a completely new level. It extends beyond individual companies or systems, fostering collaboration and connectivity agnosticism. This evolution opens doors to new business models and enables ecosystem growth. Unlike digitization and digitalization, which can be confined to products from a single company, digital transformation involves the seamless integration of diverse digital solutions. It transcends borders between companies and systems, allowing the combination of various solutions for enhanced value, leveraging the universality of digital content and context. (Vrana & Singh, 2021)

Digital transformation has implications for the overall business strategy, organizational structure, and company culture. Besides integrating digital technologies, digital transformation results in organizational and social changes within companies. (Tagscherer & Carbon, 2023)

This unification of things improves processes and functionality, opening possibilities that may not have been conceived before. Digital transformation is the key to harnessing the full potential of the fourth industrial revolution. (Vrana & Singh, 2021)

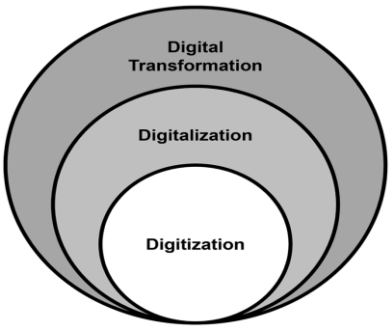

Figure 10. Digitization, Digitalization and Digital Transformation (Tagscherer & Carbon, 2023).

These three concepts can be visually represented, as shown in Figure 10. Therefore, it is deduced that digitization and digital technologies serve as core elements. The technical process of encoding analog information into a digital format enables further digitalization activities, although it does not alter the essence of value creation itself. With the change in business processes, products, or business models based on digital technologies, businesses move to the stage of digitalization. Through the implementation of digitalization efforts, specific facets of a company can be enhanced, contributing additional value to its operations. In contrast to digitalization, digital transformation is perceived as not confined to a particular area. It encompasses the continued efforts to change the organization's strategy, culture, and mindset. Digital transformation can be described as the continuous process of expanding the scope of digitalization. (Tagscherer & Carbon, 2023)

3.2.2 Types of digitalization

Digitalization can be categorised into internal and external approaches, each offering diverse advantages in value creation for businesses. On one hand, internal digitalization involves the use of digital technologies to transform internal operations, innovate manufacturing processes, and enhance internal value chains. On the other hand, external digitalization focuses on reshaping the external dimension, including customer value propositions and the development of new products and services. (Tagscherer & Carbon, 2023)

The identification of whether an activity is directly associated with customer contact serves to distinguish between the internal and external dimensions of a company's digitalization activities. For example, products or services and their development have a direct association with customers, marking them as externally focused. On the other hand, internal activities like manufacturing, supply chain management, or the establishment of the IT backbone are indirectly linked to the customer, thereby being classified as internally focused. Digital business strategy is additionally linked to internal digitalization activities. Due to the origin of the manufacturing process, Industry 4.0 is perceived as internally oriented. (Tagscherer & Carbon, 2023)

Internal digitalization aims at reducing costs and enhancing the efficiency of internal operational processes. It includes the implementation of digital information and communication technology solutions, such as technologies like video conferencing and digital training for internal processes. (Salamah et al., 2024; Zhao et al., 2023). The focus of internal digitalization lies in optimizing business processes that constitute companies' operations and supply chains. The increased connectivity and real-time data analysis capabilities are anticipated to lead to reduced setup requirements, processing times, and errors, ultimately resulting in heightened productivity. (Tagscherer & Carbon, 2023)

However, external digitalization emphasizes leveraging digital technology to enhance interactions with stakeholders. Not only that external digitalization can reduce inter-company communication costs, facilitate partnerships with suppliers, and other partners, but it can also accurately anticipate customer needs, thereby fostering increased customer loyalty. (Salamah et al., 2024; Zhao et al., 2023) Moreover, from an external perspective, "servitization" gained importance for manufacturing companies within a scientific and practical context. Servitization can be seen as the process of increasing value through service and transforming a company offering product centered to product-service systems the manufacturing process. (Tagscherer & Carbon, 2023)

Overall, these approaches contribute to overall efficiency and effectiveness in both internal operational processes and external interactions with stakeholders and customers. (Salamah et al., 2024). However, digitalization and digital innovation cannot be directly associated with one perspective alone. Due to the broader nature and potential application within a company's internal or external dimension, digital innovation and digitalization projects can be in the company's internal or external perspective, depending on the context of its application. Digital transformation is seen as an overarching concept that influences both internal and external dimensions. (Tagscherer & Carbon, 2023).

3.2.3 Industry 4.0

Industry 4.0 can be defined as the "development of production and value creation systems by linking the real and the digital world" (Bigliardi et al., 2022). This marks the advent of the fourth Industrial Revolution, propelling the establishment of a more interconnected ecosystem within various functional areas of a firm. (Seyedghorban et al., 2019)

Industry 4.0 is a term derived from the German word Industrie 4.0 which originated in 2011 at the Hannover trade fair. It was a German government high-tech strategy to promote digitalisation/computerisation of manufacturing and increase automation compared to the third industrial revolution. (Jagtap et al., 2021)

To understand the significance of digitization, it is crucial to examine the historical evolution of the industry, as these changes over time have paved the way for the emergence and adoption of digitization. The evolution of industries has been a continuous transformation, marked by distinct revolutions that have redefined the production, distribution, and consumption of goods and services. The First Industrial Revolution (Industry 1.0) began with the shift from manual to machinery production with the discovery of steam engines. Industry 2.0 recognized the importance of mass production, driving automation and introducing electric and combustion engines (Ezzat, Kassem, & Abd Elkader, 2019). Industry 3.0 started with the manufacturing of the first industrial robot and the introduction of numerically controlled (NC) machines, marking the implementation of partial automation within the context of industry and production (Ezzat, Kassem, & Abd Elkader, 2019), (Jagtap et al., 2021).

Industry 4.0 is the revolution of digitization, positioning itself as a strategic technological direction that integrates various technologies to enhance the efficiency and effectiveness of the supply chain. It shifts the focus of organizations toward the value chain, maximizing the value delivered to consumers and customers by improving competitiveness (Ezzat, Kassem, & Abd Elkader, 2019). In Figure 11, the distinctive characteristics of each era are highlighted.

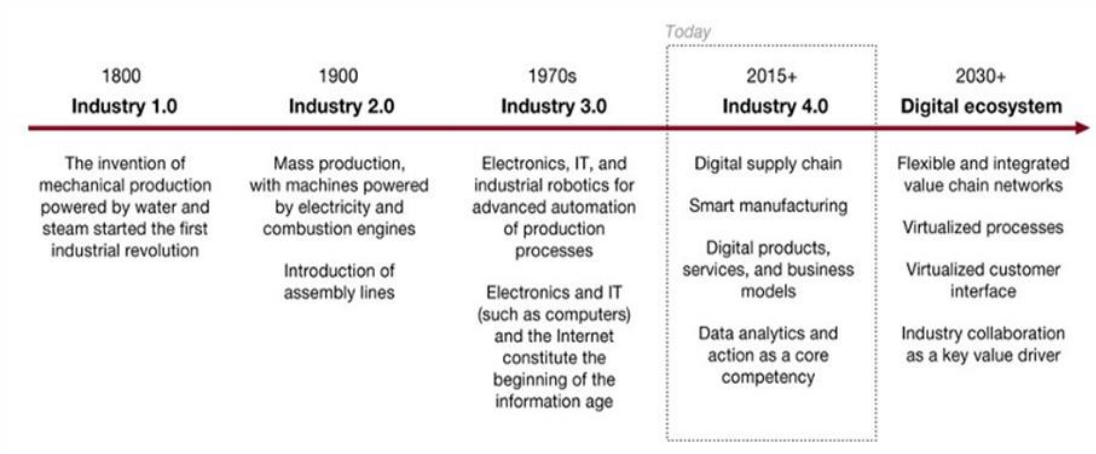

Figure 11. Characteristics of Different Industrial Eras.

Industry 4.0 is transforming the way in which companies achieve, improve, and distribute their products. Manufacturers are incorporating new technologies into their manufacturing facilities and processes. Organizations are required to embrace this

impending change in their operations, as well as in the larger supply, due to the shifting business trends in network chains. Industry 4.0 seeks to deliver real-time information on production, machines, and component flow by combining smart manufacturing, smart goods, and the IoT. These data are combined to help managers to make decisions, track performance, and track materials in real time. (Chauhan et al., 2022)

Using these technologies, companies within the supply chain can experience a digital transformation, resulting in improved performance and the capacity to maintain or increase competitiveness. The integration of the digital technologies is a pivotal aspect of the digitalization process in the supply chain. (Bigliardi et al., 2022)

The following Figure 12 illustrates enabling technologies that have already shown an impact in the various study areas for digitalization and sustainability.

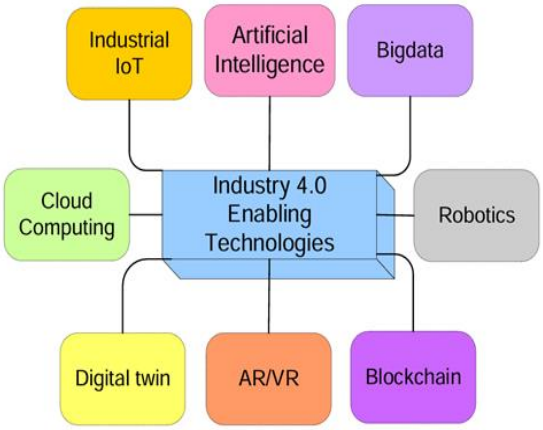

Figure 12. Industry 4.0 Enabling Technologies (Chauhan et al., 2022).

In other literature, one may encounter technologies similar to those mentioned, with variations in names or additional components. For example, in Bigliardi et al. (2022), these technologies are mentioned: Internet of Things (IoT), Advanced analytics (involving techniques like Artificial Intelligence (AI) or Machine Learning (ML)), Augmented Reality (AR), Virtual Reality (VR), Blockchain, robots, 3D printing, and drones are discussed. Similarly, Jagtap et al. (2021) outlines nine pillars, including Robotics and automation, Big data, Simulation (encompassing digital twin), System integration, Internet of Things, Cybersecurity, the Cloud, 3D printing, and Augmented Reality.

Therefore, the most significant technologies commonly found in most of the reviewed literature, which are more relevant for the study of this thesis, will be described. Posteriorly, these technologies will be linked to Sales and Operational Planning (S&OP) as the enablers of successful digitalization.

3.2.3.1. Internet of things (IoT)

Internet of Things (IoT) is a network of physical objects (things) which are embedded with sensors and actuators, as well as software that allows the exchange of information with other devices over the Internet. In short, IoT includes everything connected over the Internet, but IoT is being used to define things that communicate with each other. (Jagtap et al., 2021)

IoT interact within a company and between the company and its supply chain enabling agility, visibility, tracking, and information sharing to facilitate timely planning, control and coordination of the supply chain processes. (Bigliardi et al., 2022)

It is a commonly utilized and readily accessible tool for a variety of Supply chain management (SCM) tasks, such as creating real-time quality/maintenance data, inventory tracking, information sharing, joint ordering, quality supervision, quality-controlled logistics, enabling enhanced reverse logistics, collecting product data while in use, and providing visibility on parts and raw materials to increase operational efficiencies and revenue opportunities. (Chauhan et al., 2022)

IoT can be used by various stakeholders. This makes information available in real-time to all the stakeholders connected to the SC. The integration of radiofrequency identification (RFID) tags, sensors, barcodes, and communication protocols enables them to obtain real-time data. IoT assists with real-time tracking and tracing with the assistance of global positioning systems (GPS) and other identification technologies. Recently, there has been rapid progress in wireless communication technologies and sensors, which enable the adoption of IoT-based systems to monitor items from any remote location through internet connectivity. (Chauhan et al., 2022)

3.2.3.2. Artificial intelligence (AI)

AI is defined as the ability of machines to communicate and take on behaviours peculiar to humans; as a result, this technology is particularly suited to solving problems that require a high degree of accuracy and speed. Most of the artificial intelligence techniques are applied in the field of manufacturing. The most widely used technique is Artificial Neural Network (ANN) which belongs to the machine learning field. Artificial Neural Network (ANN) allows identifying patterns from a huge amount of data. It is mainly used in demand forecasting, pricing, supplier selection and consumption forecasting. (Bigliardi et al., 2022)

AI in industrial applications can be categorised as descriptive, predictive, or prescriptive. Descriptive AI mines the data generated by sensor-enabled operations to uncover new relationships leading to improvements in process design and control. Predictions and prescriptions may be generated by AI if cause-and-effect relationships are at least partially understood. An example of predictive AI is condition-based maintenance which depends on accurate estimates of future failure times. Prescriptive AI generates recommendations for operational actions. (Jagtap et al., 2021)

3.2.3.3. Blockchain

A Large amount of data is being generated by sensors used within the supply chain. These data can be readily available in real time but need to be accessed in a secure environment. This may be achieved using Blockchain. Blockchain is resistant to any alteration of its data and therefore is being aggressively pursued by industries. In short, it is a distributed and secure ledger which can be retrieved and written from any approved location and its data is stored on a peer-to-peer network rather than in a central location. (Jagtap et al., 2021)

Blockchain often refers to a completely distributed system of cryptography for recording and storing a linear event log of networked actor interactions that is consistent and immutable. It has the potential to significantly increase security, efficiency, accountability, and trust, as well as reduce costs. Additionally, blockchain is thought to be able to solve SCM traceability problems and aid in fostering more intimate and reliable relationships. (Chauhan et al., 2022)

3.2.3.4. Digital twin

One of the most common definitions, provided by NASA, states that a Digital Twin is an integrated multi-physics, multi-scale, probabilistic simulation of a product or system that uses the best available physical models, sensor updates, etc., to mirror the life of its corresponding twin. Additionally, a Digital Twin involves the automatic exchange of information between the virtual model and the physical model, with the virtual world constantly updated with real-time information from the physical world. The virtual model, if authorized, can make decisions that are directly implemented in the physical world. (Sandén, Emma, & Falk, 2021)

Moreover, a digital twin, as described, is an almost perfect replica of a process or product with clearly defined parameters and variables. It functions as a cyber-physical device, creating a high-definition visual representation of a physical object through the use of multiple IoT sensors. Machine learning algorithms are then employed to analyze the vast amounts of data collected by the digital twin, aiding in organizational and strategic decision-making. Digital twin serves as a pivotal tool within Industry 4.0, elevating the technical maturity level of organizational structures by facilitating digitalization, integration, and automation in both production and supply chain networks (Chauhan et al., 2022).

3.2.3.5. Big Data Analytics

Big data is a popular enterprise system or platform that appears to provide additional functions for gathering, storing, and analyzing massive amounts of generated data from various sources to achieve value addition. (Chauhan et al., 2022).

The term big data analytics can be defined as the use of advanced analytics approaches, like predictive and statistical analysis, data mining, etc. on a large number of datasets draw valuable insights and useful information by uncovering hidden patterns and correlations to achieve higher operational efficiency, better forecast customers' demand and explore new opportunities. (Agrawal & Narain, 2021)

3.2.4 Challenges & Barriers

Most companies are currently not yet fully prepared to confront the challenges brought about by digital transformation. These challenges include fast-paced innovation, restructuring of business processes, or organizational structures, which must be tackled when digital technology is introduced to organizations and their employees. The introduction of digital technology creates a need for swift adaptation to the fast-paced changes, which often lead to high levels of uncertainty within the organizational

environment. Effective leadership is essential to capitalize on digital opportunities within this dynamic business landscape and to navigate these challenges successfully. (Tagscherer & Carbon, 2023)

Integration of technology poses a significant obstacle for Industry 4.0, particularly concerning data security. Enterprises face challenges in safeguarding their data and information amidst the adoption of technologies such as the Internet of Things, which increases susceptibility to industrial espionage and unauthorized access. Furthermore, human resource management presents another hurdle, as staff members require adequate training to operate effectively within this transformed environment. In supply chain management, data integration and privacy management emerge as the most critical obstacles to overcome. (Mohamed, Sallam, & Mohamed, 2023)

3.3 Supply chain performance

Beamon (1999) believes that Supply chain performance can be defined as the efficient and effective measure of assessing a company's performance in the areas of planning, sourcing, producing, delivering, and returning. Measuring performance helps determine if a company is meeting their expectations and customer needs. An analysis of a company's supply chain assists in the identification of areas needing improvement to avoid production disruptions and possible added expenses. The goal of an efficient supply chain is to minimize inventory levels, increase profits, and share them with other supply chain involved companies. This is also accomplished by being more competitive in the industry in terms of product quality and delivery. Cochrane (2005) stated that measuring supply chain performance presents a tricky situation due to plentiful interrelated variables. Often, the cause-and-effect link in supply chain management is so complex that it is difficult to pinpoint an action to a reaction. Therefore, every action must be measured against every possible reaction to determine the consequences. This is typical in the example where a company decides to increase their production of a product with the assumption it will result in increased sales. The excess product is now an inventory level that must be stored and can restrict the company in terms of product development. Therefore, the company did not achieve its desired result and was not efficient in the production phase.

3.3.1 Definition of Supply Chain Performance

Neely (2005) provided a framework for performance measurement in manufacturing that can be adapted to supply chain performance. This framework measures the performance inputs and resources of the manufacturing system, the efficiency of the processes and actual operations, the quality of the product or service, and the value to the customer. Value to the customer is especially important as it links to the postmodern theory of the customer being the most important part of the supply chain. It identifies different customer behaviors and segments and aims to understand customer requirements and value so that these can be transformed into more specific measures. Supply chain performance refers to the measurement and evaluation of the effectiveness and efficiency of a supply chain system (Baba et al., 2019). It encompasses the overall performance of all the activities, processes, and entities involved in the flow of goods, services, and information from raw material suppliers to the end customers.

The performance of a supply chain is the efficiency of that supply chain in providing products to the consumers. It is widely accepted that supply chain performance can be defined as the supply chain's success in meeting customer and corporate expectations (Lambert, 2005). Supply chain performance does not just concern a single measure but is based upon an evaluation of many desired goals of the supply chain. These goals can be categorized into qualitative and quantitative. Qualitative measures refer to the actual operations that are used in the supply chain, such as new product development or supplier selection. Quantitative measures are usually performance measures, such as lead time and filling rate (Neely, 2005).

3.3.2 Importance of Supply Chain Performance

It implies that what you cannot measure, you cannot manage. And what you cannot manage, you cannot improve. Though intuitively appealing, the adage raises a more basic question. Why would one want to manage or improve something? The answer, of course, is that the desired target of management or improvement is an entity that provides value. If we consider various business organizations as entities structured to deliver value to their various stakeholders in exchange for inputs. For private and public companies, the objective of value delivery implies improvement in their financial performance and their ability to satisfy the needs of customers and investors. "High performance" is a phrase often used to describe entities that do an above-average job in delivering value. At this point, it is worth noting that supply chains, in their various configurations, are the engine that drives value delivery. (Mofokeng and Chinomona, 2019)

Beamon (1999) argues that a supply chain's performance is vital to an organization's success. A high performing supply chain can yield a number of benefits. These may include improved efficiency, greater customer satisfaction, improved quality, and higher sales and profits. The importance of supply chain's performance can be best described by the statement "to measure is to manage," an adage that can be traced to the early 20th century. It has gained wide acceptance in the business community in recent years and is now a fundamental principle of modern management.

3.3.3 Key Performance Indicators for Supply Chain

Key Performance Indicators are essential metrics used to evaluate the performance of a supply chain. These indicators help in measuring various aspects of supply chain operations, including cost, quality, delivery, and responsiveness (Porter, 1985), (Fawcett et al., 2008), (Zelbst et al 2009) as following :

Cost KPIs: These metrics assess the overall cost efficiency of the supply chain, including factors such as transportation costs, inventory holding costs, and procurement costs.

Quality KPIs: Quality indicators focus on the quality of products and services throughout the supply chain, including supplier quality, production quality, and customer satisfaction.

Delivery KPIs: These indicators measure the timeliness and reliability of product delivery, including on-time delivery rates, lead times, and order fulfillment accuracy.

Responsiveness KPIs: Responsiveness metrics evaluate the agility and flexibility of the supply chain in responding to changes in demand, market trends, and disruptions.

Inventory Management KPIs: These metrics assess the efficiency of inventory management, including inventory turnover, stock out rates, and carrying costs.

Overall, the selection of KPIs should align with the strategic objectives of the supply chain and provide a comprehensive view of its performance. A balanced set of KPIs enables supply chain managers to identify areas for improvement and make informed decisions to enhance overall supply chain performance.

3.4 S&OP and digitalization

Digitalization and Sales & Operational Planning (S&OP) are closely related and mutually beneficial. According to Gomes & Ferreira (2023), S&OP in Industry 4.0 can be enhanced by integrating technologies such as artificial intelligence, big data analysis, and the Internet of Things (IoT), which enable more precise and agile decision-making. Furthermore, the integration and benefits of S&OP allow companies to fully leverage Industry 4.0 advancements like automation, data analytics, and connectivity, enhancing the entire supply chain from demand forecasting to final product delivery. This comprehensive integration maximizes the advantages of Industry 4.0, ensuring improved efficiency and performance across all supply chain activities.

Digital S&OP provides real-time analytical capabilities to help identify issues in all stages of the sales and operations planning process, thereby helping stakeholders to focus on the most pressing issues.(Kandemir, Özceylan, & Tanyaş, 2022).Therefore, the use of Information Technology tools in S&OP is usually seen as a prerequisite for an effective and mature S&OP(Ohlson, Riveiro, & Backstrand, 2022)

3.4.1 Enablers of successful digitalization of S&OP

The screened literature has not set distinct enablers excessively for digitalization of sales and operations planning. However, several authors have addressed the enablers for the digitalization of the supply chain. As mentioned above S&OP is a crucial element but also core of the supply chain.

Zekhnini et al. (2020) and Ghadge et al. (2020), argue that enablers of digitization in the supply chain could be defined as supply chain digitalization facilitators. Several technologies that play the role of facilitators were defined, including: additive manufacturing (3D printing), advanced robotics, digital twins ,big data analytics,(internet of things) IoT, AI, cloud computing, social media, block chain, (augmented reality)AR ,wearable electronics and drones. The most relevant of these technologies have been described in the previous sections.

These technological tools help transform the traditional supply chain process into data driven, customer oriented and smart processes from the digital supply chain (Agrawal & Narain, 2018).

For these technological enablers listed above to do their work, there other enablers related to process, people, information access, communication and top management involvement need to be considered (Thun et al 2022).

The different technologies described above are listed below with the applications they may have in the field of S&OP.

3.4.1.1. IoT

Agrawal & Narain (2021) enumerate the following applications of IoT related to Sales and Operational Planning (S&OP):

- **Monitoring and controlling systems**: IoT devices that collect data on machine performance and system efficiency help managers and automated controllers maintain real-time insights. This is crucial for operational planning as it ensures that production systems are functioning optimally and can meet demand forecasts.
- **Information sharing and collaboration**: Enhanced information sharing and collaboration between people and things, as well as among things themselves, improves situational awareness. This reduces information delays, which is vital for aligning supply chain operations with sales forecasts and ensuring that production plans are based on the most current data.
- **Data generation for analytics**: The tremendous amount of data generated by IoT devices can be fed into analytics and intelligence tools to make informed decisions. For S&OP, this data helps identify market trends and changes in customer preferences, leading to more accurate demand forecasting and better alignment of supply and production plans.
- **Locating goods in a warehouse**: IoT devices that help locate goods in a large warehouse improve inventory management. This is directly related to operational planning, as knowing the precise location and status of inventory allows for more efficient order fulfillment and inventory control, ensuring that stock levels meet sales demands.
- **Tracking the location of goods**: IoT devices that track the location of goods in transit provide real-time data on the movement of raw materials and finished products. This information is critical for both sales planning and operational planning, as it allows for accurate tracking of supply chain logistics, ensuring timely delivery of products to meet customer demand.

  IoT applications in S&OP enhance the ability to monitor and control systems, improve information sharing, generate valuable data for decision-making, and manage inventory and logistics effectively.

3.4.1.2. AI

Agrawal & Narain (2021) describe the applications of AI analytics, among which the following are the most related to Sales and Operational Planning (S&OP):

- **Analyzing supply and demand patterns** : AI and machine learning tools that analyze data from logistics and supply chain operations help identify patterns in supply and demand, including seasonal and temporary variations. This comprehensive analysis eliminates human error, making supply chain planning and procurement processes more accurate and efficient.
- **Supplier relationship management**: AI converts passive data from supplier relationship management into actionable information. This includes data on supplier effectiveness, audits, credit scores, and delivery performance, aiding in making informed decisions about supplier selection and management.
- **Managing unstructured data**: AI's data cleansing capabilities help maintain and update unstructured data, reducing redundancy and ensuring data accuracy. Clean and standardized data are vital for accurate demand forecasting and inventory management.

  The main area of S&OP where Machine Learning techniques are utilized is forecasting. The most common ML-technique employed is supervised learning, predominantly utilizing Artificial Neural Networks (ANNs). S&OP is a process where a significant amount of data is collected, making ML-techniques well-suited for identifying patterns and extracting insights. (Ohlson, Riveiro, & Backstrand, 2022)

3.4.1.3. Blockchain

From the applications of Blockchain mentioned by Agrawal & Narain (2021), the following are the most related to Sales and Operational Planning (S&OP):

- **Accuracy of inventory management**: Blockchain ensures that no single item is stored at two unique locations simultaneously due to the nature of a distributed ledger. This eliminates duplication and ensures that items are not lost in the distribution chain. Real-time visibility at both ends of the distribution system enhances inventory accuracy and reliability, to maintain optimal stock levels and meet customer demand efficiently.
- **Supply chain transparency**: By recording every product movement on a public ledger, blockchain provides unparalleled transparency. Real-time tracking reduces human error and increases organizational transparency. This transparency ensures that all stakeholders have accurate and up-to-date information on product locations and movements, facilitating better planning and coordination.

In summary, the applications of blockchain in increasing inventory accuracy, enhancing transparency, enabling trustless transactions, and promoting sustainability directly support and improve S&OP processes.

3.4.1.4. Big Data

Agrawal & Narain (2021) enumerate the following applications of big data analytics related to Sales and Operational Planning (S&OP):

- **Demand forecasting and production planning:** Big data analytics transforms traditional forecasting by incorporating customer data and market information along with internal data to enhance forecast accuracy. This is directly related to S&OP as it improves the alignment of sales forecasts with production plans.
- **Sensing demand, consumer preferences, and determining optimal prices:** These capabilities help supply chain managers to catch emerging market trends and issues, which are essential for effective S&OP.
- **Supporting inventory decisions:** By providing better insights related to uncertain customer demands, big data analytics helps in making informed inventory decisions, a key aspect of S&OP to ensure balance between supply and demand.

These applications enhance the overall effectiveness of S&OP processes by improving demand sensing, forecast accuracy, and inventory management.

In the following Table 4 by Kandemir, Özceylan, & Tanyaş (2022), the different steps in the S&OP process are matched with digital transformation building blocks. The research findings indicate the importance of integration of external data into S&OP and applications of big data in S&OP.

Table 4. Matching digital transformation building blocks with S&OP processes.

	Operational backbone	**Digital platform**
Product review	- New Product Introduction (NPI) Information - Predecessor-successor match - Launch dates - End-of-lie dates	- NPI information
Demand forecasting	- Historic sales - Product transition - Product hierarchies - Finished goods inventory - Corporate promotions - Calendar features - List prices	- Forecasting algorithms - Breakdown algorithms
Consensus process	- Sales budget - Corporate promotions - Salesforce insight - Backorders	- Forecast outputs - Hosting inputs from various stakeholders - Root cause investigation

Inventory planning	- Lead times - Historic sales - Forecasts - Seasonality	- Item clustering - Forecast - Differentiated decoupling points - Differentiated inventory management policies
Supply planning	- Production capacity information - Routes - Material and work-in-process (WIP) inventory - Procurement lead times - Bill-of-material (BOM)	- Optimized production plans
Demand & Supply reconciliation	- Netted demand with type visibility - Back orders - Available supply information - Financial data (costs, prices, profitability)	- Scenario generation, optimization and/or simulation
Distribution planning	- Sales orders - Forecast - Safety stock - Production schedule - On-hand inventory	- Allocation information - Distribution requirements - Route optimization - Loading optimization - Real-time production tracking

3.5 S&OP and SCP

Sales and operations planning (S&OP) is a relevant process to provide coordination and integration intra- and inter-companies, while keeping their decision autonomy among the Supply Chain (SC). (Affonso, Marcotte, & Grabot, 2008)

The S&OP process supports vertical integration, in relating strategic and financial plans to operational plans. It also supports integration between companies in the SC, simply linking the company's commercial department with the customer purchase service, and the company's purchasing department with the commercial department of the suppliers, as can be seen in Figure 13. So, the S&OP process remains an integration pillar in Supply Chain Management. (Affonso, Marcotte, & Grabot, 2008)

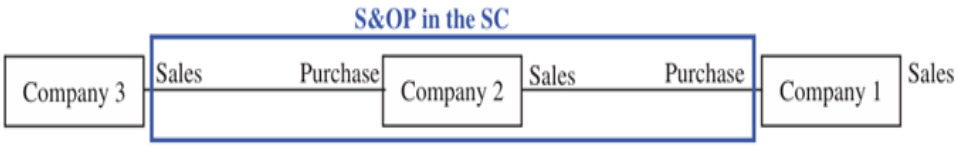

Figure 13. S&OP in the SC. (Affonso, Marcotte, & Grabot, 2008).

The benefits of implementing Sales and Operations Planning (S&OP) are several, among which those that improve Supply Chain Performance (SCP) can be highlighted.

For example, S&OP can lead to higher customer service and often lower finished goods inventories for make-to-stock companies, higher customer service and often smaller customer order backlogs with shorter lead times for make-to-order companies, and higher customer service, quicker response, and often lower component inventories for finish-to-order/postponement companies. (Wallace & Stahl, 2008)

Additionally, better visibility into future resource problems, such as too much or too little work, and a better demand/supply balance across the company's supply chain are crucial. The process also drastically reduces the need for detailed forecasting and scheduling, providing a "window into the future" that enables proactive decision-making by allowing people to foresee future problems like a large increase in workload, an upcoming new product launch consuming substantial plant capacity, or a forecasted downturn in demand later in the year. (Wallace & Stahl, 2008)

These improvements in supply chain performance stem from higher customer satisfaction; lower and more balanced inventory; lower lead times; more stable production rates; more cooperation across the entire operation; better forecasting; more efficient decision making; and a greater focus on the long-term horizon.By addressing these areas, companies can achieve a more stable and balanced supply chain, ultimately leading to better overall control of the business and becoming masters of their own destiny. (Goh & Eldridge, 2019; Wallace & Stahl, 2008)

Goh and Eldridge (2019) conducted a study that empirically examines the link between these S&OP coordinating mechanisms and supply chain performance using data obtained from experienced S&OP practitioners.

The S&OP coordinating mechanisms considered are: S&OP Organization, Procedure, Information, Performance Management, Strategic Alignment, and S&OP Culture, which are described below.

S&OP Organization refers to the structured coordination among members within an organization, emphasizing clear communication of tasks, behaviors, and role expectations. Rather than focusing on hierarchical formality, mature S&OP implementations highlight defined roles and responsibilities, including a formal S&OP function with executive-level participation. Researchers and practitioners broadly agree that key internal stakeholders should actively participate in S&OP meetings to ensure effective collaboration and decision-making.

S&OP Process refers to a formal and standardized series of actions, including written policies, rules, job descriptions, and standard procedures. It involves a defined, common S&OP calendar and follows a standard format or agenda for meetings, which are conducted at least once a month.

S&OP Tools and Data (Information Acquisition/Processing) refer to the mechanisms and systems used to acquire and process information to reduce task uncertainty and enable effective decision-making. This involves well-defined data requirements, including data from external supply chain parties, and the use of IT platforms, ERP systems, or advanced planning systems to process this data.

Performance management can be viewed as a form of "output control" which involves evaluating submissions from organizational units to senior management. Instead of dictating behaviors, goals are set, and employees choose behaviors to achieve them. S&OP performance metrics should balance the interests of various stakeholders within the organization.

Organizational alignment ensures synchronization of activities and goals in dynamic environments through feedback and mutual adjustment. Even with aligned interests, coordination challenges persist if actions aren't harmonized due to limited understanding of interdependent behaviors. S&OP delivers vertically and horizontally aligned plans across functions like marketing, development, manufacturing, sourcing, and finance, ensuring continual balance between supply and demand.

S&OP culture within an organization encompasses shared values and beliefs that guide behavior. It reflects the organization's recognition of the strategic implications of managing supply chain flows. Effective communication of business objectives and vision, along with fostering trust among employees and departments, is essential for cultivating a strong S&OP culture.

The research primarily used an anonymous survey, supplemented by qualitative analysis of open-ended comments from respondents. A total of 568 responses from organizations following the APICS definition of S&OP were analyzed.

In Figure 14 the conceptual framework developed in this study is depicted with the results.

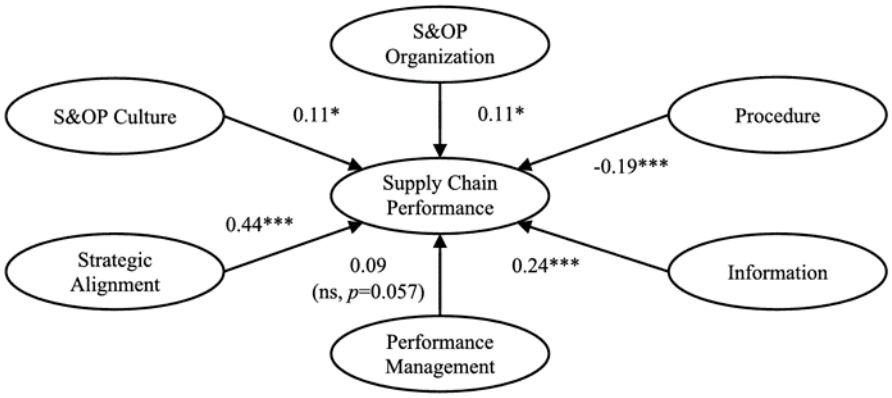

Figure 14. Structural modeling results (standardized coefficients) (Goh & Eldridge, 2019).

The results indicate that Strategic Alignment had the strongest positive effect on Supply Chain Performance compared to all other mechanisms studied. Information Acquisition/Processing, S&OP Organization, and S&OP Culture also showed significant positive effects on Supply Chain Performance. Conversely, S&OP Procedure/Schedule demonstrated a highly significant negative relationship with Supply Chain Performance.

Performance Management was not supported at the 5% level, although marginally (p=0.057).

On their own, firm size, years of S&OP experience, daily order volume, product life cycles, and product variety had no significant effects on Supply Chain Performance.

The study found that S&OP Culture had the weakest unstandardized regression weight for improving Supply Chain Performance, though it was significant (p=0.018). Respondent comments highlighted recurring issues such as lack of management support, organizational buy-in, and change management as common reasons for disappointing improvements in Supply Chain Performance from S&OP implementation.

The Performance Management mechanism was not significantly linked to superior Supply Chain Performance in the study. The positive effect of “direct supervision” or “tracking” of interdependent tasks in coordination theory does not appear to extend to S&OP. Respondent comments suggest this may be due to performance metrics not being acted upon constructively or widely socialized within the organization.

Another key finding from this study is that a highly formalized procedure/schedule significantly ($p < 0.001$) dampens Supply Chain Performance rather than amplifies it. This dampening effect is generally present across various contingency environments, particularly in large companies and to a lesser extent in companies with high S&OP experience. This negative relationship persists even in "mature" S&OP implementations. While written policies, rules, job descriptions, standard procedures, deadlines, guidelines, and specifications can coordinate teams, more successful S&OP programs tend to convene meetings as needed and use bespoke processes tailored to the situation, especially after gaining more than five years of S&OP experience.

3.6 Digitalization and Supply chain performance

In many articles read, it has been found that digitalization has a positive impact on supply chain performance (Zhou et al., 2023; Zhao et al., 2023; Salamah et al., 2024). The integration of digitalization into the supply chain is referred to as supply chain digitalization, a term used in all the articles reviewed.

Supply chain digitalization (SCD) is defined as the extent to which the firm adopts and deploys digital supply chain systems to transact with players along the supply chain. (Zhou et al., 2023). Supply chain digitization is a driving force, integrating digital technologies like big data, cloud computing, blockchain, Internet of Things (IoT), and artificial intelligence into supply chain activities. SCD focuses on “data-driven decision-making, offers a digital traceability service but also significantly improves the transparency and integrity of the supply chain(Zhao et al., 2023; Salamah et al., 2024)

In these three example literatures, surveys were conducted using questionnaires to confirm whether the hypotheses formulated have reliability and validity. The hypothesis common to all three is that digitalization is positively related to supply chain performance. Additionally, attempts were made to test other relationships with factors such as traceability, agility, dynamism, resilience, integration, and efficiency.

In Zhou et al., 2023, the study utilized questionnaires distributed to operations/business managers, senior executives, or CEOs in China. Participating firms were required to have used at least one type of digital technology in supply chain transactions prior to completing the questionnaire, resulting in 223 responses. This study examined the relationship between supply chain digitalization and supply chain performance (SCP), focusing on the factors of traceability and agility, as well as the influence of dynamism.

Supply chain **traceability** refers to a firm's ability to continuously track and monitor the history as well as the current status of goods/services from the origin to their final clients. Traceability plays a powerful role in overcoming information processing bottlenecks. In Particular, it can update, process and transfer information with minimal delays and errors, helping firms determine where problems may occur, solve problems quickly and make data-driven decisions to improve supply chain performance.

Supply chain **agility** is defined as firms' ability to adjust to abnormal changes in terms of demand and supply patterns. It serves to sense external information about changing customer preferences and competitive activities to make decisions and take actions that can respond to changes and disruptions.

Both supply chain traceability and agility provide firms with the ability to effectively manage the potential of supply chain digitalization and apply it into supply chain activities and functions, thereby effectively creating more added value for the supply chain.

Supply chain **dynamism** refers to the extent to which products and processes undergo radical transitions within supply chains. Given the constant evolution of business and technology environments, understanding the impact of supply chain dynamism on the relationship between supply chain digitalization and performance is crucial. High supply chain dynamism introduces substantial uncertainty and operational threats, necessitating extensive information processing. To effectively navigate this environment, firms must gather extensive market and partner data to enhance traceability and agility. This enables them to accurately anticipate changes, identify risks, and mitigate uncertainty promptly.

In Figure 15, the conceptual framework developed in this study is depicted with the results.

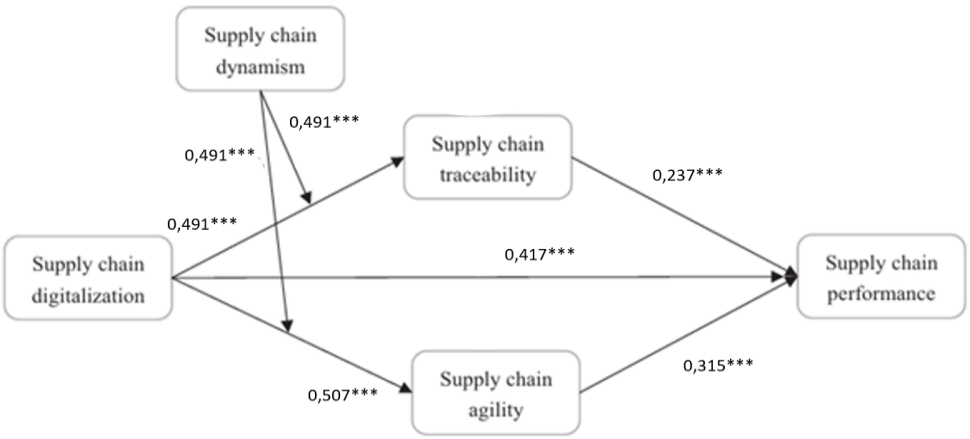

Figure 15. Structural modeling results. (Zhou et al., 2023).

The conclusions of this study demonstrated that digitalization indeed had a positive impact on the supply chain. Supply chain digitalization was associated with improved supply chain performance, providing managers with the confidence to initiate a digital transformation journey. Furthermore, the study identified supply chain traceability and supply chain agility as positively associated factors with supply chain digitalization and supply chain performance.

For manufacturing firms, the study emphasized the importance of utilizing supply chain digitalization to enhance supply chain traceability for performance improvement, rather than focusing solely on supply chain agility. Conversely, for service firms, supply chain agility emerged as a stronger partial mediator.

In dynamic supply chain environments, the study highlighted the significance of supply chain traceability over supply chain agility in the relationship between supply chain digitalization and supply chain performance.

In the study by Zhao et al., 2023, questionnaires were distributed to manufacturing enterprises with a specific level of digitalization situated in the Yangtze River Delta region of China. A total of 210 valid questionnaires were collected and retained. This study examined the relationship between supply chain digitalization and supply chain performance, as well as the factor of resilience, composed of absorptive capability, response capability, and recovery capability.

Supply Chain Resilience (SCR) refers to a supply chain's capacity absorb the shock of a disruptive event, effectively respond to such disruptions, and recover quickly to its initial state or attain an improved operational state. It underscores the response capability and recovery capability of supply chains when confronted with unforeseen risks. SCR comprises three distinct dimensions: absorptive capability (prior to disruption), response capability (during disruption), and recovery capability (following disruption). These three capabilities operate independently in addressing disruptions.

Absorptive capability emphasizes the ability of a supply chain system to absorb and withstand supply chain disruptions by using its original redundant resources and other risk preparation activities. It is considered the first line of defense for supply chains to deal with disruption events. A supply chain with absorptive capability means firms involved fully understand the state of supply chain operations and prepare accordingly before disruptive events occur. It is composed of supply chain situational awareness, redundancy, and visibility.

Response capability is a supply chain’s ability to respond correctly to risk on time by adjusting the flow of activities and resource allocation in the face of a disruption event, is the second line of defense against supply chain disruptions. Response capability means that firms know what to do and can adjust their normal functions to respond to disruptions on time when faced with a highly uncertain market.

Recovery capability refers to the ability of a firm to quickly reach its original operating or a better state by using optimal methods to resolve risk shocks quickly and cost-effectively in the later stages of risk occurrence, is the last line of defense for supply chain systems against the risk of disruption. When absorptive and response capability cannot maintain the initial operational state, recovery capability needs to be urgently enhanced.

It emphasizes the reconfiguration of internal and external resources and capabilities to help the supply chain recover quickly to its initial state.

In Figure 16, the conceptual framework developed in this study is depicted with the results.

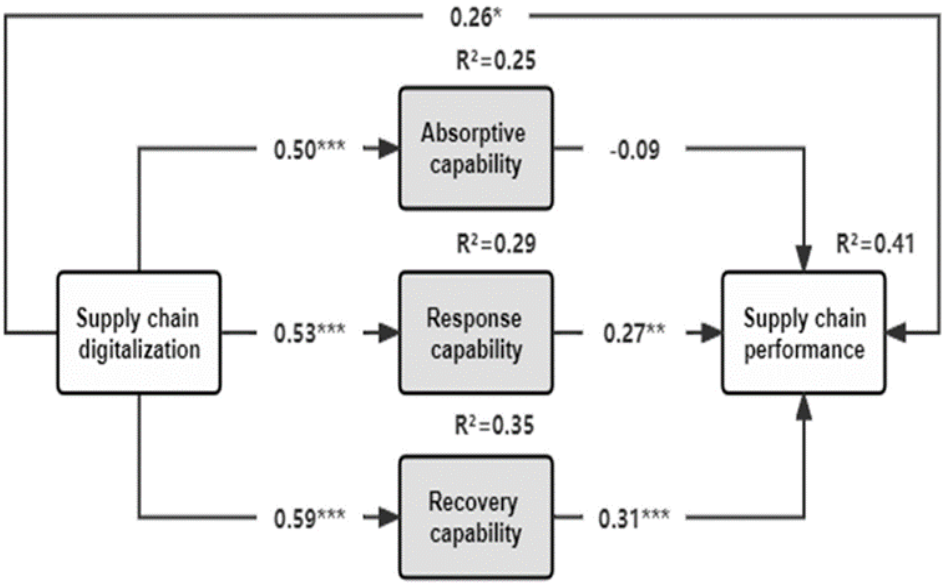

Figure 16. Structural modeling results. (Zhao et al., 2023).

It concludes that the establishment of SCD will not only have a direct impact on SCP but also enhance risk response efficiency and risk adaptability of a supply chain by improving response and recovery capability, thus bringing a stronger improvement to SCP.

In a study conducted by Salamah et al., 2024, questionnaires were distributed to manufacturing firms across diverse industries located in Turkey, that may hinder investment in digital technologies 293 questionnaires were deemed usable. This study examined the relationship between supply chain digitalization and supply chain performance (SCP), focusing on the factors of integration and efficiency, as well as the influence of dynamism.

SC Integration stands as a cornerstone in contemporary business strategy, epitomizing a firm's collaborative alliance with major supply chain partners to orchestrate and streamline various supply chain activities. SCI operates through two fundamental dimensions—supplier integration and customer integration.

The objective of **supplier integration** is to cultivate symbiotic collaborations with major suppliers, fostering mutual understanding and synchronized supply chain processes. This entails comprehensive processes such as information sharing, joint planning, and collaborative product development. High levels of supplier integration confer strategic advantages, allowing firms to curtail operational costs, bolster profitability, accelerate new product development, and create additional value for customers.

Customer integration, emphasis is on streamlined information sharing and collaboration with major customers, with a focus on enhancing overall business performance. This

collaborative effort includes sharing market insights, understanding shifts in buyer preferences, and co-developing market-oriented offerings. Moreover, customer integration facilitates agile responses to market changes, enhances customer satisfaction, stimulates sales growth, and augments market share.

Efficiency, underscores an organization's ability to produce goods and services with minimal costs by minimizing waste and optimizing resource utilization. Efficiency is a critical component for organizations seeking a competitive advantage. In the supply chain context, the pursuit of efficiency is particularly pronounced, with the aim of achieving the lowest possible costs while meeting customer standards, including accuracy in delivery and lead time.

In Figure 17, the conceptual framework developed in this study is depicted with the results.

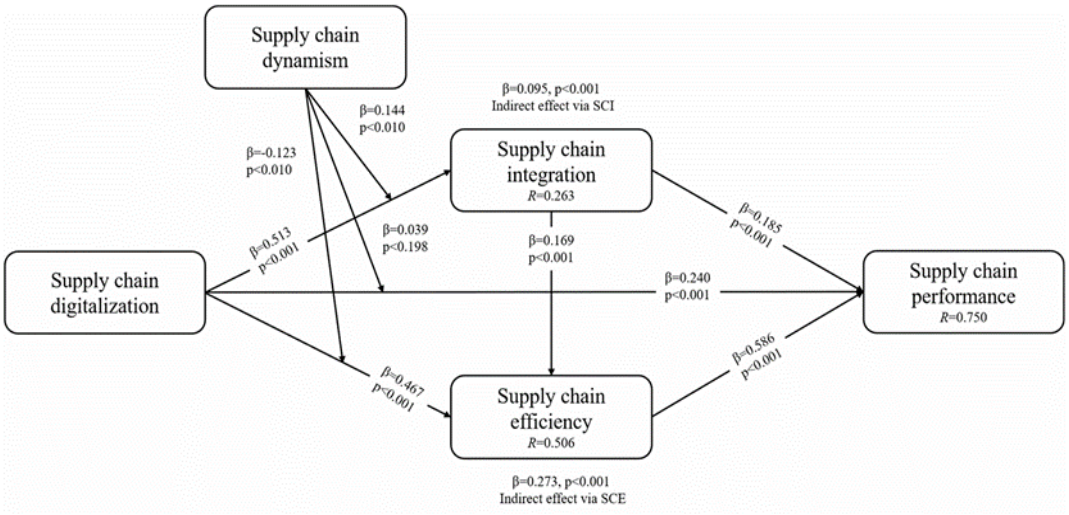

Figure 17. Structural model results. (Salamah et al., 2024).

The analysis of the structural model firmly establishes the significant and positive impact of digitalization on supply chain integration, efficiency, and performance.

This discovery suggests that digitalization's impact on performance is channeled through the enhancement of integration and efficiency, aligning with the concept of digitalization as an enabler.

The positive moderating influence of supply chain dynamism on the relationships between digitalization and supply chain integration signifies that the effect of digitalization is amplified in supply chain environments characterized by greater volatility and rapid change.

Contrary to their initial expectations, the analysis did not reveal a statistically significant moderating effect of supply chain dynamism on the relationship between digitalization and supply chain performance. This suggests that the impact of digitalization on supply chain performance remains relatively consistent regardless of the degree of supply chain. It suggests that digitalization initiatives have the capacity to yield performance improvements even in less dynamic or more stable supply chain contexts.

Intriguingly, the examination of the connection between digitalization and supply chain efficiency revealed an unexpected significant negative moderating role played by supply chain dynamism. This suggests that while digitalization positively impacts supply chain efficiency, this effect is dampened in highly dynamic supply chain environments. This could be attributed to the challenges posed by increased dynamism, such as the need for rapid adaptation to changing market conditions and heightened uncertainty.

Consequently, while digitalization can enhance efficiency, its effectiveness in doing so might be hindered by the complexities introduced by a highly dynamic supply chain context.

Although there are some studies demonstrating this positive effect of digitalization on SCP, it is worth noting that many of them emphasize that simply implementing and investing in digital technologies is insufficient for successful transformation. Only 16% of firms experience performance improvement after embarking on supply chain digitalization. Firms must shift their mindsets and reconfigure business processes to effectively leverage the digital information captured by these advanced technologies (Zhou et al., 2023). There is a need for a comprehensive digitalization strategy that aligns with the organization's goals and supports seamless integration across the supply chain (Salamah et al., 2024).

Despite the challenges and high costs associated with digitalization, if utilized correctly, the benefits of undergoing the digitalization process outweigh the costs of implementation in supply chains. (Gomes Filho et al., 2021)

We concluded this chapter by presenting our conceptual framework in the next chapter.

4 Conceptual Framework

This chapter illustrates the expected relationship between the relevant concepts described before. It works as a boundary for the data collection and maps out how the authors projected the reviewed literature on the studied companies.

Based on the reviewed literature above the following conceptual framework -shown in Figure 18- illustrates the expected relationship between S&OP, Digitalization and Supply chain performance. It works as a boundary for the Data collection and maps out how the Authors projected the reviewed literature on the Studied companies.

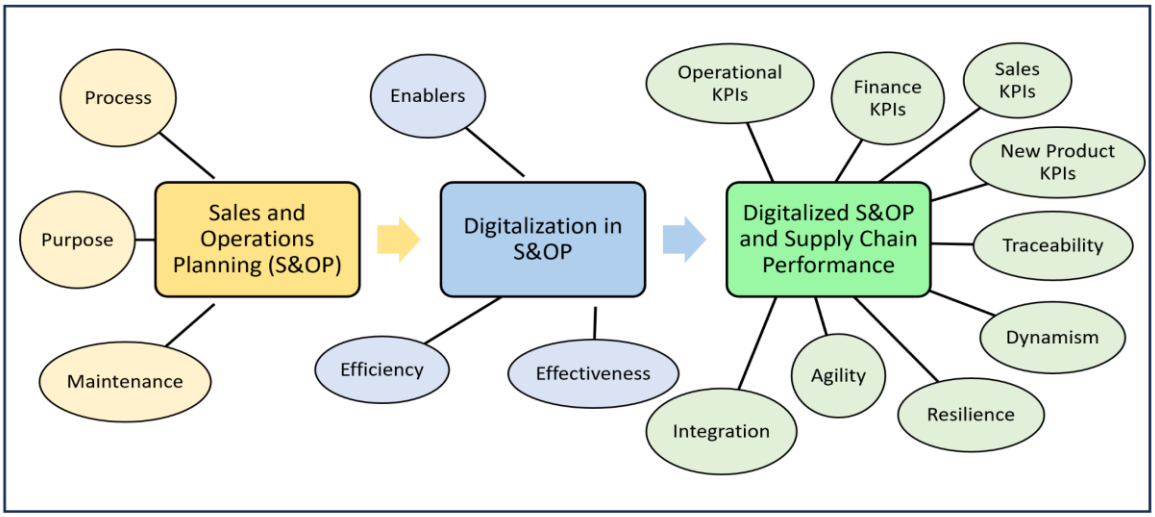

Figure 18. Conceptual framework for data collection and Analysis.

The model consists of three main areas, starting with Sales and Operations Planning (S&OP). This area delves into the S&OP process, exploring the steps and methodologies involved, such as planning, coordination, and execution phases. It also examines the purpose of S&OP, which includes aligning supply and demand, improving customer satisfaction, and optimizing inventory levels. Additionally, it looks into the maintenance of S&OP processes, ensuring they remain effective and responsive to changing business conditions.

The second area focuses on the digitization of S&OP. It investigates the enablers of digitalized S&OP, identifying key digital tools and technologies that facilitate the process, such as advanced analytics, artificial intelligence, machine learning, and cloud-based platforms. Furthermore, it analyzes the impact of these digital tools on the efficiency and effectiveness of the S&OP process, highlighting improvements in data accuracy, faster decision-making, and enhanced collaboration.

Finally, the model examines the effect of digitalized S&OP on the supply chain, highlighting nine different areas: operational KPIs, financial KPIs, new product development KPIs, sales KPIs, agility, traceability, resilience, dynamism, and integration. It explores how digitalized S&OP influences operational metrics like lead times and order fulfillment rates, financial performance indicators such as cost savings and profit margins, and new product development metrics related to market introduction speed and success.

Additionally, it assesses the impact on sales performance metrics, including sales growth and market share, as well as the supply chain's agility, traceability, resilience, dynamism, and level of integration. This comprehensive model underscores the transformative potential of digitalization in S&OP and its significant impact on various aspects of supply chain performance.

5 Cases studies

Below are the case studies conducted in this thesis. This research involved the execution of two semi-structured interviews with employees hailing from distinct companies, Hitachi Energy and Alfa Laval. These interviews served as pivotal sources of qualitative data, offering insights into various aspects related to the central research inquiries. The questions posed during these interviews are documented and provided in Annex I.

After conducting the interviews, this section compiles the results obtained from each company and compares them.

5.1 Hitachi

5.1.1 Introduction

Hitachi Energy is a global leader in providing innovative solutions and services across the energy value chain. Headquartered in Switzerland, with operations in 90 countries and a workforce of 40,000, the company drives the energy transition towards a carbon-neutral future. With a rich history dating back to the 19th century, the merger with ABB's Power Grids in 2020 solidified its position as a powerhouse in sustainable energy technologies. (Hitachi Energy, 2024)

The expertise spans the utility, industrial, and infrastructure sectors, offering cutting-edge solutions that prioritise sustainability, flexibility, and security. Leveraging an unrivalled installed base in over 140 countries, Hitachi Energy collaborates with customers and partners to accelerate the global energy transition. Beyond technological innovation, the company prioritises its impact on communities, striving to improve lives and inspire positive change worldwide. (Hitachi Energy, 2024)

Through sustainable partnerships with stakeholders across industries and geographies, Hitachi Energy drives collaborative efforts to shape a more resilient and inclusive energy future. As an industry's most trusted partner, it is committed to delivering top-class solutions that fulfil the promise of a sustainable tomorrow, today. (Hitachi Energy, 2024).

The HVDC business unit- in Hitachi energy-is the organisation under investigation. The unit is responsible for designing, executing and maintaining HVDC stations. The main aim is to reduce energy losses during transmission which can reach as low as 10% in DC technology while the losses in AC transmission can reach up to 40%. The unit works on projects that connect power grids between two or more geographical areas. This could be two sides of a country, two countries or two continents, onshore and offshore.

The project consists of at least two converters' stations and each station consists of many electrical and mechanical apparatuses. The project (product) lifetime is about 50 years then in most cases it goes again into an upgrade or service project. The project life cycle from (bid and proposal till running and commissioning) expands anywhere from 6 to 10 years and maybe more depending on the project complexity and challenges encountered.

The unit of study is operation project planning and control. The unit is responsible for planning projects. It includes project line planning, projects controlling, forecasting and other several functions. The main goal of the unit is to ensure the forecasted projects are matched with available resources but also the resources are prioritised based on the need. The interviewee is the global manager of the unit under study operation project planning, A mechanical engineer with many years of experience in planning and control in various industries including oil & gas and energy.

5.1.2 S&OP in Hitachi Energy HVDC

The main perceived aim of conducting the S & OP process is to avoid and emulate the bottleneck. Ensuring that there is no surplus or shortages in Supply or demand side. Sales and operation are the involved functions, and they should reach an agreement and no department is allowed to deviate from this planning.

The S&OP process in the HVDC unit follows five main steps. It starts by sales working on their demand plans and production sets the potential resources. Then those plans are given to the S&OP process owner who identifies the deficiencies and draws attention to them with recommendation on prioritisation. These recommendations are then highlighted to line managers but also the higher management for appropriate action. Finally, the performance is measured to see the deficiencies between planned and achieved.

The Company details projects which are broken down into several products. However , There was no evidence of groping different components from various projects into one planning group(aggregation).

5.1.3 The Impact of Digitalization in the S&OP process in Hitachi Energy HVDC.

The Digitalization Strategy in HVDC is about using digital technologies in All functions of the business and S&OP is not an exception. The company has gained lots of benefits using digital tools. Using digital tools has helped more in reducing bottlenecks. The process becomes faster especially when it comes to data mining and cleaning. As a monthly conducted process, the company used to consume almost 27 days before digitization which leaves two to three days for Analysis and recommendation. This has totally disappeared after digitization. Machine learning and AI are some of the tools that are used in S&OP.

The interviewee says, *"Digitization has Helped to increase the accuracy, to predict the outcome, really useful for predictions that is very much helpful now since we are more digital".*

Digitalizing S&OP has positively affected both the efficiency and effectiveness of the process itself but also the efficiency and effectiveness of the Supply chain. On the effectiveness side the accuracy of prediction has increased which increased the

confidence on the outcome of the process. The S&OP process becomes more efficient because the number of the resources to do it is lesser than before as there are many automed executed tasks. Nonetheless All the output of S&OP still has to be interpreted in a way that is easier to explain to the organization. The necessity of human intervention comes from the fact that the output of S&OP in many cases is a complicated model and data that is very difficult for a normal layman to understand.

However, the higher management does not give the credit entirely to digital tools, they believe that effective communication through the human element is very crucial.

There is no evidence that the company uses digital tools in measuring the effectiveness and efficiency of the digitalized S&OP process. The company relay, instead, on the previous month or year outcome and drew a comparison on that base. One reason for this is the long-life cycle of the projects that can extend to 10 years from tendering till execution. There are no separate KPIs to measure the S&OP process. However, the success of the process is evaluated by its effect on the inter supply chain performance.

There are some challenges that are associated with digitalized S&OP and the lack of data is the biggest correct direct format challenge in digitalized S&OP.

5.1.4 Digitalized S&OP and Hitachi Energy HVDC Supply Chain Performance

Several Supply chain KPIs have improved in the company as a result of digitalized S&OP. new product introduction has improved a lot especially when it comes to ramp-up time, and time to market. In terms of operational factors, capacity utilization is a winner. while fill rate, obsolescence and stockout is not affected as the company is Engineer to order base. Supply chain Dynamism and Agility has improved a lot; this comes as a result of increased predictions (forecasting) accuracy and ability to shift between different projects easily. Supply Chain Traceability has also improved across various supply chain partners. Integrating both the supplier and customer side with the internal Supply chain has also improved.

The interviewee says, *"Digitalization in Supply chain in general-including S&OP- helps us increase traceability. Traceability not only internally but also on the supplier side and it is some customer's requirements".*

Supply Chain Resilience is, Surprisingly, not affected as the interviewee believe that there are many other things accents it beyond the digitalized S&OP.

The interviewee says, *"There are many things beyond Digilized S&OP and many other involving parties, lots of geopolitical considerations come in".*

The authors have failed (due to data) to obtain sufficient data that helps to see how digitization has helped the S&OP to progress in Grimson and Pyke S&OP integration framework.

5.2 Alfa Laval

5.2.1 Introduction

The Alfa Laval website is the source of information in this (5.2.1) section.

Established in 1883, Alfa Laval has emerged as a global supplier, renowned for its products in heat transfer, separation, and flow management. Built on a foundation of excellence, Alfa Laval is dedicated to enhancing the productivity and competitiveness of its clients across diverse industries worldwide. Through a meticulous understanding of their unique challenges, the company delivers sustainable solutions tailored to their specific requirements, with a focus on energy, environment, food, shipyards, and shipping sectors.

Within the Nordic region, Alfa Laval Nordic AB operates as the sales and service division of Alfa Laval in Sweden, seamlessly integrated into a larger Nordic organization spanning Denmark, Finland, and Norway. With a workforce of 200 professionals distributed across these regions, Alfa Laval Nordic markets a comprehensive portfolio of products, systems, and services, showcasing the company's core technologies: Heat Transfer, Separation, and Flow Technology. Additionally, Alfa Laval Corporate AB, headquartered in Lund, serves as the central hub for global operations, steering the company's strategic initiatives on a worldwide scale.

Since its inception, Alfa Laval has navigated an illustrious journey, marked by significant milestones that underscore its evolution into a respected international entity. From its manufacturing facilities in Lund, Eskilstuna, and Tumba to its global headquarters, the company continues to embody a legacy of innovation, dependability, and customer-centricity, driving progress and prosperity across industries worldwide.

The Interviewee is S&OP head gasket and plate heat exchangers unit, one of the main groups in the company. Responsible for planning of factories in 8 countries, Lund factory is the biggest. Handing full global demand and acting as a bridge between demand and factories. Worked in various industries Medical, technology and supply chain. Designed and implemented S&OP for the entire Alfa Laval. MSc in computer science and industrial economics.

5.2.2 S&OP in Alfa Laval

The main aim of the S & OP process in Alfa Laval is to eliminate cross functional Silos and have a common plan that everyone sees and understands. The company suffered from lots of backorders, Inventory obsolescence and other operational expenses that could have been avoided by good planning and coordination.

The interviewee says *"There were functional Silos (Silo oriented) between commercial (sales), sourcing (procurement), finance, and R&D and all these departments were totally disconnected. For instance, sales would want to sell 1000 items while production would make 1200 from and procurement would source for 800. Each January managers got surprised from the inventory obsolescence, backorders and many other things that they could have avoided. "* .

Subsequently and as a result of implementing the S & OP process; the entire company has developed a better understanding for the common planning concept. Lots of losses are avoided and many operational KPI are enhanced. The company becomes more prepaid to take bigger investments. The sales team is confident about their promises to the customers because they learned the meaning of numbers and the consequences of their promises. Operations, on the other hand, felt more heard and appreciated but also got the chance to plan well and even on a tactical level avoiding the rush for overtime and contingency workers which not only costs money but also affects the quality in some instances.

There is a dedicated function to perform and maintain the S&OP in Alfa Laval. The process typically consists of five steps on a monthly basis. To begin with, the S&OP team collects the required data for the process. Secondly, forecasts are prepared and sent to sales managers for manual inputs and adjustment thai form (The demand planning). Thirdly, the operational resources and capacities are calculated and prepared to form (The supply planning). Fourthly, the S&OP process owner arranges a meeting between sales and team in order to discuss the deficiencies, form (pres S&OP meeting). Finally, the discrepancies are taken to the S & OP executive meeting. S&OP plans are also shared with R&D, Finance and HR for their input in some instances.

5.2.3 The Impact of Digitalization in S&OP process in Alfa Laval

The term Digitalization was explained to the interviewee as using digital tools like AI, Machine learning, BI and basically any tool that utilizes the computer power to perform tasks.

Alfa Laval uses Various systems and technological tools in different parts of the S & OP process. These tools include So 99 for demand planning and forecasting. The company also uses what so called "engines" do the math and working in machine learning so called "board" then the visualization takes place using and using Microsoft power Bi.Digital supply chain office also utilize what So called "blue yonder" for spare parts flow management and planning.

Digitalizing the S&OP process has helped Alfa Laval increase both the efficiency and effectiveness of the process itself but also of the supply chain. Forecasting, for instance, is better when excel is combined with other digital tools than before. it becomes accurate

and relatively consumes less time than before. While supply demand is not benefiting to the same extent of forecasting, still the company feels that they have a better control than before. Effectiveness, however, is the least affected aspect as the interviewee thinks that it has always been high due to other factors like high service level, but also fragile measures used to evaluate the customer satisfaction.

While Alfa Laval uses a set of measures like Plan adherence and forecast accuracy to evaluate the efficiency of their S&OP process, the company has not yet started using Digital tools in measuring and evaluating the efficiency of their S&OP process.

Despite the benefits- mentioned above-that digitization brought into the S&OP process in Alfa Laval, the company encounters some challenges with digitization. Scaling is one thing, and this is linked to budgetary containment and convincing top management with its benefits which requires a solid business case. The present need of human intervention is another thing as there is a need for manual checking from time to another.

The interviewee says *"It does not work all the time, needs lots of cleaning and needs human intervention and you find things late. Lots of logical filters have been implemented before sending it around. AI and ML used for deviations. No one is hired to do this. It costs money to hire and needs lots of approval before adding new roles".*

Digitalization has helped the Alfa Laval S&OP process to move to advanced stages in S&OP integration framework as shown in Figure *18* below.

5.2.4 Digitalized S&OP and Alfa Laval's Supply Chain Performance

Digitalized S&OP has improved several KPIs that Alfa Laval uses to evaluate their supply chain performance. These KPIs are used to assess operational, sales, financial, procurement and new products development.

Operational KPIs like inventory on hand, obsolete inventory, inventory turnover and capacity utilization are the most benefited operational KPIs while expediting frequency is hard to measure as it is handled by separate functions. All injuries, safety, variance to standard cost and quality was not affected at all.

Sales KPIs witnessed improvement in terms of forecast accuracy, variance to baseline forecast, Customer delivery on time (DOT) and Delivery service levels (DSL). However, The interviewee believes that sales growth, market share are affected by other factors than S&OP and digitalized S&OP.

The KPI related to new product introduction has also improved but not directly as a result of digitalizing S&OP. Digitalizing S&OP has helped in the NPD (New product development) internal measures.

procurement KPIs including ideal inventory days of supply (IDS), Cycle stock, safety stock, strategic stock, Overstock, Supplier delivery on time (DOT).

The financial planning has generally improved. There was high interaction with financial controllers last year S&OP plan forms the base on the new year's budget. Digitalized S&OP has also enhanced CapEx planning and return on capital (ROC).

The interviewee says *"We work a lot with Financial controllers, budget starts form S&OP last year input and used for capex plan. Digitization helped us taking to finance in numbers of languages, both of sales and operation work with finance become easier".*

Supply chain Dynamism and Traceability is not affected by digitalizing S&OP process in Alfa Laval. Furthermore, SC Integration Agility, However, has witnessed some enhancement. Because of digitalized S&OP the company can now utilize manufacturing capacities in different regions to support another region's demand. Supply Chain Resilience has also gained benefits from digitalized S&OP especially when it comes to Absorptive capability while Recovery capability and response capability comes secondly and third respectively. Finally SC visibility has also improved due to using power Bi.

5.3 Comparative Analysis of Cases Study and Literature Review

This comparative analysis aims to explore how the detailed, contextual understanding provided by a case study aligns with, or diverges from, the broader patterns and themes identified in the existing body of research. By juxtaposing these two approaches, we can highlight unique findings, validate established theories, and identify potential gaps or new directions for future research.

5.3.1 S&OP-The Process and Maintenance

The perceived importance and benefits of S&OP in the studied entities seems to match the pre described in the reviewed literature. The Urgency of achieving a balance between supply and demand as stated by Wallace (2004) is what pushes these entities to implement and maintain an S&OP process. Nonetheless, the perceived benefits by Alfa Laval seem to outweigh the ones that Hitachi has. The Authors believe that this difference is due to the highest level of customisation required in the Hitachi project, compared to relatively lower customisation in Alva Laval. We believe that more Standardization in Hitachi will allow them to gain more benefit from S & OP.

The process of S&OP on Both companies -more or less -adopt 5 steps process as an S&OP process. When this process is compared with literature, we find that the first four steps of the process are typically the same. The fifth step, however, deviates a bit. While the literature specifies a big portion of that stage for monitoring and evaluating both companies closes the S&OP process by S&OP executive meeting, taking the evaluating and mentoring job into different business activity.

It is noticed that even for a project-based company, the project is broken down into products and the S&OP take place on the level of the product. There is no Evidence that a group of projects are combined and then aggregated into product groups as suggested by Bozarth and Handfield (2019).

The involved parties in the practical side of the story seem to be more than what the literature describes. While academia focuses on Manufacturing and Sales as a sole and (only) functions of the process, the investigated firms also include HR and work closely with Finance. This might be due to simplifications that researchers assume when addressing certain topics, but the reality is always different. the basic concept that we learn in SCM that financial, Material and information flow cannot be segregated. A modern entity has a separate department (called HR) that procure and manage the required human capacities for the operation department.

5.3.2 The Impact of Digitalization in S&OP process

In general, we see a positive impact of digitization in the S & OP process. However, that positive impact seems to be overrated in some areas. While the efficiency of the process improved in agreement with Salamah et al (2024) and Zhao et al (2023), there are many questions about the effectiveness of it but also measuring these two factors. Alfa Laval, for instance, believe that their effectiveness has not improved because of Digilized S&OP, despite improving forecast accuracy by using Machine learning, they believe they have fragile measure and un adequate DLS for measuring it. On the other Hand, Hitachi, and despite the initial confidence that sales teams gained from digitised S&OP, the company did not complete a full life cycle to assess its effectiveness.

When it comes to enabling successful S&OP digitization, it seems that there is an agreement between empirical data and literature. Both companies use, with some extent, the technological tools listed as enablers by Zekhnini et al. (2020) and Ghadge et al. (2020). There is also common agreement with Thun et al (2022) on his claim of the need for information access, people and effective communication as important facilitators of S&OP; Digital tools alone will not do the job!

The following Figure 19 shows how Digitization helped Alfa Laval progress in the S&OP Framework by Grimson and Pyke.

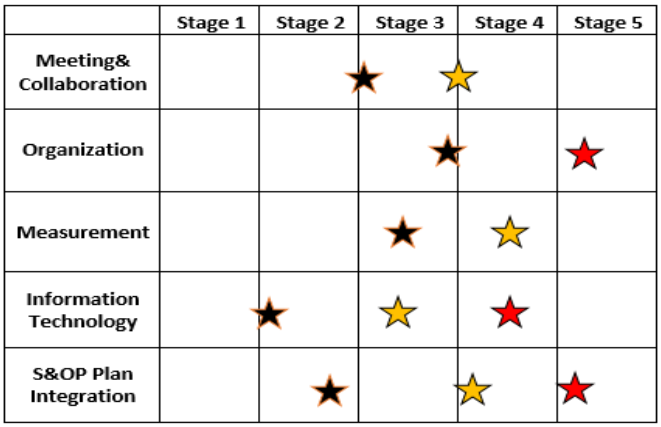

Figure 19. Alfa Laval S&OP process maturity progress with respect to Digitalization.

★ Indicates the position before digitalizing the S&OP process.

★ Indicates the position with digitalizing the S&OP process.

★ Indicates the potential except position with better digitalization in the S&OP process.

The figure above shows that digitization helped to improve S&OP in almost all five dimensions except for organization. Collaboration and meeting is the least improved factor that might be linked to the role of human factor and effective communication as discussed in the literature above. Organization is expected to be improved if more digitization is adopted and this is linked with the fact that top management is not willing to pay for it unless they benefit from it, so more digitization will generate more money which will help improve S&OP organization. Measurement, Surprisingly and despite of improvement, is not expected to be affected more with digitalization this support the fact that both literature and managers believe the lack of distinct S&OP performance measures is beyond digitization, like long cycle life in Hitachi case . As expected, Information technology and integration has improved and will continue to improve with more digitization.

5.3.3 Digitalized S&OP and Supply Chain Performance

Operational KPIs are by far the most affected and improved KPIs of the investigated companies supply chain. The enhancement in Alfa Laval seems to be more; this could be to the organizational prescription to S&OP. The only disagreement with Özceylan, & Tanyaş (2022) and Wallace (2004) is that neither expediting frequency nor quality has improved.

Sales KPIs are not so different for operational ones except for market share where both interviewees believe that there are many other geopolitical factors beyond S&OP. New product introduction was not also affected by S&OP which contracts with literature ambitions (Salamah et al., 2020). For Hitachi every [project is a new product while Alfa Laval handles this role through a separate process.

Supply chain Dynamism and Traceability is not really affected by digitalizing S&OP process as opposite to what the literature suggest . Furthermore, SC Integration Agility, However, has witnessed some enhancement. Because of digitalized S&OP the company can now utilize manufacturing capacities in different regions to support another region's demand. While product based company Supply Chain Resilience has also gained benefits from digitalized S&OP, Project based companies believes that other geopolitical factors overtake the entire S&OP process when it comes to resilience, the thing that no reviewed literature has introduced so far .Finally SC visibility has also improved due to using power Bi: perhaps this has to do with better visualization and how it helped measuring and controlling the flow from supplier internally and on customer side.

6 Conclusions

The last chapter answers the research questions proposed initially and explains the conclusions obtained in the thesis. Finally, future areas of research are suggested.

6.1 Research questions answered

RQ1: What are the enablers of successful digitalization of sales and operations planning?

The enablers of digitization in the supply chain could be defined as supply chain digitalization facilitators. Various technologies play the role of facilitators, including the Internet of Things (IoT), Artificial Intelligence (AI), Blockchain, Digital Twin, and Big Data. These technologies have been explained and related to Sales and Operations Planning (S&OP) in detail in this thesis.

According to the companies studied, it has been found that the most commonly used technologies, due to their utility or ease of implementation, are Machine learning and AI in S&OP, for activities like demand planning and forecasting, visualization and for spare parts flow management and planning.

However, it is important to highlight that digital tools alone will not do the job. There is a need for information access, people, and effective communication as important facilitators of S&OP.AS, seen in figure 18 above the highest effect of digitalization could be seen in information technology and integration aspects while organization and collaboration does not seem to be affected by it. This could be interpreted by the need of building a strong business case to change the organizational structure and the fact that meeting & collaboration depends on other factors like incentive alignment and interpersonal skills.

RQ2: How does the role of digitalization in enhancing sales and operations planning practices impact overall supply chain performance?

According to what has been learned from the literature, the role of digitization enhances S&OP by providing numerous benefits, which positively impact SCP. This positive impact on SCP is due both to the effective implementation of digitization on its own and to the improvement of S&OP, as S&OP is a fundamental part of the supply chain.

According to what we have learned from the interviews, in general, there is a positive impact of digitization on the S&OP process. The companies have gained numerous benefits from using digital tools, which have helped reduce bottlenecks, as seen in Hitachi, for example. As a result of implementing the S&OP process, Alfa Laval has developed a better understanding of the common planning concept. However, Alfa Laval believes that their effectiveness has not improved because of digitized S&OP. Despite improving forecast accuracy by using machine learning, they believe they have fragile measures and an inadequate digital logistics system (DLS) for measuring it.

In conclusion, both literature and interviews indicate that digitization positively impacts the S&OP process, enhancing supply chain planning (SCP).

6.2 General conclusions

In conclusion, this thesis investigates the impact of digitalization on Sales and Operations Planning (S&OP) and its influence on supply chain performance (SCP). Two large companies, Hitachi Energy and Alfa Laval, were selected for the study due to their significant differences: Hitachi Energy is a project-based company, while Alfa Laval is a product-based company with an extensive global supply chain.

The research methodology involved a literature review to investigate and learn about the three main topics: S&OP, Digitalization, and SCP and their interactions. Additionally, semi-structured interviews were conducted with representatives from both companies to study and analyze how it is carried out in each company.

The study identifies key digital technologies as enablers of successful digitalization of sales and operations planning, including the Internet of Things (IoT), Artificial Intelligence (AI), Blockchain, Digital Twin, and Big Data. These technologies are explained and connected to S&OP within the thesis.

The thesis concludes that while digitization significantly enhances S&OP and SCP by improving efficiency and accuracy, it also requires effective implementation, access to information, skilled personnel, and robust communication channels.

6.3 Future Research

For future research, it would be interesting to study a broader range of companies to analyze and understand more comprehensively how companies are implementing digitization in Sales and Operations Planning (S&OP) and how this affects the supply chain (SC). Additionally, this study has only conducted one interview with each company, so it would be valuable to interview more employees working in S&OP to gather additional opinions and diverse perspectives.

Expanding the scope of companies and interviews could provide a richer understanding of the complexities and details involved in the integration of digitization into S&OP practices and its impact on the overall dynamics of the supply chain.

It will also be interesting to see a future work that instigates and develops separate measures for assessing the Digitalized S&OP. The lack of distinct KPIs for Digitalized S&OP- even S&OP- itself and apart from the overall supply chain performance has been present both on literature and Studied companies.

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Appendices.

Appendix A. Interview questions

S&OP and Digitization

Significance of S&OP:

- What is the primary objective of implementing S&OP in your organization?
- What benefits has your company experienced because of implementing S&OP?
- Considering alfa Laval energy as a company product based, how does your company define the Sales and Operational Planning (S&OP) process? (is it the 5 known steps)

Implementation and Maintenance:

- How is the S&OP process carried out in your company?
- What process do you follow to develop and maintain the S&OP in your company?
- Involved departments? How do you ensure alignment between sales forecasts, production plans, and inventory levels through SOP?

Impact of Digitalization in S&OP:

- How does alfa Laval digitalization strategy influence S&OP process?
- Have you experienced significant changes in SOP because of digitalization efforts? Good? Bad? In which areas?
- What kind of digital tools and technologies does your company use to improve Sales and Operational planning? And how these tools impacted your planning?
- What benefits have you experienced because of digitalization in terms of efficiency, effectiveness, or customer satisfaction?
- Have you faced key challenges/issues during the digitalized S&OP process? How have you addressed them?
- Do you have separate measures for evaluating S&OP effectiveness?
- How did digitization help in measuring the efficiency of S&OP?

S&OP KPIs

Which one of the following has improved because of digitization in S&OP:

- Operations include line fill, inventory on hand, obsolete inventory, expediting frequency, stock outs, variance to standard cost, quality, and capacity utilization?
- When a new product introduction is important, measures include development cost, time to market, ramp-up time, and number of successful introductions?
- Sales team include top line sales growth, market share, forecast accuracy and variance to baseline forecast?

- Finance such as market share, sales dollars, stock price and return on invested capital?

Digitalized S&OP and Supply Chain Performance

Performance Indicators:

- What key performance indicators (KPIs) do you use to evaluate the performance of your supply chain?
- How did/could Digitalized S&OP affect these KPIs?

Supply Chain **dynamism** refers to the extent to which products and processes undergo radical transitions within supply chains.

- How digitalized S&OP helps your organization in achieving supply chain dynamism?

Supply Chain **Agility** is defined as firms' ability to adjust to abnormal changes in terms of demand and supply patterns.

- How does a digitalized supply chain help your organization in achieving supply chain agility?

Supply Chain **traceability** refers to a firm's ability to continuously track and monitor the history as well as the status of goods/services from the origin to their final clients.

- How does a digitalized supply chain help your organization in achieving supply chain traceability?

Supply Chain **Resilience** refers to a supply chain's capacity to absorb the shock of a disruptive event, effectively respond to such disruptions, and recover quickly to its initial state or attain an improved operational state.

- How does a digitalized supply chain help your organization in achieving supply chain resilience?
- How does it affect Absorptive capability?
- How does it affect Response capability?
- How does it affect Recovery capability?

SC **Integration** stands as a cornerstone in contemporary business strategy, epitomizing a firm's collaborative alliance with major supply chain partners to orchestrate and streamline various supply chain activities.

- How does a digitized supply chain help your organization in achieving supply chain integration?
- How does it affect Supplier Integration?
- How does it affect customer integration?

Efficiency, as defined by, underscores an organization's ability to produce goods and services with minimal costs by minimizing waste and optimizing resource utilization.

- How does a digitized supply chain help your organization in achieving supply chain efficiency?
- How has digitalization been integrated into your supply chain?
- Have you observed improvements in supply chain visibility and coordination due to digitalization?
- What future opportunities does your company see in adopting digital technologies in the context of S&OP and supply chain performance improvement?

Positioning! Where would put your current S&OP?

	Stage 1 No S&OP Processes	Stage 2 Reactive	Stage 3 Standard	Stage 4 Advanced	Stage 5 Proactive
Meetings & 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 • Suppliers & 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: Product Manager, Supply Chain Manager	• Formal S&OP team • Executive participation	• Throughout the organization, S&OP is understood as a tool for optimizing company profit.
Measurements	• No measurements	• Measure how well Operations meets the sales plan	• Stage 2 plus: • Sales measured on forecast accuracy	• Stage3 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 & 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 & collaborative process • Constraints applied in both directions	• Seamless integration of plans • Process focuses on profit optimization for whole company

Is there anything else that you feel it's important to add?

Appendix B. Grimson and Pyke matrix

	Stage 1 No S&OP Processes	Stage 2 Reactive	Stage 3 Standard	Stage 4 Advanced	Stage 5 Proactive
Meetings & 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 • Suppliers & 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: Product Manager, Supply Chain Manager	• Formal S&OP team • Executive participation	• Throughout the organization, S&OP is understood as a tool for optimizing company profit.
Measurements	• No measurements	• Measure how well Operations meets the sales plan	• Stage 2 plus: • Sales measured on forecast accuracy	• Stage3 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 & 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 & collaborative process • Constraints applied in both directions	• Seamless integration of plans • Process focuses on profit optimization for whole company