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Ensuring sustainability with sales and operations planning process

Supply chain management
Master's thesis

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Managing supply chains is becoming more complicated as businesses try to be both efficient and environmentally responsible. This thesis explores how sales and operations planning (S&OP) process can help companies meet their sustainability goals by improving how they manage resources, balance supply and demand, and make sustainability a core part of their strategy. The study looks at key elements of S&OP, such as demand forecasting, supply planning, and teamwork between departments, to understand how they contribute to sustainability.

This research combines insights from academic studies and interviews with professionals from different industries, including manufacturing, IT leasing, and consulting. The findings highlight common challenges businesses face in making S&OP more sustainable, such as collecting reliable data, managing costs, and complying with regulations. However, the study also shows that advanced technologies—such as artificial intelligence, the Internet of Things, and blockchain—can improve visibility, support better decision-making, and help create more sustainable supply chains.

A major part of sustainability in supply chains is making sure that long-term goals become part of daily operations. This thesis examines how businesses can move from short-term cost-cutting to a broader approach that includes environmental and social responsibility alongside financial goals. By including sustainability in S&OP, companies can reduce risks linked to limited resources, changing regulations, and evolving customer expectations. The research shows that successful integration requires strong teamwork within the company and with external partners, such as suppliers and logistics providers.

The study also looks at how predictive analytics and automation can improve sustainability within S&OP. By using real-time data and advanced forecasting models, companies can better predict market needs, reduce waste, and optimize production schedules. The findings also stress the need for clear sustainability metrics that companies can track through the S&OP process, helping them measure progress and make informed decisions.

This thesis contributes to current knowledge by providing guidance for making S&OP processes more sustainable. It highlights the importance of teamwork, data-driven decision-making, and aligning business operations with sustainability goals. The findings suggest that S&OP can be a strong tool for making supply chains more efficient and environmentally friendly. The study provides valuable insights for business leaders and policymakers who want to improve sustainability in supply chain operations. As corporate social responsibility and environmental awareness become more important, S&OP's role in supporting sustainable supply chain practices will continue to grow.

Key words: Sales and operations planning process, sustainability, demand forecasting, supply planning

Pro gradu -tutkielma

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Toimitusketjun hallinta on muuttumassa yhä monimutkaisemmaksi, kun yritykset pyrkivät yhdistämään tehokkuuden ja ympäristövastuullisuuden. Tässä tutkielmassa syvennytään tutkimaan, kuinka myynnin ja toiminnan suunnitteluprosessi (S&OP) voi tukea toimitusketjuja kestävän kehityksen tavoitteiden saavuttamisessa parantamalla resurssien hallintaa, tasapainottamalla kysyntää ja tarjontaa sekä ottamalla kestävän kehityksen osaksi strategiaa. Työssä tarkastellaan S&OP:n keskeisiä osatekijöitä, kuten kysynnän ennustamista, tarjonnan suunnittelua, eri osastojen välistä yhteistyötä, ja pohditaan, miten ne voivat yhdessä edistää kestävyyttä.

Tutkimuksessa yhdistyy syvällinen akateemisen kirjallisuuden läpikäynti ja asiantuntijahaastattelut eri aloilta, kuten esimerkiksi valmistavan teollisuuden, teknologiaorganisaation ja konsultoinnin näkökulmista. Tutkimustulokset toivat esiin yritysten kohtaamat haasteet S&OP:n ja kestävän kehityksen yhdistämisessä. Haasteina nähtiin esimerkiksi datan luotettavuus, kustannusten hallinta ja sääntelyvaatimusten täyttäminen. Tutkimuksen perusteella huomattiin kuitenkin, että kehittyneen teknologian, kuten tekoälyn, IoT:n ja lohkoketjujen avulla voidaan parantaa toimitusketjun näkyvyyttä, helpottaa päätöksentekoa ja edistää kestävämpiä toimintatapoja.

Toimitusketjujen kestävyyden varmistamiseksi pitkän aikavälin tavoitteiden liittäminen osaksi päivittäistä toimintaa on todella tärkeässä roolissa. Tässä tutkimuksessa tarkastellaan edellä mainittujen asioiden lisäksi, kuinka yritykset voivat siirtyä lyhyen aikavälin kustannusten optimoinnista kohti laajempaa lähestymistapaa, jossa taloudellisten tavoitteiden lisäksi huomioidaan sekä ympäristö-, että sosiaalinen vastuu. Sisällyttämällä kestävyyden S&OP-prosessiin yritykset voivat minimoida riskejä, jotka liittyvät rajallisiin resursseihin, sääntelyn aiheuttamiin muutoksiin ja asiakkaiden odotusten vaihteluihin. Tutkimus osoittaa, että kestävä integraatio vaatii vahvan sisäisen yhteistyön lisäksi kumppanuuksia ulkoisten toimijoiden, kuten toimittajien ja logistiikkapalveluiden tarjoajien kanssa.

Tutkimuksessa tarkastellaan myös ennakoivan analytiikan ja automaation merkitystä S&OP:ssa. Reaaliaikaisen datan ja ennustemallien avulla yritykset voivat ennakoida markkinoiden tarpeita, vähentää ylituotantoa ja optimoida tuotantoaikataulujaan. Lisäksi tutkimuksessa korostetaan selkeiden kestävyysmittareiden merkitystä, joiden avulla yritykset voivat seurata edistymistään ja tehdä tietoon perustuvia päätöksiä S&OP-prosessin aikana.

Tämä tutkielma tarjoaa käytännön ohjeita S&OP-prosessin muuttamiseen siten, että se tukee yrityksen kestävyystavoitteita. Tutkielma tuo esiin tiimityön, tietoon perustuvan päätöksenteon ja liiketoiminnan kestävän kehityksen tavoitteiden yhdistämisen merkityksen. Tulosten perusteella S&OP:ta voidaan käyttää tehokkaana työkaluna toimitusketjujen optimoinnin lisäksi myös ympäristöystävällisyyden parantamisessa. Tutkimus tarjoaa arvokasta tietoa yritysjohtajille ja päättäjille, jotka haluavat parantaa toimitusketjunsa kestävyyttä. Tutkimus on ajankohtainen ja tärkeä, sillä yhteiskuntavastuu ja ympäristötietoisuus korostuvat entisestään, ja S&OP:n rooli kestävien toimitusketjujen tukemisessa kasvaa.

Avainsanat: S&OP prosessi, kestävä kehitys, kysynnän ennustaminen, toiminnan suunnittelu

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1 Introduction

The increasing complexity and unpredictability of global markets, combined with the growing focus on sustainable development, have made it crucial for companies to ensure their supply chains are both efficient and sustainable. In today's interconnected business world, companies face increasing pressure from customers, regulators, and investors to adopt practices that are not only cost-effective but also environmentally and socially responsible. As concerns about climate change and social issues continue to grow, stakeholders expect companies to take steps to reduce their environmental impact and contribute to society in positive ways. This has pushed many companies to seek strategies that make sustainability a part of their supply chain management. One such strategy could be sales and operations planning (S&OP) process, which efficiently implemented can play a key role in helping companies achieve these sustainability goals by managing resources, balancing supply and demand, and aligning different departments within the organization.

S&OP is a planning process that brings together teams from sales, marketing, and operations to forecast demand, optimize inventory, and adjust production plans accordingly. By managing production schedules and resources in a more efficient way, companies can align their activities with sustainability goals, reducing waste, energy consumption, and emissions. One of the main benefits of S&OP is its ability to prevent overproduction, which can lead to unnecessary use of resources and more waste. By ensuring production is closely aligned with actual demand, S&OP helps companies avoid having too much inventory, which in turn reduces the environmental impact from excess production and the disposal of unsold goods (Nemati et al., 2017). Additionally, including sustainability goals in the S&OP process ensures that companies are not just focused on short-term profits but are also taking steps to reduce their long-term environmental and social effects (Azevedo et al. 2021, 133).

Sustainability in supply chains means meeting current needs without compromising the ability of future generations to meet their own needs. It involves three main areas: economic, environmental, and social factors (Brinkmann, 2022). A sustainable supply chain aims to be efficient while also considering the long-term effects on natural resources, ecosystems, and communities. This approach goes beyond simply improving cost efficiency to also include the health of the environment and the welfare of society. (Yun & Ülkü 2023.) The S&OP process can help achieving these sustainability goals by helping companies create and apply strategies that take both current needs and long-term sustainability into account. By planning carefully and considering sustainability when making

decisions, S&OP ensures that sustainability becomes a central part of the business strategy, not just an afterthought. (Azevedo et al. 2021, 132.)

This study focuses on how S&OP can support sustainability in supply chains. By improving how resources are used, optimizing production, and reducing waste, the S&OP process helps companies reach their sustainability goals without sacrificing efficiency (Azevedo 2021, 133). It highlights the importance of balancing short-term operational needs with long-term sustainability goals, ensuring that the supply chain is both efficient and responsible. Integrating sustainability into the S&OP process gives companies a structured way to reduce their environmental impact while staying competitive in today's fast-paced market.

1.1 Research question

Even though many companies recognize the importance of sustainability, they often face challenges in aligning their operations with these goals (Hristov et al. 2022, 76). While the S&OP process is known to support operational efficiency, its role in promoting sustainability across the entire supply chain is less clear. A key issue is that S&OP processes are often designed to optimize short-term goals, which can conflict with long-term sustainability objectives. (Jonsson et al. 2021.) For example, excess inventory or overproduction might meet immediate demand but result in increased waste and energy use (Afy-Shararah et al. 2022, 381).

To meet the research goals, this study will address the following key question:

- How can S&OP process contribute to supply chain's sustainability goals?

By addressing this topic, the research will assess whether S&OP helps businesses manage both financial success and environmental and social responsibilities. Recognizing the role of S&OP in sustainability is important for companies looking to use resources efficiently, reduce waste, strengthen collaboration with stakeholders, and comply with regulations.

1.2 Structure of the thesis

The thesis is organized into seven chapters, each providing a clear and structured exploration of the topic. After this introductory chapter, chapter two gives a detailed overview of the sales and operations planning process, explaining its goals, principles, and importance in managing supply chains effectively. Chapter three focuses on sustainability in supply chains, exploring practices that support environmental care and social responsibility, such as reducing waste, using resources

wisely, and improving ethical practices. In chapter four, the relationship between sustainability and S&OP is examined. This chapter looks at how S&OP can be aligned with sustainability goals to improve operations while addressing long-term environmental and social concerns. It also identifies challenges and opportunities in combining these areas.

Chapter five explains the research methods used in the thesis. It describes how data was collected and analyzed to provide a clear and reliable understanding of S&OP as a tool for supporting sustainability in supply chains. This includes the use of qualitative methods, like semi-structured interviews, to gather valuable insights. Chapter six presents the findings from the interviews. This chapter analyzes the information shared by participants, highlighting real-world examples, challenges, and successful practices related to S&OP and sustainability. Finally, chapter seven brings together the research and interview findings to form conclusions. It summarizes the main results, connects the theory to practice, and offers recommendations for businesses and policymakers. It also points out the limitations of the study and suggests ideas for future research to further explore how S&OP can support sustainability in supply chains.

2 Sales and operations planning process

The sales and operations planning process is a regular and ongoing monthly planning process. It is typically led by senior management and aims to balance supply and demand. The goal of the process is to optimize the use of resources such as production, distribution, and procurement (Nemati et al. 2017, 1). The S&OP process covers areas like production, production capacity, distribution, procurement, and financing. It ensures that these plans and capabilities are aligned with the overall business strategy. This process also evaluates both vertical and horizontal alignment within the organization. Vertical alignment refers to the connection between strategy, action plans, objectives, and decisions at different levels, while horizontal alignment focuses on the coordination of activities (Tavares et al. 2012, 2).

S&OP should be seen as a way for a company to develop and integrate its existing plans with its strategic goals. Although many companies have used this process for decades, managing it successfully remains a challenge (Laukkanen 2020, 3). The main objective is to achieve a good balance between supply and demand, which is crucial in supply chain management. S&OP is a cross-functional process that involves various managers, including those from sales, marketing, customer service, production, operations, logistics, supply chain, and procurement (Lapide 2007, 21).

Research shows that using the S&OP process correctly brings significant benefits to a company's performance (Ambrose 2016, 35). For example, a study by Bower (2006, 20) found that companies with an effective S&OP process saw a 14 % increase in operating margin, a 4 % rise in contribution margin, a 55 % reduction in inventory capital, and a 17 % increase in new product value. These results demonstrate the broad advantages of successfully implementing the S&OP process.

2.1 Process

Sales and Operations Planning is a process or framework that helps a company differentiate between task-specific plans and integrated plans (Gattorna et al. 2009, 161). To provide a clearer understanding of the process, the following section outlines the basic structure of the sales and operations planning process. While the specific process cycle may differ between companies, this chapter outlines the general sales and operations planning cycle, as described by Githens (2009, 162).

Figure 1 Sales and operations planning process cycle (Githens 2009, 162)

2.1.1 Demand planning

Demand planning is a continuous process that converts customer and market forecasts into the required volumes (Collin et al. 2006, 426). This involves creating early forecasts, often based on historical data. These demand forecasts are made early in the process and are based on known activities. The planning process evaluates sales forecasts in relation to company targets and budgets, aiming to address any potential gaps in these targets. At this stage, a meeting is held to agree on the demand forecasts and clarify any uncertainties (Gattorna et al. 2009, 161).

Although demand forecasts are just estimates and not guaranteed information, they are essential for creating sales and operational plans. These plans help the company adjust its operations based on forecasted needs, such as required components, business investments, or production and service capacity (Collin & Lorenzin. 2006, 422). The process moves to the next phase once there is agreement on the forecasts between the involved parties (Gattorna et al. 2009, 161).

2.1.2 Supply planning

Supply planning is a phase that helps matching demand with available capacity while also playing a key role in making strategic decisions. These decisions include managing inventory, planning transportation, and allocating resources effectively. By including these factors in the planning process, companies can build a supply chain that is more flexible and efficient, improving overall

operations and ensuring better customer satisfaction. (Stadtler et al. 2015, 94-95.) This phase takes the forecasts and compares them to the available resources and capacity. This stage also identifies where the forecasted demand does not match production capacity or if there's unused capacity. During this phase, the company reassesses any shortfalls in demand, production, and capacity. It is also essential at this point to consider different scenarios to understand the impact of storage and any potential resource constraints that could affect customer service. The process moves forward once these issues are resolved (Harrison et al. 2019, 230).

2.1.3 S&OP meeting

According to Vollman et al. (2005), the goal of sales and operations planning is to balance demand and supply and to alert early about potential issues if an imbalance occurs. At this stage, a preliminary meeting is held to identify unresolved gaps between demand and supply capacity. Proactive planning identifies remaining gaps or decisions, which are addressed in the final phase of the cycle, that is the meeting. In the preliminary meeting, other materials for the meeting are summarized and distributed to participants. The cycle moves to the next phase once the preliminary meeting is concluded. (Gattorna et al. 2009, 163.)

2.1.4 Sales and operations meeting

In the main meeting, the company's management reviews operational decisions. These decisions include production volume, marketing needs, procurement, budgeting, and product development. (Harrison et al. 2019, 231.) The meeting also reviews and resolves identified gaps and problems. Metrics to examine these issues may be discussed. At the end of the meeting, a general sales and operations plan is signed. (Gattorna et al. 2009, 163.) For supply chain agility, it is important that suppliers are informed about demand in terms of product quantities and timeframes (Collin & Lorenzin 2006, 422). This activity returns to the beginning of the cycle once the plan is signed, as the sales and operations planning process is a routine and continuous tool prepared at regular intervals to support business strategy (Gattorna et al. 2009, 163).

2.2 Characteristics of a high-quality S&OP

A good sales and operations planning process has one plan but many interpretations. This means that sales plans are expressed in a correct currency, production plans in thousands, and procurement plans in volume measures. The procurement plan contains a suitable collection of business elements

without too many internal or external factors considered. Capacity constraints should be realistic, and illustrative capacity can be used as an aid. (Gattorna et al. 2009, 165.)

For the process to work effectively, all components must work together and fulfil their roles. Components include operations and logistics, supply chain, marketing, sales, and finance. (Lapide 2007, 22.) For efficient operation, the company needs to deliver the required amount of product to the customer within the desired timeframe without generating excess inventory. This can be accomplished by continuous alignment of demand and supply. When all functions are aligned, the company can reduce inventories, improve utilization rates, lower costs, and improve customer satisfaction. (Nabil 2018, 176.)

Each function has its own area of responsibility. Operations and logistics develop plans based on demand forecasts. The supply chain then ensures proper synchronization of demand and supply functions. Marketing creates new demand plans to keep the supply chain competitive. The sales team's input is to develop sales plans and identify future sales opportunities. Finance converts demand and supply plans into financial terms, providing clear financial plans, such as budgets. If all these functions work seamlessly together, the process is likely to succeed. (Lapide 2007, 22.)

A good sales and operations planning process not only ensures that all elements work smoothly together but also includes clearly defined time frames. Gattorna's (2009, 165) model illustrates how different time zones in the process allow for varying levels of flexibility.

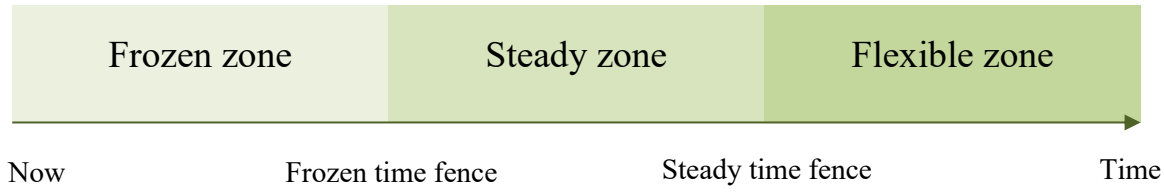

Figure 2 Time fences (Gattorna 2009, 165)

The far-right side of the graph represents a flexible zone, where changes can be made with minimal restrictions and at a low cost. As we move into the steady zone, changes are still possible, but careful management is necessary since many activities may already be underway. Finally, in the frozen zone, changes are very costly because the process is too close to execution, and most

activities are already fixed. The boundaries of these zones vary depending on a company's environment and cost structure. (Gattorna 2009, 165.)

Wallace (2006, 20) emphasizes that a hallmark of an effective S&OP process is avoiding overly detailed demand forecasts. When the process functions correctly, detailed forecasting becomes unnecessary, and unusual demand for specific products is effectively managed. Keeping demand forecasting simple in the S&OP process can help reduce mistakes and make the supply chain more flexible. Overly detailed or complex forecasting can create inefficiencies and slow down decision-making, especially in fast-changing markets. By concentrating on the most important metrics and encouraging teamwork in planning, businesses can more effectively predict and handle unexpected situations, leading to smoother operations and better customer satisfaction. (Thomé et al. 2012, 10.)

2.3 S&OP maturity model

When talking about high-quality S&OP process, maturity models need to be discussed. The maturity model shows that as companies improve their S&OP process, they move from simply responding to issues to predicting them, working together, and eventually fully coordinating their efforts. Their goals also change over time, starting with making a basic plan, then a workable plan, followed by a profitable one, and finally a plan based on real demand. As businesses get better at using S&OP, they include other departments like sales and marketing and use technology to manage data and reporting more easily. The maturity model also serves as a helpful guide for companies wanting to strengthen their S&OP process. (Raman 2017, 12.) Below is introduced an S&OP maturity model produced by Lapide (2005, 19):

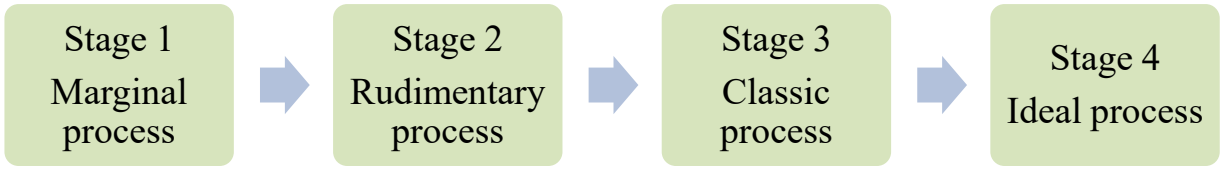

Figure 3 S&OP maturity model (Lapide 2005, 18)

The sales and operations planning process develops through four stages, each offering more advanced integration and efficiency. At stage 1, the marginal S&OP process relies on minimal technology. Departments work independently, often using spreadsheets, and there is little effort to align plans across the organization. Moving to stage 2 requires setting up a formal process where departments begin to share and harmonize their plans. (Lapide 2005, 18.) For S&OP to be world class, the supply chain's global plan needs to be to the shared with the entire organisation (Neto et al. 2022, 10).

In stage 2, the rudimentary S&OP process introduces some structure, such as scheduled meetings and shared demand plans. However, participation is inconsistent, and plans are not fully integrated. Departments use separate software systems, sharing data manually, which limits collaboration. To move to stage 3, organizations need executive support to ensure meetings are taken seriously and encourage collaborative, consensus-driven planning. (Lapide 2005, 18-19.) An effective S&OP process improves visibility of demand and supply both within the company and across the supply chain. It also helps make revenue management more predictable, enhances promotion planning, and supports more accurate budget allocation and strategic planning at the company level. (Kumar & Srivastava 2014, 20.)

At stage 3, the classic S&OP process aligns demand and supply plans more effectively. Regular meetings are held, where rough drafts of demand and supply plans are adjusted collaboratively. Input from key customers and suppliers is included, and technology systems start to integrate, enabling shared updates across departments. Progressing to stage 4 involves increasing the frequency of meetings and improving collaboration with external partners. (Lapide 2005, 19.) The effectiveness and benefits of the sales and operations planning process can be evaluated by looking at the meetings, the alignment of plans, and the technologies used. Meetings are assessed based on how often they occur and the level of attendance. Plan alignment focuses on how well demand and supply plans are coordinated, both within the company and with external partners like suppliers and customers. (Aveskamp 2023, 22.)

Stage 4, the ideal process, is more of a benchmark than a fully achievable state. It uses real-time systems to track supply and demand, triggering meetings when issues arise. Virtual meetings allow instant adjustments to plans using advanced tools like a global S&OP workbench. These tools help optimize supply and demand plans quickly. At this stage, external collaboration with customers and suppliers is fully integrated, creating seamless alignment both within the company and with its partners. (Lapide 2005, 19.)

Wagner et al. (2014, 195) describe the maturity model by outlining key dimensions that contribute to an effective sales and operations planning process. The first dimension, process effectiveness, ensures that S&OP follows the right approach. It includes the need for structured planning. This means identifying a scope, that defines the key activities and data required. It also defines collaboration and alignment, which focuses on sharing information and working together efficiently. The second dimension, which is process efficiency, ensures that planning is done with minimal effort. This includes information preparation and sharing, which helps avoiding unnecessary work, which improves the scheduling and organization of S&OP meetings. The next dimension, people and organization dimension ensures clear roles and responsibilities within the S&OP process. It includes roles, responsibilities, and structure, which define accountability, and knowledge, commitment, and sponsorship, which reflects employee engagement and support from management. Lastly, information technology strengthens S&OP by supporting systems and functionalities, ensuring seamless integration, and maintaining master data for accurate and reliable information in decision-making.

The S&OP maturity model serves as a tool to help companies evaluate their current planning processes and identify their technology needs. It allows organizations to determine which stage of the S&OP process they are currently in, though it is important to note that companies may tend to overestimate their level. (Lapide 2005, 19.) As companies move through the stages of maturity, they can better align their supply chain functions, make smarter decisions, and achieve stronger long-term results. By following the maturity model, businesses can develop their S&OP processes in a way that improves daily operations while also supporting their long-term strategic goals. (Grimson & Pyke 2007.)

Once a company understands its current stage, the focus should be on progressing to the next stage rather than skipping multiple stages, as doing so can be overly ambitious and likely to fail. Comparing the current processes to those of the next stage helps identify gaps that need to be addressed. Each gap should be evaluated based on the costs and benefits of the required process and technology changes. From this evaluation, the company can create a roadmap outlining when and how each initiative will be implemented. It is advisable to start with initiatives that deliver clear, proven benefits in the shortest time. (Lapide 2005, 19.)

While the S&OP maturity model may not lead every company to Stage 4, it can significantly improve their processes over time. With the proper implementation of enabling technologies and guided process changes, companies can achieve substantial benefits as they move closer to more

advanced stages of the S&OP process. (Lapide 2005, 28.) Mature sales and operations planning process is important for helping businesses make more profit and run their supply chains better (Hansali et al. 2021, 1511).

Danese et al. (2018, 2040) suggest a maturity model with five dimensions and five stages that acts as a guide for companies looking to improve their S&OP processes. By evaluating their current level of maturity and working on specific areas that need improvement, businesses can better match supply with demand, improve teamwork between departments, and respond more effectively to changes in the market. Along with adopting new technologies, it is also important for companies to create a culture of ongoing improvement and gain strong support from top management. Using the maturity model as a strategic tool can help organizations not only improve how efficiently they operate but also strengthen their position in the market. S&OP should be integrated as a permanent function within the company rather than treated as a short-term project with a set deadline (Wagner et al. 2014, 200).

2.4 Demand forecasting

Demand forecasts are a critical tool in sales and operations planning. In fact, demand forecasting can be considered a key factor in the efficiency of supply chain operations (Chopra et al., 2001, 198). Many business plans and decisions rely on forecasts (Kolassa et al., 2016, 6). According to Galleco-Garcia (2021, 1), forecasting serves as the foundation of effective planning. Successful planning depends on accurately forecasting how the company, its various departments, and their environments will evolve. Not only must forecasts be made, but they also need to be regularly updated. Drake (2012, 8) emphasizes that failure to update demand forecasts is a significant cause of the bullwhip effect. The 'bullwhip effect' refers to the increasing variability of orders as they move up the supply chain, from retailers to wholesalers, from wholesalers to manufacturers, and from manufacturers to suppliers (Sucky, 2009, 1).

When discussing demand forecasting methods, a distinction can be made between quantitative and qualitative approaches. Both techniques are essential. Quantitative techniques are valuable for analysing cause-and-effect relationships based on past data. In contrast, qualitative techniques are beneficial for understanding how the future may differ from the past (Moon, 2018, 85). Quantitative analysis aims to generate precise numerical predictions, while qualitative analysis focuses on providing structurally sound forecasts (Kim et al., 2021, 5).

The primary concept of quantitative demand forecasting is to analyse past data and apply documented models of demand (Moon, 2018, 87). Quantitative demand forecasting can be conducted using methods such as time series models. A time series model is employed to describe the relationship between the historical data of a variable and a random disturbance term. The advantage of time series models is that, as they rely solely on historical observations, they are cost-effective to implement (Song & Gang, 2008, 210). While time series models can become complex when dealing with large volumes of data, the use of algorithms for example, significantly simplifies the process of analysing different time series (Wick, 2020, 37).

The time series model helps explaining the relationship between a variable's history and random disturbances that affect it. An advantage of time series models is that they are cost-effective since they only need historical data as input (Song & Gang 2008, 210). While time series models can be challenging to work with when there is a large amount of data, using tools like algorithms makes it easier to organize and analyze different time series (Wick 2020, 37).

Exponential smoothing is one of the most effective and reliable methods for predicting a time series. To understand it better, we'll look at it without considering trends or seasonality. In this case, the variation in demand forecasts comes from random factors, like long-term shocks that affect the time series, and short-term shocks, which also impact it. For an accurate assessment, it's helpful to distinguish between these two types of effects. In practice, it's best to assume that the number of random changes in level is small. The best way to predict demand is to use all available data, calculating a long-term average over the entire time series. (Kolassa & Siemsen 2016, 51-52.)

To calculate a demand forecast for a specific period, you multiply the smoothing parameter by the forecast error and then add this result to the previous time period's forecast. The smoothing parameter is a value between zero and one and can be estimated, for example, with a moving average. A moving average is similar to a weighted average of past observations over time, but in a moving average, only the most recent observations are included, each given equal weight, while older ones have a weight of zero. The demand forecaster decides how many recent observations to include. There are up to 30 variations of exponential smoothing models, but most modern software can automatically select the best model for each business using random data samples. (Kolassa & Siemsen 2016, 54.)

Another model for quantitative demand forecasting is regression analysis. The simplest form is simple linear regression, which analyzes one independent variable at a time. Linearity means assuming a linear relationship between the dependent and independent demand variables. This can

be done, for example, by comparing the demand data for a specific month with the monthly advertising expenses for that month for a specific product. (Moon 2018, 107.)

Qualitative demand forecasting involves using the opinions, knowledge, and intuition of experienced individuals to create formal forecasts. While quantitative demand forecasts can be derived from various sources, the most common internal sources include senior managers, marketing, and the sales team. Senior managers typically offer better insights into long-term changes, whereas the marketing and product development teams are more focused on short-term changes. However, it is the sales team that most frequently produces qualitative forecasts, as they possess the most valuable insights into future demand from individual customers (Moon, 2018, 113-115).

One qualitative demand forecasting method is the sales force composite method. In this method, forecasts are made based on the knowledge and experience of salespeople and sales management. This method can be used, for example, by conducting surveys among the staff, and the results can be used to make predictions about future changes in demand. (Moon 2018, 125.)

Demand forecasting models used by companies are often a combination of both quantitative and qualitative methods (Badulescu, 2021, 661). Quantitative forecasts are generally more accurate than qualitative ones. Therefore, qualitative forecasts are often used to complement quantitative forecasts, enhancing the overall accuracy of predictions when both aspects are considered. However, qualitative techniques can also be used independently, particularly in project-based enterprises. These techniques are most effective when supported by a structured performance process, measurement, and regular feedback (Moon, 2018, 131).

3 Sustainability in a supply chain

In recent years, an increasing number of multinational corporations have promised to work only with suppliers who meet social and environmental standards. These corporations typically require their direct suppliers to follow these standards and ask those suppliers to ensure their own suppliers do the same. This creates a chain reaction of sustainable practices throughout the entire supply network. (Villena & Gioia 2020, 86). Many people, whether from large or small and medium industries, use natural and human resources to boost company profits. However, this can lead to negative long-term effects. While profits may rise in the short term, the production process can cause environmental damage, leading to increased costs for cleanliness, health, and sustainability. This ultimately harms the company's reputation. (Anggraini & Tanjung 2020, 648.)

3.1 ESG and SDGs

ESG (Environmental, Social, and Governance) is used to evaluate how a company focuses on sustainability, including its environmental care, social responsibility, and business practices. These standards look at how a company protects the environment, treats its employees and partners, and manages its leadership and finances ethically. (Cristina & Zalles 2022, 31.) ESG is an important framework for businesses to grow in a sustainable way. Making ESG part of management and investment decisions is now essential worldwide. This study aims to provide useful advice to businesses, government regulators, financial institutions, and researchers. Companies should improve governance, leadership, and employee training to reduce risks. Governments should create fair policies and reporting systems to regulate ESG and make investment decisions easier. Financial institutions can analyse governance to provide better investment advice. Encouraging ESG across different sectors will help businesses grow while protecting the environment and society. (Li et al. 2021, 25.)

Companies and investors in emerging markets are paying more attention to ESG issues. There is a growing need for companies to align their ESG reports with the UN SDGs (United Nations Sustainable Development Goals), so it is important to understand how a company's ESG actions affect a country's progress toward these goals. Companies need to rethink their future business strategies to remain profitable. (Soni 2023.) In 2015, all United Nations member states adopted the 2030 Agenda for Sustainable Development, which outlines a common plan for achieving peace and prosperity for both people and the planet, both now and in the future. The agenda includes 17 Sustainable Development Goals (SDGs), which urge all countries, whether developed or

developing, to take immediate action in global cooperation. These goals stress the importance of ending poverty and other hardships while also improving health, education, and economic growth, reducing inequality, and addressing climate change, all while protecting oceans and forests. (United Nations 2025.)

Figure 4 United Nations Sustainable Development Goals (United Nations 2025)

Each year, the UN Secretary General publishes a report on the progress of the SDGs, developed with support from the UN System. This report uses data from national statistics and regional sources, following the global indicator framework. (United Nations 2025.) But how can companies achieve these goals? The next chapters will introduce strategies that will increase companies' sustainability.

3.2 Green supply chain management

Green supply chain management (GSCM) focuses on optimizing the flow of materials and information throughout the value chain. It emphasizes considering ecological and social factors in business decisions. Prioritizing sustainability in management decisions goes beyond managing risks and uncertainties. It helps companies save costs, improve efficiency, and attract new customers and suppliers. Additionally, it can provide a competitive edge and increase profits. This approach impacts all areas of a business, especially those with high emissions and waste. (Kumar et al. 2012,

1279.) GSCM can be divided into six components: green procurement, green manufacturing, green logistics, reverse logistics, eco-design and sustainable packaging (Achillas 2019).

Green supply chain framework was introduced by Achillas (2019) and is presented as follows:

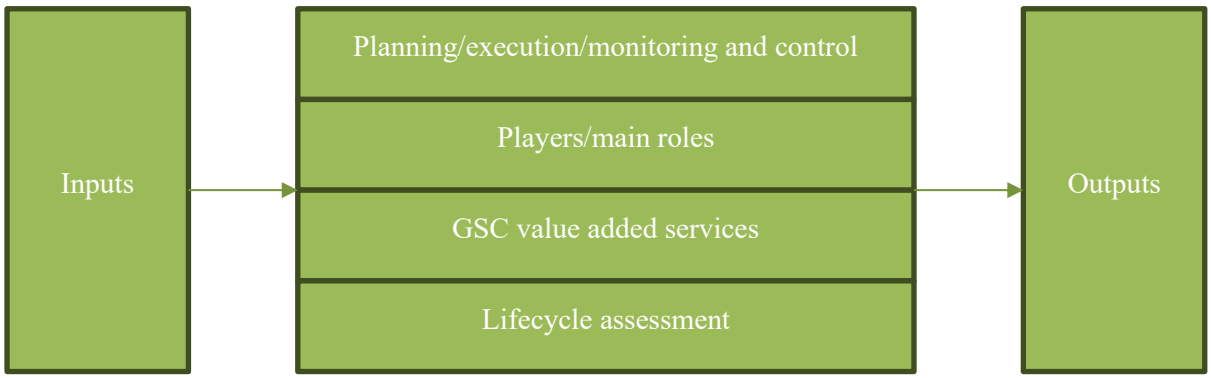

Figure 5 Green supply chain framework (Achillas 2019)

This framework highlights the wide range of areas involved in green supply chains, bringing together environmental, business, and technological goals. Its purpose is to guide organizations in managing their supply chains to meet sustainability objectives while also gaining competitive benefits. (Achillas 2019.)

It starts by identifying key factors—such as laws, market demands, and new technologies—that drive companies toward adopting more environmentally friendly practices. These factors are described as inputs in the framework. The process includes green logistics, life cycle assessments, and other sustainable activities, all coordinated through planning, execution, and monitoring. (Achillas 2019.) The process also has its boundaries. The boundaries can be cultural, organizational, political, informational, legal, proximal, technological, temporal or economic. (Sarkis 2012.)

A central part of the framework is the need for collaboration between different organizations, showing the importance of managing relationships with suppliers, customers, and other key partners. It also emphasizes the role of reverse logistics and closed-loop supply chains, where products are designed to be reused or recycled to reduce their environmental impact throughout their entire life cycle. (Achillas 2019.) It is important to connect forward and reverse supply chain processes to create more efficiencies and improve operations. Currently, the most common way to

achieve this is by sharing resources like equipment, facilities, and personnel. (Plaza-Úbeda et al. 2020.)

The green supply chain management framework brings several important benefits. It helps businesses lower their environmental impact by reducing waste, cutting emissions, and reusing materials through practices like reverse logistics. The framework also encourages companies to work closely with suppliers and other partners, improving cooperation and efficiency. Additionally, it helps businesses save money by using fewer resources and ensures they follow environmental laws while meeting consumer demand for eco-friendly products. Overall, this approach helps companies become more sustainable and competitive. (Achillas 2019.)

3.3 Closed-loop supply chains

In this approach, materials and products are reused or recycled within the supply chain, forming what is known as a circular economy. Manufacturers collect used products, take them apart, and either reuse or recycle their parts. This helps to reduce waste and the use of new resources. A closed-loop supply chain enhances resource efficiency, reduces waste, and lowers environmental impacts. (Guide & Van Wassenhove 2009, 10.)

A closed-loop supply chain could be comprehensively described as follows:

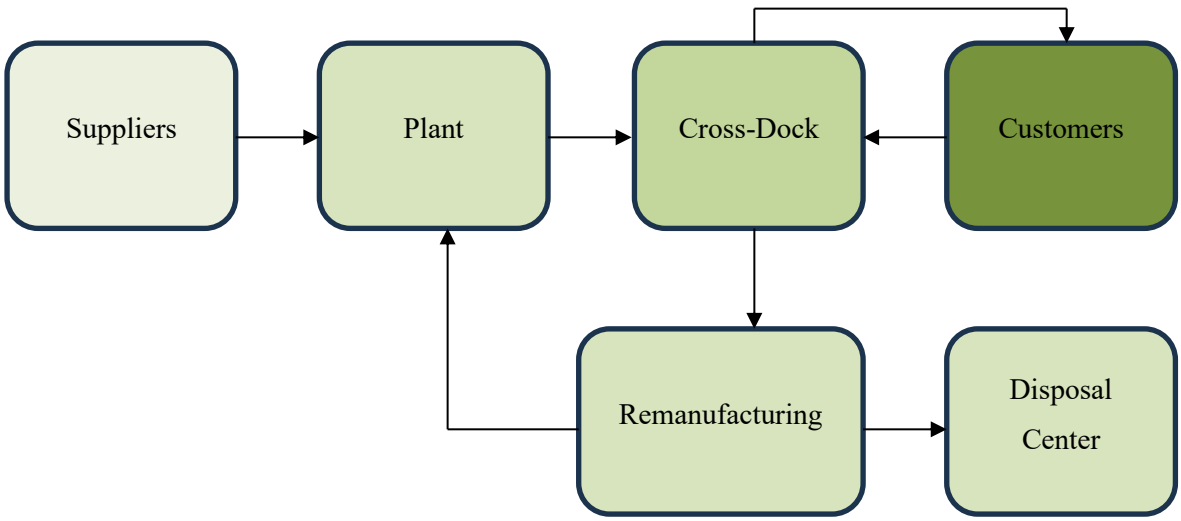

Figure 6 Closed-loop supply chain network (Tavana et al. 2022)

The closed-loop supply chain network consists of suppliers, a manufacturing plant, cross-docking centers, customers, remanufacturing facilities, and disposal centers. This arrangement allows for effective management of both forward flows of materials; from suppliers to customers and reverse

flows from customers back to remanufacturing or disposal centers. (Tavana et al. 2022.). Along with the components mentioned, Liu et al. (2020, 23-24) discuss the idea of dual-channel sales and collection in a global closed-loop supply chain. This method combines both online and offline sales and collection channels, improving the flexibility and efficiency of the supply chain network.

From a forward logistics perspective, this process involves moving raw materials from suppliers to the manufacturing plant and then delivering them to customers through cross-docking. This method enables quick transfers of products without requiring a lot of storage space. From a reverse logistics perspective, this part of the process includes collecting returned products from customers to be sent for remanufacturing or disposal. It uses methods like recycling and refurbishing to reduce waste and make better use of resources. (Tavana et al. 2022.)

3.4 Life cycle assessment

Environmental factors should be included in various types of decisions, especially those related to goods and services. To achieve this, it is essential to have access to relevant knowledge. When examining the environmental impacts of products and services, it is crucial to take a life cycle perspective. This approach helps prevent shifting problems from one stage of the life cycle to another or from one geographical area to another. Additionally, it is important to conduct a thorough assessment of environmental issues to avoid transferring problems from one area of concern to another. (Finnveden et al. 2009, 17.)

Life cycle assessment (LCA) is a method that helps companies measure the environmental impact of their products from the start of production, including raw materials, to the end of their life when they are disposed of. The use of life cycle assessment aids in minimizing the environmental impact of a product from cradle to grave. (Rebitzer et al. 2004, 702-703.) LCA can be used to compare the potential environmental impacts of different products, systems, or services. It helps identifying ways to improve organization’s environmental performance at various stages of their life cycles and supports decision-makers in strategic planning, setting priorities, or redesigning products and related processes effectively. (Boirron et al. 2021, 9-10.)

Life cycle assessment is defined by Hellweg & Milà i Canals (2014, 1109) as the compilation and evaluation of the inputs, outputs, and potential environmental impacts of a product system throughout its life cycle. This process is generally carried out in four main steps: goal and scope definition, inventory analysis, life cycle impact assessment (LCIA) and interpretation. One of the main challenges is organizing and presenting the wide range of LCA and specialized models in a

practical way to address different types of life cycle sustainability questions (Guinée et al. 2011, 94). LCA framework is defined by Su et al. (2017, 311) as follows:

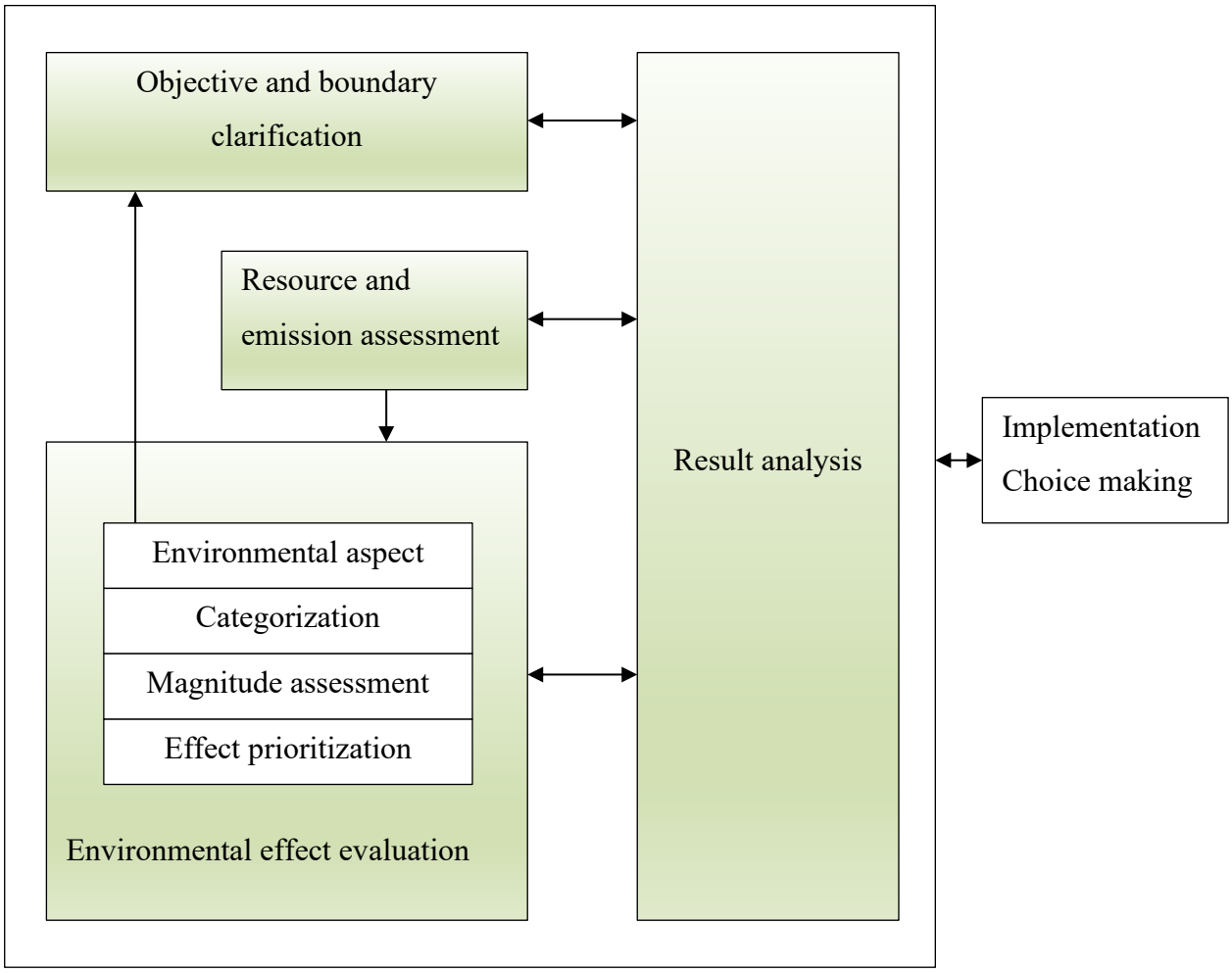

Figure 7 LCA framework (Su et al. 2017, 311)

The figure outlines the steps of a life cycle assessment framework used to analyse a product's environmental impact throughout its lifecycle. It begins with goal and scope definition, where the purpose, objectives, and boundaries of the assessment are defined. This is followed by life cycle inventory analysis, which involves collecting data on material usage, energy consumption, and emissions at each stage of the building's lifecycle. The next phase, life cycle impact assessment, evaluates these data by identifying the types of environmental impacts, grouping them into categories, measuring their magnitude, and prioritizing them based on importance. These findings are then reviewed in the interpretation phase, which helps identify areas for improvement and actionable insights. Finally, the results inform the application and decision stages, supporting sustainable design, construction, and operational practices. This was later enhanced to include

dynamic adjustments, reflecting changes in usage patterns, technological advancements, and environmental conditions over time. (Su et al. 2017.)

According to Hellweg & Milà i Canals (2014, 1109.), the first step of LCA involves outlining the objectives and establishing the system boundaries. For example, in an LCA focused on freight transport, one objective could be to compare the sustainability of rail versus road transport. The system boundaries might include various stages such as resource extraction and processing, manufacturing of vehicles and infrastructure, vehicle operation, and disposal. Defining the goal and scope is crucial when interpreting results, as these decisions shape how data is collected and how the system is modelled and assessed. These choices greatly affect the reliability of the conclusions and recommendations drawn from the LCA results. (Hauschild et al. 2018, 62.)

The second step is to gather data on the inputs and outputs associated with each stage of the life cycle. This information is then summarized for the entire system. Typically, this analysis includes quantifying hundreds of emissions and resource usages. (Hellweg & Milà i Canals 2014, 1109.) Gathering data can be made through big data for example. The potential uses of big data are vast, and big data techniques can support the entire life cycle of a product. (Li et al. 2015, 682.)

In the third step, the emissions and resource usage data are categorized based on their environmental impacts and converted into common units for comparison. For instance, CO2 and CH4 emissions can be expressed in terms of CO2-equivalent emissions using their global warming potentials as defined by the intergovernmental panel on climate change (IPCC). There is widespread agreement on the data and modeling methods used for certain impact categories. (Hellweg & Milà i Canals 2014, 1109.) The metrics can be for example cumulative energy demand, cumulative fossil energy demand, cumulative renewable energy demand, consumptive water footprint and water emissions footprint. (Guine et al. 2002, 7-8.)

The final step involves interpreting the results from the inventory and impact assessments to address the objectives. For instance, in the context of freight transport, an LCA might indicate that road transport has more significant negative impacts on human health and ecosystems compared to rail transport. (Hellweg & Milà i Canals 2014, 1109.) While LCA offers a general structure for carrying out an assessment, it allows for significant interpretation. Additionally, it must be complemented by other tools or methods to support decision-making. These could include for example risk assessments, site-specific environmental evaluations or cost analyses. During the scoping phase, it is helpful to determine where and how these additional tools will enhance the insights provided by the LCA. (Curran 2013, 276–277.)

3.5 Energy efficiency and emissions reduction

Businesses aim to lower the energy they use in manufacturing and reduce the emissions they produce. This can be achieved through more energy-efficient machines, using renewable energy, or adopting carbon offset programs. Improving energy efficiency in the manufacturing process can significantly reduce operational costs and carbon emissions. (Brown & Sovacool 2011.) Renewable energy systems can also be integrated into existing manufacturing power systems. Matching the energy needs of manufacturing with the availability of renewable energy can increase the use of these sources, leading to lower energy costs and reduced CO_2 emissions. (Materi et al. 2021, 677-678.) Below are presented the footprint and reduction options in different stages of product's life cycle (Ji et al. 2014, 214).

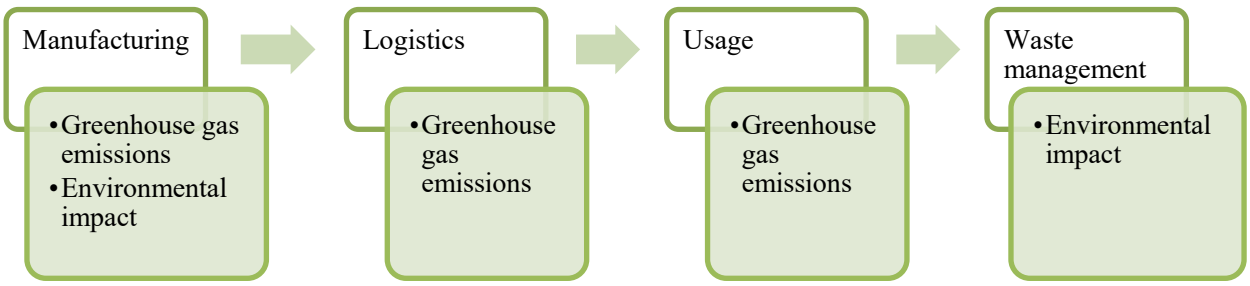

Figure 8 Footprint in different phases of life cycle (Ji et al. 2014, 214)

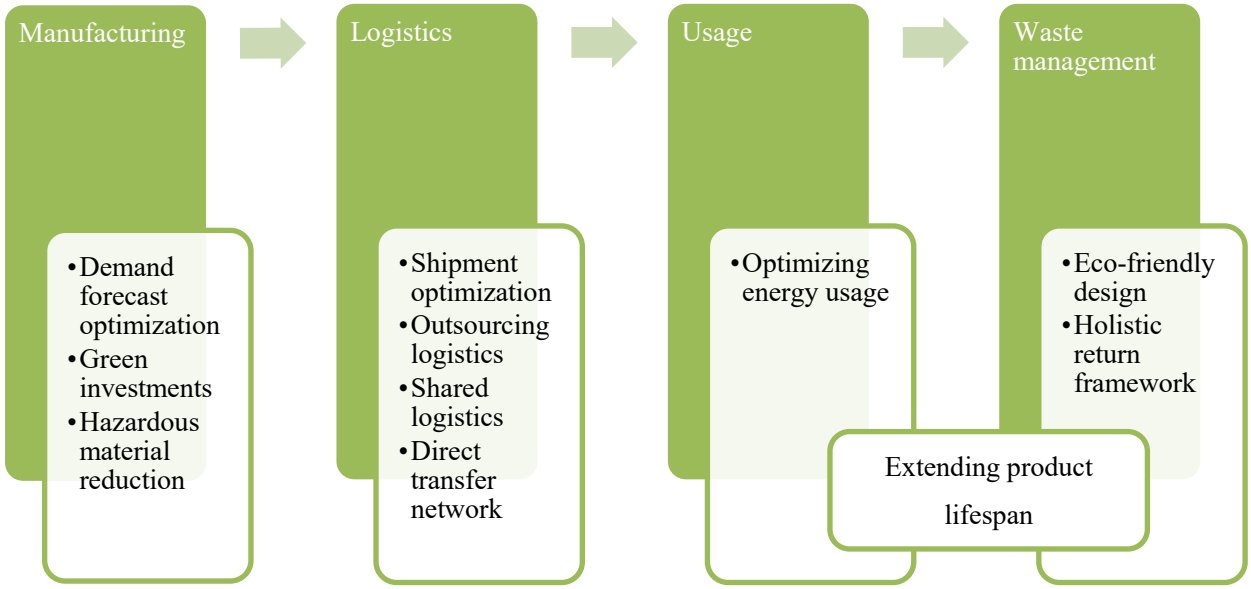

Figure 9 Environmental footprint reduction (Ji et al. 2014, 214)

As environmental damage and global warming increase, governments are enforcing rules to limit company emissions. This means businesses must focus on managing their impact on nature and carbon emissions. Strategies to reduce environmental harm include removing toxic materials, improving demand predictions, making transportation more efficient, saving energy, and expanding recycling programs. Aligning business practices with sustainability rules can lower costs and reduce harm to the environment. In the long run, companies must balance economic success with environmental and social responsibility to build a more sustainable future. (Ji et al. 2014, 218.) Using smart technologies, clean energy, and efficient resource management can help businesses grow while reducing harm to the environment (Feroze 2024, 31).

A significant potential for energy savings remains largely untapped in industrial systems because it is tied to operations and management practices that are challenging to regulate. Industrial systems are common in manufacturing settings, but their applications vary widely. Achieving complete system optimization cannot be done solely through component standards, labeling, or a "one size fits all" approach. For these reasons, most voluntary agreements (VAs) across the EU have focused on energy consumption in industrial processes. While VAs typically target large industrial energy users, they are increasingly being applied to medium-sized industrial users, the service sector, and more recently, the transport and public sectors. (Rezessy & Bertoldi 2011, 7127-7128.)

Some VAs depend heavily on financial support from public authorities to help signatories implement measures to meet their targets, such as funding for energy audits and plans. Other VAs complement energy or CO2 taxation by offering the possibility of tax credits or rebates if certain energy efficiency commitments are met. All existing VAs include specific targets for participating parties and often require various planning and implementation activities to help signatories achieve these targets. In return for these commitments, authorities may delay legislation, provide easier access to environmental licenses, offer financial support for certain actions, grant energy or carbon tax exemptions or reductions, and create programs that recognize government and public efforts. They may also provide information on energy-efficient technologies, government assistance, and training in energy management. (Rezessy & Bertoldi 2011, 7128.)

Reducing carbon emissions is mainly done for environmental reasons, but decision-makers must also show how their choices benefit key stakeholders, such as through economic gains or competitive advantages. Rising energy costs and concerns about energy security, especially in areas affected by supply disruptions, have led to greater awareness of energy expenses. This has driven improvements in energy efficiency programs, though progress has been slower in regions with

stable energy supplies. (Fernando & Hor 2017, 71.) A challenge with some widely supported policies, such as biodiesel incentives or subsidies for energy efficiency, is that they can be very costly. This can be due to technical challenges or how people react to them. The real costs are often hidden and only become clear when examined by economists, making these programs seem cheaper than they actually are. (Gillingham & Stock 2018, 69.)

Manufacturing companies are improving how they manage energy, but efforts to reduce carbon emissions are still behind. This is expected to change as businesses develop better energy management systems that also reduce costs. To make this shift happen, the government and private sector need to work together to create local carbon emission standards and long-term plans to help the manufacturing industry lower emissions. The lack of clear carbon emission standards and limited information on green technology make it difficult for manufacturers to set goals and reduce emissions. The government can help by offering incentives to encourage companies to track and cut their carbon emissions through better energy management. (Fernando & Hor 2017, 71.)

4 Achieving sustainability through S&OP

According to Bachar (2022) integrating sustainability data into the sales and operations planning process allows us to use this data in more impactful ways. It helps us plan for future supply chain needs while factoring in our commitment to making better, more sustainable decisions. This is just one of many ways companies can work toward their sustainability goals. S&OP can make sustainability data actionable by embedding these objectives into the planning process, tracking performance against targets, assessing impact, and enhancing sustainability efforts through simulations and planning adjustments.

4.1 Sustainability through demand forecasting

In sustainable supply chain management, using predictive models is essential. These models help companies get ready for future situations, allowing them to meet customer needs and respond effectively to changing market demands. Choosing the right demand forecasting method is essential for sustainable development in manufacturing. A suitable forecasting method helps companies prevent both overproduction and shortages. (Chu & Nghiem 2023, 17.)

Stockouts and overstocks can lead an organization making unsustainable decisions (Abiade 2024, 2). Accurate demand forecasts are essential for maintaining optimal inventory levels, helping to prevent both stockouts and excess stock (Dalal et al. 2024, 2). This strategy allows retailers to match their supply with customer demand, reduce waste, and improve their overall inventory management (Ikpe & Shamsuddoha 2024, 9).

Kolassa (2023) highlights four reasons why demand planning is essential for a company to achieve sustainability. First, more accurate forecasts can help reduce waste by enabling better planning of capacities and safety stock. Second, good forecasting provides insight into the effects of future actions, such as estimating the potential waste of perishable items. Third, forecasting is essential for sustainable business operations, as companies with poor forecasts may find it difficult to meet demand and stay competitive. Lastly, the article highlights the environmental impact of the forecasting process itself, particularly in terms of resource use and CO2 emissions.

Supply chains have become more complex and larger due to the continuous flow of materials. Effective planning, management, and control of these large material flows are essential for long-term social and economic development in today’s global business environment. A company's management and manufacturing systems should include a demand forecasting system that predicts

independent demand or consumption accurately. This accurate forecasting allows for sufficient production of final products and parts without causing overproduction or shortages. In the end, manufacturing systems built on advanced forecasting play a key role in supply chains, supporting environmental protection and long-term sustainability by ensuring that production and material flows are appropriate within regional or global supply chains. (Hart et al. 2016.)

Forecasting, in the short term, plays an important role in improving supply chain performance and supports sustainable business growth that aligns with market needs and competition. Short-term forecasts are essential for a company's planning and management. Accurate forecasts help reduce costs, streamline processes, and increase customer satisfaction, which leads to higher profits and improved operational safety. (Borucka 2023, 18.)

In demand forecasting research, artificial intelligence is highlighted as a key technique in Industry 4.0, along with other methods using the Internet of Things (IoT) and modern data collection technologies. This is made possible by the rapid growth of companies and their increasing use of computers and digital tools. However, many smaller businesses are less advanced, with some relying mainly on managers' experience rather than on mathematical methods for forecasting. (Borucka 2023, 18.)

4.2 Sustainability through supply planning

Effective inventory control in a supply chain is essential for companies aiming to meet customer demands while also managing costs (Dolgu & Prodhon 2007, 269). With a focus on sustainable development, the approach to evaluating supply chain financing performance has changed. Current evaluation systems mainly focus on economic benefits and financial indicators. However, to support sustainability, additional non-financial indicators, such as social contributions and environmental protection, should also be included. (Liang et al. 2018, 14.)

To support sustainable development, commercial banks must consider all stakeholders when making decisions about supply chain financing. This means looking beyond financial indicators that focus on economic interests to include non-financial indicators that reflect long-term social and environmental impacts. These non-financial indicators should be aligned with both current and future societal goals, using a more scientific and efficient approach. Supply chains that do not follow this approach could face reduced or terminated investment contracts. Such a strategy would help commercial banks significantly reduce their investment risks in supply chain financing. (Liang et al. 2018, 14.)

Sustainability could be considered as an application to three key areas: economic or financial factors, environmental protection, and the well-being of communities and individuals—known as the triple bottom line (TBL) of sustainability. This approach aims to improve economic and social quality of life while keeping environmental impacts within nature's limits. In this framework, the best solutions to any challenge provide lasting benefits across all three areas. (Arowoshegbe et al. 2016, 92.)

Following the triple bottom line theory, supply chains can benchmark and evaluate their sustainability performance to improve products and processes. This approach encourages firms to adopt financing strategies that consider the long term, enhancing their sustainability practices. A holistic approach like this can help reduce the negative impacts on society and the environment. (Liang et al. 2018, 15.)

The approach to evaluating supply chain financing performance has evolved, with more scientific development concepts gradually becoming central. This shift means that supply chain evaluations now focus not only on profitability but also on the triple bottom line, creating potential benefits for the economy, society, and the environment. (Liang et al. 2018, 15.) For example, a study by Tundys & Wiśniewski (2023) found out that TBL factors play a key role in creating strong and sustainable supply chains.

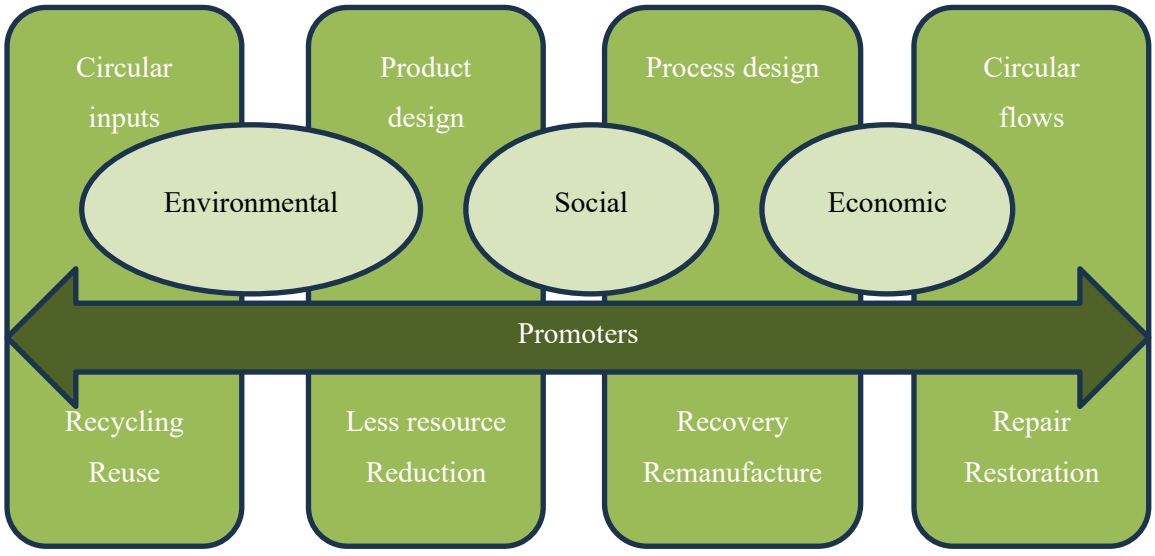

Figure 10 Triple Bottom Line framework (Santiago et al. 2023, 677)

The proposed model connects the four components of circular supply chain management with the three dimensions of the triple bottom line and uses the Rs of the circular economy as key links in the process. The Rs—reuse, recycling, recovery, reduction, remanufacturing, repair, and restoration—are essential for maintaining a circular supply chain, as noted by several researchers. This model also includes the TBL dimensions, which focus on environmental, social, and economic aspects. From this perspective, sustainable development integrates social fairness, strong economic foundations, and environmental care. (Santiago et al. 2023, 676-677.)

Addressing all the Rs of the circular economy and the TBL dimensions is crucial for understanding the connections between social pressure, environmental responsibility, green economic incentives, supply chain management, and sustainable circular supply chain design, as well as improving cost-saving capacity. (Santiago et al. 2023, 676-677.) By taking in account all the aspects of TBL in sales and operations planning meetings, managers can adjust their strategic planning in a way that supports sustainable economic, environmental and social development (Duarte Azevedo et al. 2021, 134).

4.3 SS&OP

Transitioning from a traditional to a sustainable sales and operations planning (SS&OP) process requires incorporating the perspectives of both internal and external stakeholders into the planning process, supported by integrated IT systems. This highlights the importance of joint planning with external stakeholders to challenge internal decisions and drive pro-environmental and social changes within the organization. This emphasizes the need for collaboration, advanced IT systems, and integration across functions to create a demand response that meets customers' sustainability needs. (Roscoe et al. 2020, 3537.)

IT systems alone are not sufficient to enable an effective SS&OP process. Instead, information sharing is essential to fostering collaboration and communication between internal and external stakeholder groups. IT is crucial for helping firms deliver sustainable value to stakeholders while creating competitive advantages for themselves. Specifically, software tools that improve information visibility among supply chain partners and facilitate sharing of sustainability-related data during planning are critical for achieving firm sustainability. Collaborative planning and integrated IT systems provide more accurate information about supplier activities, enhancing the quality and accountability of supply and logistics plans. (Roscoe et al. 2020, 3537.)

According to Sengupta & Dreyer (2024, 108) the shift to sustainable S&OP faces four main challenges: cultural, capability, collaborative, and contextual factors:

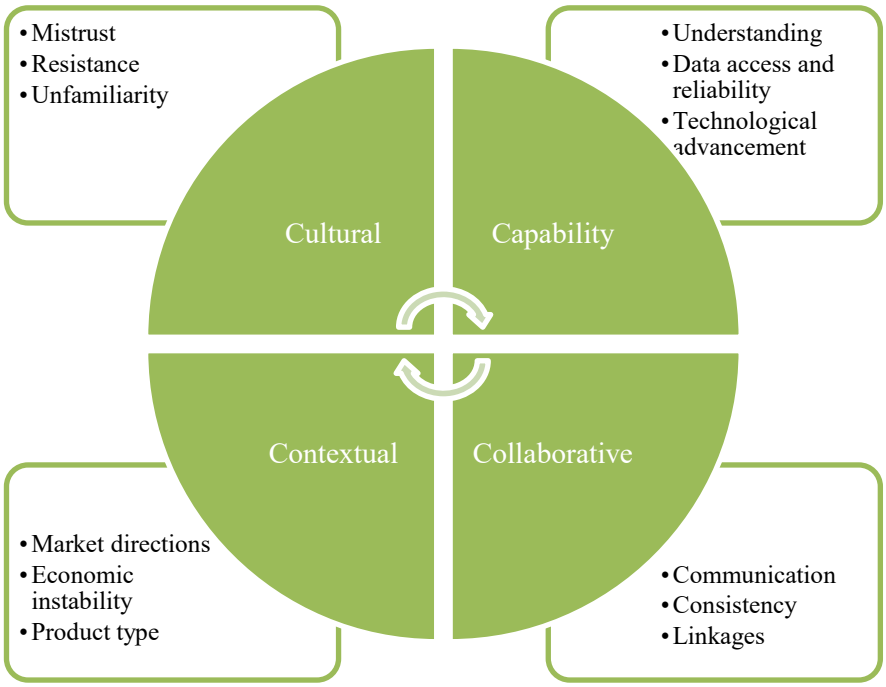

Figure 11 Sustainable S&OP challenges (Sengupta & Dreyer 2024, 108)

Culturally, some companies are skeptical about adopting digital tools or are satisfied with their current systems, while others lack experience with technologies like big data and blockchains. Capability challenges include limited understanding of technology, poor data quality, and immature systems, which make adoption difficult. Collaboration issues stem from trouble coordinating with different stakeholders, lack of standardized systems, and dependence on suppliers, which complicates integration. Contextual factors, such as industry trends, market uncertainties, and product complexities, also affect progress. Tech-savvy industries and eco-conscious customers are more open to sustainable changes. (Sengupta 2024, 108–110.)

As Bachar (2022) explains, using sustainability data in S&OP helps businesses make better decisions by integrating these goals into their planning. This allows them to track progress, measure the impact of their actions, and make ongoing improvements through tools like simulations and scenario planning. Ivanov and Dolgui (2020, 77) also point out that using real-time data can make decision-making faster and more effective.

Collaboration with both internal and external partners is a key part of SS&OP, (Roscoe et al. 2020). Advanced IT systems and open information sharing improve communication, coordination, and

accountability, which are all crucial for reaching sustainability targets. Barratt and Oke (2007, 1230) add that collaboration helps build trust between stakeholders, leading to stronger partnerships and reducing risks in the supply chain.

As has been stated earlier, demand forecasting also plays a critical role. According to Abiade (2024) and Kolassa (2023), accurate forecasting prevents overproduction and shortages, cutting waste and improving resource use. Borucka (2023) highlights how technologies like artificial intelligence (AI) can support more precise and sustainable forecasting. Similarly, Mageto (2021, 6) shows that advanced forecasting methods, combined with big data, can improve demand planning and lead to better sustainability results.

On the supply side, managing inventory effectively and adopting sustainable financing strategies are just as important. Liang et al. (2018) argue that supply chain performance should include not only financial measures but also environmental and social factors. Santiago et al. (2023) suggest that following circular economy principles, like reuse, recycling, and recovery, helps businesses reduce their environmental impact while staying financially strong. Additionally, Yun & Ülkü (2023, 27) highlight that including sustainability in supply chain management can improve long-term resilience and lower risks.

The circular economy principles, when combined with the triple bottom line approach (considering environmental, social, and financial factors), help businesses balance their responsibilities to the planet, society, and profitability. Ghosh (2022, 9) points out that these practices not only help protect the environment but also allow companies to meet regulatory requirements and customer expectations for sustainability.

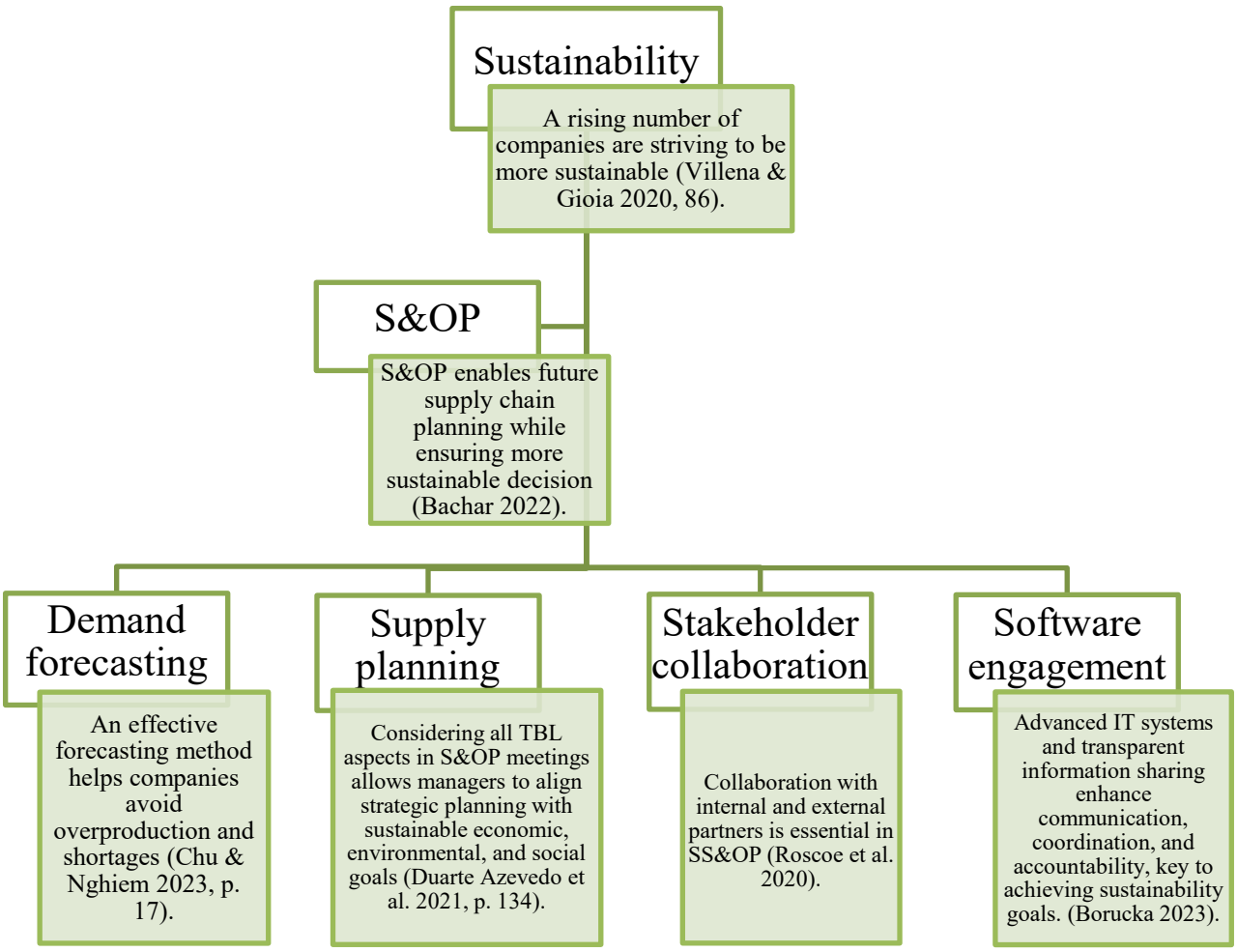

Figure 12 S&OP as an enabler to sustainability

The framework shows how sales and operations planning is helping companies to make their supply chains more sustainable. As more businesses aim to include sustainability in their operations (Villena & Gioia 2020, 86), S&OP provides a structured way to balance business goals with environmental and social responsibility (Bachar 2022).

A key part of sustainable S&OP is demand forecasting, which helps companies avoid both overproduction and shortages. By using good forecasting methods, businesses can use resources more efficiently, reduce waste, and improve supply chain operations (Chu & Nghiem 2023, 17). Along with forecasting, supply planning is also important for sustainability. When managers consider economic, environmental, and social factors in their planning, they can make better decisions that support sustainability goals (Duarte Azevedo et al. 2021, 134).

Working together with internal and external stakeholders is also necessary for sustainable S&OP. Strong partnerships help businesses stay committed to sustainability and build trust (Roscoe et al. 2020). At the same time, software and technology play a big role in improving communication, coordination, and accountability. Using advanced IT systems allows companies to track sustainability progress and improve planning (Borucka 2023). By combining forecasting, planning, teamwork, and technology, S&OP helps businesses create more sustainable supply chains while also meeting their financial goals.

Even though there are clear benefits to adding sustainability into S&OP, more research is needed on this topic. This creates opportunities to develop better models and explore how sustainability can be further integrated into supply chain practices across industries. Han & Um (2024, 18) suggest that more studies are required to connect operational strategies with sustainability, especially in situations with uncertainty or disruptions.

In conclusion, this chapter shows that businesses can succeed operationally and become more sustainable by rethinking their S&OP processes. By adopting advanced technologies, encouraging collaboration, and using frameworks like the triple bottom line and the circular economy, companies can help create a sustainable future while achieving their financial and operational goals.

5 Research methodology

This chapter explains the research methods used in this thesis, focusing on the important role of the sales and operations planning process in making manufacturing supply chains more sustainable. The study uses a qualitative approach, combining a review of academic research with interviews to provide a clear and complete understanding of how S&OP supports sustainability goals. By blending theoretical knowledge with practical experiences, the research explores how S&OP can tackle key environmental, social, and economic challenges in supply chain management. This approach ensures a balanced view, showing both strategic ideas and real-world uses of S&OP for sustainable practices.

5.1 Research design

This research focuses on understanding both the theory and real-world use of the sales and operations planning process in creating sustainable supply chains. To achieve this a detailed review of academic literature was conducted. To receive concrete empirical findings, interviews with professionals working in the field were arranged. The literature review provides a solid foundation by exploring key ideas such as sustainable supply chain management, the triple bottom line, and green supply chain practices, helping to understand the theory behind sustainability. The interviews add practical insights by showing how these ideas are applied in businesses and revealing the challenges they face in adopting sustainable practices. By combining these two perspectives, the research offers a well-rounded understanding of how S&OP can help address environmental, social, and economic issues in supply chains. This approach ensures the study captures both the importance of the theory and the practical realities businesses experience.

5.2 Data collection

The academic literature provides the theoretical background for this study. It looks at topics such as the S&OP process, principles of sustainability, and the role of collaboration and technology in supporting sustainability goals. Relevant studies were found using databases like Scopus, Web of Science, and Google Scholar. Peer-reviewed articles, books, and trusted online sources were used to understand how S&OP connects to sustainability.

In addition, data was collected through semi-structured interviews with professionals working with different supply chains operations, for example manufacturing, consulting, technology solutions. These interviews explored how businesses include sustainability in their S&OP process. Questions

focused on real examples, challenges, and the role of technology and partnerships. The open-ended format allowed participants to share detailed insights, providing diverse perspectives. Interviews were conducted either remotely or in person, recorded with the participants' permission, and later transcribed and summarized for analysis.

The interviewees were selected from organizations with varying supply chain practices and sustainability approaches, allowing for a comprehensive understanding of how S&OP can act as an enabler for sustainable supply chain management. Choosing two interviewees from a same company, allowed broader inside information.

The participants included two employees from an IT leasing company, one representative from a manufacturing company, one professional from a technology company, and one consultant specializing in supply chain management. The IT leasing company participants provided insights into how S&OP integrates with circular economy practices, particularly in the context of asset lifecycle management. The manufacturing company representative contributed perspectives on how S&OP can drive resource efficiency and waste reduction. The technology company participant discussed the role of data-driven decision-making in S&OP to achieve sustainability goals, while the consultant shared cross-industry observations on best practices and challenges in implementing sustainable S&OP processes. All the interviewed companies and employees wanted to remain anonymous on the interview. Therefore, we will specify these companies by numbers and employees with their titles as shown down below.

Table 1 Interviewed companies and employees

Company	Industry	Interviewee
Company 1	Sustainable IT leasing	• Senior Logistics Manager • Production & Logistics Director
Company 2	Manufacturing	• Global Supply Planning Director
Company 3	Consulting	• Manager, Supply Chain and Operations consulting
Company 4	Technology company	• SCM Sales Executive

These interviews aimed to explore key themes such as the alignment of S&OP with corporate sustainability strategies, the integration of sustainability metrics into the S&OP process, and the challenges organizations face when embedding sustainability within their supply chain planning.

5.3 Data analysis

This chapter explains how the collected data was examined to understand how sales and operations planning supports sustainability. The analysis was based on semi-structured interviews conducted remotely through Microsoft Teams. All interviews were recorded with the participants' permission, then transcribed and carefully reviewed to identify key findings.

To ensure a clear and structured approach, the interview transcripts were read thoroughly, and responses were compared to find common ideas and differences. Since all interviews followed the same structure—covering company background, current sustainability efforts, sustainability in the S&OP process, and challenges and opportunities—the responses were grouped under these key topics allowing for a thematic analysis. Organizing the data in this way helped to highlight important insights about how S&OP contributes to sustainability.

The analysis showed several important ideas about how businesses include sustainability in S&OP. Major theme was how companies are trying to align their S&OP process with their overall sustainability goals. Another key theme was the use of sustainability metrics in S&OP. Technology was also highlighted as an important tool for making S&OP more sustainable. Despite these efforts, companies also face challenges when trying to integrate sustainability into S&OP. Some struggle with outdated IT systems that do not support sustainability tracking, while others experience resistance from employees who are used to traditional ways of working. However, interviewees also saw opportunities, such as stronger partnerships with suppliers and better compliance with environmental regulations, which could encourage businesses to focus more on sustainability.

Because interviewees came from different industries, including IT leasing, manufacturing, technology, and consulting, the study captured a wide range of views on how sustainability fits into S&OP. The IT leasing company representatives discussed how S&OP supports circular economy practices, especially in managing product lifecycles. The manufacturing company participant focused on using S&OP to reduce waste and improve resource efficiency. The technology company representative explained how data and digital tools help track sustainability performance, while the consultant provided a broader view of common challenges and best practices across different industries.

5.4 Ethical considerations

This research followed strict ethical guidelines to ensure that all participants' rights and privacy were protected. Before each interview, participants were clearly informed about the study's purpose, the type of questions they would be asked, and how their answers would be used. Their permission was obtained before any recording took place. To maintain privacy, participants could choose whether their company name should be included or kept anonymous in the thesis. They also had the option to decide if their name and job title should be mentioned or if only their title should be used. Additionally, they were asked if they wanted to review the interview content before it was included in the thesis and whether direct quotes could be used. All collected data was securely stored to ensure confidentiality and maintain trust. By following these ethical steps, the study ensured a fair and respectful research process while gathering valuable information.

5.5 Research quality

This research methodology combines insights from academic studies with real-world perspectives from interviews. This approach helps explain how the S&OP process contributes to sustainability in manufacturing supply chains. By connecting theory with practice, the study highlights the importance of S&OP in addressing sustainability challenges and achieving development goals. The findings aim to provide useful recommendations for both academic and industry audiences, offering practical ways to integrate sustainability into S&OP processes.

6 Interview results

Incorporating sustainability into supply chain operations is becoming a strategic priority for companies across industries. Sales and operations planning processes can play a pivotal role in driving sustainability by ensuring efficient logistics and supply chain management. This chapter presents the results of interviews conducted with five professionals across diverse industries to gather insights on the role of sales and operations planning in enhancing supply chain sustainability. The findings will provide valuable insights into the practical applications of S&OP as a driver for supply chain sustainability and offer a nuanced understanding of industry-specific practices and challenges.

6.1 Sustainability in the interviewed companies

Based on the interviews, sustainability is now a key part of corporate strategy, shaping how companies manage supply chains, operations, and relationships with stakeholders. Many businesses are adopting sustainable practices to cut waste, lower carbon emissions, and ensure responsible sourcing and logistics. It is no longer just a regulatory requirement but an essential part of long-term success, competitiveness, and resilience. Companies must see sustainability as a way to encourage innovation and efficiency, not just as an obligation.

This analysis looks at how four different companies incorporate sustainability into their operations. While each company faces challenges in fully integrating sustainability into supply chains, they all aim to balance financial success with environmental responsibility. Each company uses different strategies, technologies, and partnerships to meet sustainability goals, showing how businesses at different stages approach this vital issue.

Company 1 makes sustainability a central part of its business model by focusing on extending the life of IT products. The company follows a circular economy approach by refurbishing and reusing devices, which reduces waste and environmental impact while creating economic value. This practice aligns with global sustainability goals and helps the company stand out as a leader in the IT leasing industry.

To achieve these goals, the company works with suppliers and recycling partners to maintain strict environmental standards. It also uses renewable energy to run its operations and keeps track of transportation emissions, looking for ways to reduce its carbon footprint. Although the company has strong sustainability efforts, most of them are focused on day-to-day operations rather than long-

term strategy. To improve, the company recognizes the need to incorporate sustainability more deeply into strategic planning.

Company 2 sees sustainability as an important part of its supply chain, working to cut carbon emissions across manufacturing, procurement, and logistics. It ensures that suppliers follow environmentally friendly practices and invests in energy-efficient technologies, such as low-emission production and green energy sources.

One of the company's key sustainability efforts is optimizing its logistics. By improving transportation routes and combining shipments, the company has reduced transportation-related emissions. However, it struggles with gathering reliable data to balance cost, lead time, and sustainability. The lack of transparency across the supply chain makes it difficult to measure the full impact of emissions. To address these issues, the company is increasingly using data-driven decision-making, advanced analytics, and digital tools. These efforts are designed to make sure sustainability is not only a consideration but a key factor in procurement and logistics planning.

Company 3 is a consulting company that helps businesses integrate sustainability into their supply chains. Since many organizations struggle with sustainability due to a lack of clear frameworks, the company provides assessments to identify weaknesses and opportunities for improvement. The company emphasizes that collaboration is necessary for meaningful sustainability progress. It works with suppliers, customers, and regulators to ensure that companies embed sustainability into procurement and operations.

One of the main challenges its clients face is visibility—without strong data collection and analysis, it is difficult to track and improve sustainability efforts. To address the issue, the company assists organizations in incorporating sustainability metrics into decision-making, ensuring that environmental impact is considered alongside costs and efficiency. Another key point the company stresses is leadership commitment. Companies that prioritize sustainability at the highest level of management tend to drive real change, while those that treat it as a secondary concern struggle to make meaningful progress.

Company 4 takes a technology-first approach to sustainability, using advanced tools to improve environmental responsibility in supply chain operations. The company applies product lifecycle management (PLM) systems to design more sustainable products, ensuring that sourcing and production are both ethical and efficient. PLM is the process of efficiently overseeing a company's products throughout their entire lifespan—from the initial idea and development to their eventual

retirement and disposal (Stark 2018, 13). By focusing on recyclable and resource-efficient product design, the company minimizes waste throughout its supply chain.

Additionally, Company 4 uses artificial intelligence, the Internet of Things, and blockchain to track emissions, improve logistics, and increase transparency. AI helps to forecast demand more accurately, reducing waste and overproduction. IoT devices monitor real-time energy consumption and emissions, allowing for quick adjustments to improve efficiency. Blockchain technology ensures supply chain transparency, making it easier to verify sustainability claims.

Despite these advancements, the company faces difficulties in ensuring data accuracy and balancing sustainability with cost-efficiency. Many green initiatives require upfront investments that do not provide immediate financial returns. As a result, the company is focused on long-term planning and refining its sustainability-driven technologies to achieve better environmental outcomes.

Although these companies are committed to sustainability, they face several common challenges. One major issue is the availability of accurate and standardized data. Without clear and reliable sustainability metrics, companies struggle to measure their progress and set realistic goals.

Another challenge is the balance between financial and environmental goals. Many organizations prioritize short-term cost savings over long-term sustainability efforts. While investments in green technology and energy efficiency can bring financial benefits over time, high upfront costs often slow adoption. Companies need to shift their mindset to view sustainability as a long-term investment rather than an immediate expense.

Regulatory uncertainty is another significant barrier. Different regions have varying environmental regulations, making compliance difficult for global supply chains. Companies must remain flexible and proactive in adapting to evolving laws while pushing for more consistent global sustainability standards.

Despite these challenges, there are many opportunities for progress. Advanced technologies such as AI, IoT, and blockchain can significantly improve visibility, optimize supply chain efficiency, and reduce waste. Businesses that integrate these technologies effectively can improve both sustainability and operational performance. Additionally, companies that engage stakeholders—such as suppliers, logistics providers, and customers—in their sustainability efforts can drive industry-wide improvements. Collaboration and shared responsibility play a key role in achieving meaningful environmental impact.

As these companies continue to refine their sustainability strategies, they will be better prepared for future challenges and opportunities. Sustainability is no longer an optional goal but a critical component of a resilient and future-ready supply chain. Companies that take proactive steps today will not only meet regulatory and consumer demands but also build a competitive advantage in an increasingly sustainability-driven marketplace.

6.2 S&OP and sustainability

All the interviewees described sales and operations planning as an essential business process that helps companies manage demand and supply while considering financial and strategic goals. While many organizations include sustainability in their supply chain management, it is not always well-integrated into S&OP. This chapter explores how companies incorporate sustainability into their S&OP processes, the challenges they face, and possible improvements.

All four companies acknowledge that sustainability is important, but they differ in how well they include it in their S&OP processes. Company 1 specializes in IT leasing and follows a circular economy model, which focuses on reducing waste, refurbishing devices, and extending product lifecycles. While sustainability is a core part of its business, it is not fully embedded in S&OP.

Currently, the company tracks transportation emissions and optimizes logistics, but sustainability is not systematically included in S&OP planning. The company sees opportunities to improve by using AI and data analytics for better demand forecasting and warehouse management, which would reduce storage needs and waste. However, the company struggles with limited data availability, making it difficult to gather standardized sustainability data to support S&OP decisions. Additionally, financial and environmental goals can sometimes conflict, as sustainability initiatives require upfront investments with uncertain short-term benefits. Regulations on e-waste and cross-border refurbishment further complicate efforts to integrate sustainability into S&OP.

Company 2 prioritizes sustainability in manufacturing, procurement, and logistics. However, like Company 1, it has not fully integrated sustainability into its S&OP processes. The company has improved transportation efficiency by using regional distribution centers to reduce emissions, but more work is needed.

A major challenge is balancing costs and sustainability. As was stated also earlier, many businesses, including Company 2, prioritize short-term financial performance over long-term sustainability. Investments in sustainability initiatives often do not provide immediate financial returns, making them harder to justify. To address this, the company is working on improving demand forecasting to

minimize waste and overproduction. It is also encouraging suppliers to adopt more sustainable sourcing practices. Advanced technologies such as AI and IoT are expected to help make its S&OP process more sustainable in the future.

Company 3, a consulting company, offers a broad view of how businesses approach sustainability in S&OP. It has developed models to assess how well companies integrate sustainability into their planning processes. According to the interviewee, many businesses still struggle to move from general sustainability goals to concrete actions in S&OP.

One of the biggest challenges is regulatory differences. Sustainability regulations vary by region, making it difficult for companies to create standardized sustainable S&OP practices. The company emphasizes that sustainability metrics should be included in demand forecasting, supply planning, and inventory management. Successful companies use scenario planning tools to balance financial and environmental goals. However, regulatory complexity remains a barrier to sustainability integration, requiring businesses to remain agile and adapt quickly.

Company 4 provides supply chain management software that helps businesses integrate sustainability into S&OP planning. Its tools allow companies to track greenhouse gas emissions, energy use, and waste reduction during the planning process, ensuring that sustainability is part of decision-making from the start.

However, a major challenge is supplier collaboration. Companies rely on suppliers and logistics partners to improve sustainability, but these partners may not always provide the necessary data or meet sustainability expectations. Encouraging suppliers to comply with environmental standards remains a challenge. To address this, the company's software includes scenario analysis, allowing businesses to weigh cost efficiency against environmental impact. AI-based demand forecasting, real-time IoT monitoring, and blockchain transparency further improve sustainability integration.

Despite these challenges, there are significant opportunities to make S&OP more sustainable. Companies can leverage advanced technologies such as AI, IoT, blockchain, and data analytics to improve demand forecasting, transportation efficiency, and traceability, helping businesses make more sustainable decisions. Additionally, embedding sustainability metrics, such as carbon footprint tracking and waste reduction targets, in S&OP planning ensures environmental factors are consistently considered.

Supplier collaboration presents another opportunity. Businesses can encourage suppliers and logistics providers to adopt sustainable practices by setting sustainability requirements for supplier

selection, driving improvements across the supply chain. Furthermore, scenario planning tools can help businesses evaluate different sustainability trade-offs, enabling them to balance cost, service levels, and environmental impact effectively.

As was shown earlier, although sustainability is becoming more important in supply chain management, it is not yet fully integrated into S&OP for most companies. The interviewed companies show different levels of sustainability adoption in S&OP, facing obstacles such as limited data, cost concerns, regulatory issues, and supplier collaboration difficulties. However, by leveraging new technologies, embedding sustainability metrics, and improving supplier engagement, businesses can transform their S&OP processes into a powerful tool for both financial success and environmental responsibility.

6.3 The role of advanced technologies and future aspects

Companies are increasingly using advanced technology to improve sales and operations planning and make their supply chains more sustainable. Industry experts explain how businesses are currently using technology and what the future might hold. This chapter is also based on interviews with company representatives, focusing on how technology supports sustainability in S&OP.

Company 1 follows a circular economy model, which means they focus on reusing and extending the life of IT equipment instead of discarding it. Sustainability is an important goal, but it is not yet fully integrated into their S&OP process. The company sees artificial intelligence (AI) and data analytics as valuable tools for improving demand forecasting, resource allocation, and transport efficiency which can lead to even better sustainability. A major challenge for Company 1 is balancing the cost of sustainability initiatives with business objectives. However, company leaders believe that using predictive analytics and automation will help them make better decisions, reducing waste while also keeping operations efficient.

Company 2 considers sustainability an essential part of its strategy, but it is still working on fully embedding it into S&OP. The company is exploring AI-driven forecasting, demand planning, and real-time data tracking to reduce waste and make supply planning more efficient. A significant issue is the lack of reliable data from smaller suppliers, which makes it harder to monitor sustainability efforts. In the future, the company expects blockchain and digital platforms to improve visibility across its supply chain. Additionally, AI is expected to play a bigger role in sourcing and logistics planning.

Company 3, a consulting company where the chosen interviewee specializes in supply chains, helps other companies evaluate their sustainability efforts using assessment models. These models help businesses identify how AI, IoT, and data analytics can improve sustainability in their operations. The interviewee stressed that companies need better transparency across their supply chains to fully integrate sustainability into S&OP. Predictive analytics and blockchain could help businesses measure their carbon footprint more accurately and make real-time data-based decisions to improve their sustainability goals.

Company 4 develops software that integrates sustainability into S&OP planning. Their platforms use AI, IoT, and blockchain to monitor energy consumption, track emissions, and optimize logistics. The company expects AI-powered scenario planning to become essential in helping companies balance sustainability with cost efficiency. In addition, digital tools will help companies track the full lifecycle of their products, improving reverse logistics and reducing waste.

All the interviewees agree that technology will play a crucial role in the future of S&OP. AI is expected to improve forecasting, helping businesses predict demand more accurately. As one expert put it, "AI will not only help us avoid excess production but also make sure our supply chain is more sustainable by reducing waste and unnecessary stock."

Blockchain will also be a game-changer for supply chain transparency. "We often struggle to get reliable data from all our suppliers," said one interviewee. "Blockchain will allow us to track materials and products from start to finish, so we can confirm that sustainability claims are real."

IoT will play a major role in tracking sustainability metrics. "If we can monitor energy use and carbon emissions in real-time, we can make immediate improvements rather than waiting for problems to arise," one interviewee explained. This ability to collect real-time data will help companies make quick and effective decisions about logistics and sourcing.

Another key development will be the use of cloud-based S&OP platforms to improve collaboration. "We need a system that combines sustainability metrics with financial and operational data all in one place," one respondent said. Companies are expected to move towards digital platforms that ensure sustainability is considered in every business decision.

Regulatory compliance was also a key concern. "Laws are becoming stricter, and we expect AI-powered compliance tools to be essential," said one interviewee. Automated tracking will help companies stay ahead of changing regulations while reducing manual work.

Lastly, circular economy models will continue evolving with the help of technology. "Reverse logistics is critical for us," one expert noted. "AI and IoT will make it easier to manage returns efficiently, ensuring that products are reused or recycled properly." By leveraging technology, companies will reduce waste and make better use of materials.

The interviewed companies agree that sustainability is becoming more important but integrating it into S&OP is still a work in progress. Technologies such as AI, blockchain, and IoT are expected to play a key role in making supply chains more sustainable. Businesses that invest in digital tools to track sustainability, improve decision-making, and ensure compliance will gain a competitive advantage. As technology continues to improve, aligning S&OP with sustainability will become a major factor in long-term business success.

6.4 Interview conclusions

The interviews show that while companies see sustainability as important in supply chain management, fully including it in the sales and operations planning process is still a challenge. Organizations understand the need to align sustainability with their business operations, but they face difficulties such as lack of reliable data, high costs, changing regulations, and issues with supplier cooperation.

S&OP can play a key role in making supply chains more sustainable if the right tools and measurements are used. The companies in this study are at different stages of sustainability adoption, but they all show that new technologies—such as artificial intelligence (AI), the Internet of Things (IoT), and blockchain—can help. These technologies improve forecasting, make logistics more efficient, and increase supply chain transparency.

However, some common problems remain. Many businesses do not have access to consistent and accurate sustainability data, making it difficult to track their progress. Financial concerns also create obstacles, as sustainability projects often require upfront investment before they bring financial benefits. Additionally, different sustainability rules across regions make it difficult for companies with global supply chains to fully implement their plans.

Despite these challenges, there are opportunities for companies willing to invest in technology and collaboration. By using digital platforms to track sustainability data, businesses can improve both their financial performance and environmental impact. Working closely with suppliers and partners on sustainability efforts can also bring positive industry-wide changes.

Looking to the future, technology will be essential in making sustainability a natural part of S&OP. AI-powered forecasting, blockchain for supply chain transparency, and IoT for tracking carbon emissions in real-time will help companies make better decisions. Businesses that adopt these solutions and move toward circular economy models will have a stronger competitive advantage.

In summary, sustainability is no longer optional, but many companies are still working to fully integrate it into their S&OP processes. Those that invest in technology, track sustainability progress, and collaborate with suppliers will be better prepared for regulatory changes, consumer demands, and long-term business success. Once integrated efficiently, S&OP can help companies to achieve their sustainability goals.

7 Conclusions and future research

This thesis examined how sales and operations planning helps make supply chains more sustainable, especially in manufacturing. By reviewing existing research and conducting interviews with industry experts, this study identified how S&OP supports sustainable supply chain management while also revealing challenges and opportunities in the process.

The results show that S&OP is essential for balancing supply and demand while making the best use of resources. When sustainability is built into S&OP, companies can cut waste, lower emissions, and improve efficiency. A key finding is that accurate demand forecasting helps prevent excess production and stock shortages, reducing wasted materials and energy. Supply planning ensures that sourcing and production decisions match sustainability goals, such as using less energy and lowering carbon footprints. Additionally, integrating sustainability considerations into supply chain decisions can help companies meet regulatory requirements, improve their reputation, and enhance long-term profitability.

Unfortunately, as the empirical findings brought up, although many companies see sustainability as important, it is not always well integrated into S&OP. Companies face several difficulties, including lack of data, financial trade-offs, unclear regulations, and problems working with suppliers. As was stated by (Roscoe et al. 2020, 3537), moving from a traditional S&OP process to a sustainable one means including input from both internal and external stakeholders in planning, with the support of connected IT systems. Many businesses prioritize short-term cost savings over long-term sustainability benefits.

Also, different regulations across regions make it harder for companies to apply the same sustainability practices everywhere. Addressing these challenges requires businesses to adopt a structured and consistent approach to incorporating sustainability into decision-making processes, ensuring that financial and environmental goals align. As was stated by Liang et al. (2018), evaluating supply chain performance should go beyond financial results while also considering environmental and social aspects. Similarly, Santiago et al. (2023) highlight that applying circular economy practices, such as reusing, recycling, and recovering materials, allows businesses to lower their environmental impact while maintaining financial stability.

Both the empirical and academical research highlighted the importance of technology. For example, Company 4 anticipates that AI-driven scenario planning will play a key role in helping businesses manage both sustainability and cost efficiency. Additionally, digital solutions will enable

companies to monitor their products throughout their entire lifecycle, enhancing reverse logistics and minimizing waste. Similarly, Roscoe et al. (2020, p. 3537) emphasize that IT plays a vital role in enabling companies to provide sustainable value to stakeholders while also gaining a competitive edge. In particular, software tools that enhance information visibility among supply chain partners and support the exchange of sustainability-related data during planning are essential for achieving business sustainability.

New technologies like artificial intelligence (AI), big data analytics, the Internet of Things (IoT), and blockchain can help solve these issues. AI-based forecasting improves accuracy, reducing waste and inefficiency. IoT allows real-time tracking of energy use and emissions, helping companies adjust their operations. Blockchain ensures supply chain transparency, making it easier to follow sustainability rules. All interviewees agree that technology will be essential for the future of S&OP. Another interesting point brought up by the empirical research was the adoption of cloud-based S&OP platforms to enhance collaboration.

It goes without saying that businesses are likely to shift towards digital systems that integrate sustainability into every decision-making process. Companies that use these tools effectively can reach their sustainability goals while keeping operations efficient. As was stated by Lapide, (2005, 19) an ideal S&OP process relies on real-time systems to monitor supply and demand, automatically scheduling meetings when problems occur. Virtual meetings enable immediate plan adjustments using advanced tools, which helps optimizing supply and demand planning efficiently. Furthermore, integrating digital solutions into S&OP can provide businesses with a competitive advantage, as they will be better equipped to respond to market fluctuations, regulatory changes, and consumer demands for sustainable products.

Another important aspect highlighted by academic literature and empirical findings is the need for teamwork. Barratt and Oke (2007, 1230) brought out how working together fosters trust among stakeholders, which strengthens partnerships and lowers risks within the supply chain. The empirical findings also revealed that companies can promote sustainability among suppliers and logistics providers by establishing sustainability criteria for selecting partners, leading to overall improvements in the supply chain. It is essential for S&OP to be more sustainable to enhance cooperation between different departments, suppliers, customers, and regulators. Companies that include all stakeholders in planning are more successful in improving sustainability. This means setting clear goals, including sustainability in decision-making, and encouraging continuous improvement.

All the interviewees were managers or directors in their own fields of work. The interviews showed how leadership also plays a big role. Also, the academic literature highlights that managers are at lead when it comes to making decisions in S&OP. For example, during the primary meeting of S&OP, the company's management evaluates key operational decisions. These decisions cover areas such as production levels, marketing requirements, procurement, budgeting, and product development (Harrison et al. 2019, 231).

Companies where top managers focus on sustainability tend to do better in making S&OP greener. When companies prioritize collaboration and transparency, they create a strong foundation for achieving sustainability goals while maintaining efficiency and profitability. Supplier engagement is crucial in ensuring that sustainability principles are upheld throughout the supply chain, as suppliers play a key role in determining the environmental and social impact of production and distribution processes.

While this research provides useful insights, it has some limitations. Since the study is based on interviews with a small number of companies, the findings may not apply to all industries. Also, because supply chain management is constantly evolving, future research is needed to explore new trends, technologies, and laws that might affect sustainability in S&OP. Further research could examine how emerging trends, such as circular economy models, impact the role of S&OP in sustainability. Additionally, exploring case studies of companies that have successfully integrated sustainability into their S&OP processes could provide practical insights and best practices for other organizations looking to do the same.

Future research should focus on developing clearer methods for adding sustainability to S&OP, considering challenges and best practices for different industries. For example, quantitative studies could help measure the financial and environmental impact of sustainable S&OP. Studying how circular economy ideas can be included in S&OP would also be valuable.

Moreover, future studies could investigate how businesses of different sizes and industries approach sustainable S&OP, as the challenges faced by small enterprises may differ from those of large multinational corporations. Identifying industry-specific solutions and strategies would provide more targeted recommendations for companies looking to implement sustainable practices.

In conclusion, this thesis shows that S&OP can improve sustainability in supply chains, but success depends on using advanced technologies, working closely with all stakeholders, and committing to long-term environmental and social responsibility. By following a structured approach to

sustainable S&OP, businesses can gain a competitive edge while making supply chains more sustainable. As sustainability continues to grow in importance for both companies and consumers, businesses that proactively integrate environmental and social considerations into their supply chain planning will be better positioned to thrive in an increasingly competitive and regulated global market. A commitment to sustainability not only benefits the environment but also enhances operational efficiency, strengthens brand reputation, and contributes to overall business success.

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Appendices

Appendix 1 Use of generative AI in scientific writing

The author utilized generative AI to enhance the grammar, clarity, and readability of the text originally written by the authors, as well as to assist in formatting the reference list. All content generated with the help of this tool was subsequently reviewed and edited by the author, who accepts full responsibility for the final content of the thesis.

Appendix 2 Interview outline in a manufacturing company

1. Company and interviewee background
    a. What is the name of your company?
    b. Should the company name be kept anonymous in the thesis, or can it be mentioned?
    c. What is your name and title?
    d. Should your name and title be included in the thesis, or only your title? Are you comfortable with the interview being recorded?
    e. Would you like to review the interview content before it is used?
    f. Can we include direct quotes from this interview in the thesis?
2. Current approach to sustainability
    a. How does your company define environmental sustainability within its operations?
    b. What is the role of sustainability in your company's supply chain planning?
    c. How do you see your company's sustainability efforts compared to others in the same industry?
3. Sustainability goals
    a. What are your short-term and long-term sustainability goals as a company?
    b. What kind of collaboration with stakeholders (such as suppliers or clients) do you think is necessary to meet these goals?

4. Sustainability in the S&OP process

    a. How is sustainability currently integrated into your sales and operations planning process?

    b. Where do you see the most potential to improve sustainability within the S&OP framework (e.g., demand forecasting, supply planning)?

    c. What challenges do you face in balancing sustainability with operational and business goals in S&OP?

    d. Can you name some concrete sustainable benefits from S&OP?

5. Challenges and support

    a. What are the biggest challenges your company faces in improving sustainability through the S&OP process?

    b. How can external stakeholders (e.g., clients, suppliers, regulators) help you achieve your sustainability goals?

    c. What role do advanced technologies (e.g., IT systems) play in helping you achieve a sustainable S&OP process?

Appendix 3 Interview outline in a technology company

1. Company and interviewee background

    a. What is the name of your company?

    b. Should the company name be kept anonymous in the thesis, or can it be mentioned?

    c. What is your name and title?

    d. Should your name and title be included in the thesis, or only your title?

    e. Are you comfortable with the interview being recorded?

    f. Would you like to review the interview content before it is used?

    g. Can we include direct quotes from this interview in the thesis?

2. Sustainability and technology solutions

   a. How does your company define environmental sustainability in the context of the supply chain solutions you offer?

   b. How do your ERP and other software solutions help clients achieve their sustainability goals within their supply chain and logistics operations?

   c. How does your company measure the impact of its solutions on clients' sustainability efforts? Are there any key metrics or case studies you could share?

3. Sustainability goals for clients

   a. What types of short-term and long-term sustainability goals do your clients typically aim to achieve through your technology solutions?

   b. How do you help clients collaborate with stakeholders (e.g., suppliers, logistics providers) to meet their sustainability targets?

   c. How do your solutions enable clients to track and improve sustainability performance across their supply chains?

4. Sustainability in the S&OP process

   a. How does your company's ERP or other software solutions support the integration of sustainability within the Sales and Operations Planning (S&OP) process?

   b. Where do you see the most potential for clients to improve sustainability within the S&OP framework through your solutions (e.g., demand forecasting, supply planning, inventory optimization)?

   c. What challenges do clients typically face when trying to balance sustainability with operational and financial goals in S&OP, and how do your solutions address these challenges?

   d. Can you share any examples of how your technology solutions have helped clients achieve concrete sustainability benefits through improvements in their S&OP processes?

5. Challenges and opportunities in sustainability

a. What are the biggest challenges your clients face in improving sustainability within their supply chains using your solutions?

b. How can external stakeholders (e.g., clients' suppliers, regulators, logistics partners) help companies achieve sustainable outcomes using your technology?

c. What role do advanced technologies (e.g., AI, IoT, blockchain) play in improving sustainability within S&OP processes and supply chain management?

d. How do your solutions support circular economy initiatives (e.g., product lifecycle management, reverse logistics) that contribute to sustainability?

Appendix 4 Interview outline in a leasing supply chain from an operational perspective

1. Company and interviewee background

    a. What is the name of your company?

    b. Should the company name be kept anonymous in the thesis, or can it be mentioned?

    c. What is your name and title?

    d. Should your name and title be included in the thesis, or only your title?

    e. Are you comfortable with the interview being recorded?

    f. Would you like to review the interview content before it is used?

    g. Can we include direct quotes from this interview in the thesis?

2. Sustainability in leasing operations

    a. How does your company define environmental sustainability in the context of IT equipment leasing?

    b. What role does sustainability play in your leasing process and overall operations (e.g., equipment lifecycle management, recycling, refurbishing)?

    c. How do you see your company's sustainability efforts compared to others in the IT leasing industry?

3. Sustainability goals
    a. What are your company's short-term and long-term sustainability goals?
    b. How do you collaborate with stakeholders (e.g., clients, manufacturers, recycling partners) to achieve these sustainability goals?
    c. How does your leasing model contribute to reducing environmental impact compared to traditional ownership models?
4. Sustainability in the S&OP process
    a. How is sustainability integrated into your company's sales and operations planning process?
    b. Where do you see the most potential for improving sustainability within your S&OP framework (e.g., demand forecasting, inventory management, reverse logistics)?
    c. What challenges do you face in balancing sustainability with operational and financial goals in S&OP?
    d. Can you share specific examples of sustainability benefits realized through your S&OP process (e.g., reducing waste, extending equipment lifespan)?
5. Challenges and opportunities
    a. What are the biggest challenges your company faces in improving sustainability through your leasing and S&OP processes?
    b. How can external stakeholders (e.g., clients, suppliers, regulators) help your company achieve its sustainability goals?
    c. What role do advanced technologies (e.g., IT systems, data analytics, AI) play in supporting a sustainable leasing model and S&OP process?
    d. How does your company ensure responsible end-of-life management for leased IT equipment?

Appendix 5 Interview outline in a leasing supply chain from a logistics perspective

1. Company and interviewee background

   a. What is the name of your company?
   b. Should the company name be kept anonymous in the thesis, or can it be mentioned?
   c. What is your name and title?
   d. Should your name and title be included in the thesis, or only your title?
   e. Are you comfortable with the interview being recorded?
   f. Would you like to review the interview content before it is used?
   g. Can we include direct quotes from this interview in the thesis?

2. Sustainability in logistics operations
   a. How does your company define environmental sustainability in the context of logistics for IT equipment leasing?
   b. What measures have you implemented to reduce the environmental impact of transporting and handling leased IT equipment?
   c. How does your logistics strategy compare with others in the industry in terms of sustainability?

3. Sustainability goals
   a. What are your short-term and long-term sustainability goals specifically related to logistics and supply chain operations?
   b. How do you collaborate with logistics partners (e.g., transport companies, warehouse operators) to achieve your sustainability objectives?
   c. How does your company manage the return and redistribution of leased equipment in a way that minimizes environmental impact?

4. Sustainability in the S&OP process
   a. How is sustainability incorporated into the logistics aspects of your company's sales and operations planning process?

b. Where do you see the most potential for improving sustainability in logistics through the S&OP framework (e.g., transportation planning, inventory optimization, reverse logistics)?

c. What challenges do you face in balancing logistics efficiency and sustainability within your S&OP process?

d. Can you provide specific examples of how your logistics operations have contributed to sustainability goals through better S&OP practices?

5. Challenges and opportunities

a. What are the biggest logistics-related challenges your company faces in improving sustainability within your leasing model?

b. How can external stakeholders (e.g., clients, logistics providers, regulators) support your logistics-related sustainability efforts?

c. What role do advanced technologies (e.g., route optimization software, IoT for tracking, AI) play in achieving sustainable logistics for IT equipment leasing?

d. How do you handle the logistics of end-of-life equipment recovery and ensure responsible recycling or refurbishing processes?

Appendix 6 Interview outline in a consulting company

1. Company and interviewee background

a. What is the name of your company?

b. Should the company name be kept anonymous in the thesis, or can it be mentioned?

c. What is your name and title?

d. Should your name and title be included in the thesis, or only your title?

e. Are you comfortable with the interview being recorded?

f. Would you like to review the interview content before it is used?

g. Can we include direct quotes from this interview in the thesis?

2. Consulting company's perspective on sustainability
    a. How does your consulting company define environmental sustainability in the context of supply chain management and S&OP processes?
    b. How does sustainability play a role in the consulting services you provide to companies?
    c. How do you assess the sustainability maturity of a client's supply chain or S&OP process before recommending solutions?
3. Sustainability goals for clients
    a. From your experience, what short-term and long-term sustainability goals are common for manufacturing clients?
    b. How do you help manufacturing companies collaborate with stakeholders (e.g., suppliers or clients) to achieve their sustainability goals?
4. Sustainability in the S&OP process
    a. How do you guide manufacturing companies to integrate sustainability into their sales and operations planning (S&OP) processes?
    b. In your experience, where do you see the most potential for improving sustainability within the S&OP framework (e.g., demand forecasting, supply planning)?
    c. What strategies or tools do you recommend to balance sustainability with operational and business goals in S&OP?
    d. Can you share any examples or case studies where an improved S&OP process resulted in concrete sustainability benefits?
5. Challenges and opportunities
    a. What are the most common challenges manufacturing companies face in integrating sustainability into their S&OP processes?
    b. How can external stakeholders (e.g., clients, suppliers, regulators) support manufacturing companies in achieving sustainable S&OP outcomes?

c. What role do advanced technologies (e.g., IT systems, data analytics, AI) play in achieving a more sustainable S&OP process?

d. What are the key trends or innovations you see shaping the future of sustainable S&OP processes?