

UNCOVERING HIDDEN THEMES IN S&OP PROCESS VIA TOPIC MODELING

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Abstract: Contemporary companies and their complex supply chains are continuously exposed to a variety of external and internal risks, which creates an imperative to shift from traditional, reactive behavior toward a model of proactive planning. In this context, the Sales and Operations Planning (S&OP) process has emerged as a key mechanism that enables the alignment of often conflicting goals across different business functions through integrated supply and demand planning. Its fundamental value lies in its ability to simultaneously achieve horizontal integration by breaking down traditional functional barriers between sales, operations, and finance, and vertical integration which ensures a direct link between long-term strategic goals and concrete operational decisions. To gain a deeper understanding of research trends in the field of S&OP, this paper analyzes scientific paper abstracts using the Latent Dirichlet Allocation (LDA) method.

Key words: Sales and Operations Planning, S&OP, Latent Dirichlet Allocation

JEL classification: M11

1. INTRODUCTION

Sales and Operations Planning (S&OP) today represents one of the most relevant managerial topics in the field of supply chain management, as

evidenced by the growing number of scientific papers and implementation examples in practice (Kalla et al., 2025). Accordingly, the S&OP process occupies a central place in modern supply chain management (Thomé et al., 2012). Its primary objective is the development of tactical plans that enable management to strategically direct business operations through the integration of marketing, sales, production, procurement, development, and financial plans into a single, unified set of plans (Thomé et al., 2012).

S&OP has evolved from Aggregate Production Planning (APP) and MRP-II systems, gradually becoming a comprehensive business process that integrates different functional areas (Bozutti & Esposito, 2019; Nemati et al., 2017). In the contemporary literature, this process is increasingly referred to as Integrated Business Planning (IBP), which is considered a mature form of S&OP as it directly links operational decisions with financial goals and profitability (Amico & Cigolini, 2023; Kim & Shin, 2024).

The particular significance of the S&OP process lies in its ability to ensure both vertical and horizontal alignment within an organization (Amico & Cigolini, 2023). Vertical alignment implies the effective connection of strategic goals with operational plans, while horizontal integration encompasses intensive cross-functional collaboration between different departments during the planning process (Amico & Cigolini, 2023).

For this reason, S&OP is considered a key mechanism for improving internal coordination, which directly reflects on the overall performance of the supply chain (Kalla et al., 2025).

The contemporary business environment further underscores the importance of the S&OP process. Companies today operate under strong pressure from disruptive technologies, global competition, shortened product life cycles, market volatility, and growing uncertainty (Amico & Cigolini, 2023). In such circumstances, rapid response to demand changes and meeting high customer expectations through greater visibility within the supply chain are of critical importance (Kim & Shin, 2024). Accordingly, organizations are increasingly investing in Information and Communication Technology (ICT) systems that enable advanced analysis of customer behavior, continuous monitoring of market conditions, and more accurate forecasting of future demand.

The development of digital technologies has fundamentally transformed the way S&OP is conducted. Professionals responsible for this process today work in an environment where companies are increasingly integrating advanced technological solutions (Jazairy et al., 2024). Functionalities such as integrated planning, constraint-based planning, optimization, and what-if scenario simulation have become essential, particularly under conditions of high complexity (Pereira et al., 2020). Moreover, risk assessment without sophisticated scenario analysis tools, real-time performance monitoring, and visual representations through dashboards is considered insufficiently reliable or even unfeasible under modern conditions (Kalla et al., 2025).

Nevertheless, despite the availability of ERP and BI systems, as well as advanced analytical tools, many companies still face challenges in the effective implementation of the S&OP process. A large number of organizations continue to rely on the manual transfer of raw data from ERP systems into separate spreadsheets to support planning (Seeling et al., 2021). Even in the presence of BI platforms, results are often unsatisfactory because different business functions create their own isolated data views (Seeling et al., 2021). An additional challenge is the fact that process and technological changes occur relatively quickly, while transformations in organizational culture and human resources are considerably slower and require significantly more time and effort (Amico & Cigolini, 2023).

Given the growing complexity of the S&OP process and its impact on business competitiveness, the academic community has devoted considerable attention to this topic over

recent decades, resulting in a growing body of scientific literature. S&OP is studied from various perspectives - organizational, technological, and strategic - leading to a high degree of heterogeneity among papers, in which it is often difficult to identify dominant research directions and trends. For this reason, by applying the LDA method (Latent Dirichlet Allocation) to a corpus of scientific abstracts, this paper seeks to provide answers to the following research questions:

RQ1: What are the dominant thematic areas in the scientific literature on S&OP?

RQ2: How has the research focus in the field of S&OP changed over time?

The structure of the paper is organized as follows. Following the introductory remarks, the second chapter provides a theoretical background on the S&OP process, covering key concepts such as demand planning, coordination mechanisms, digital support tools, and the main challenges organizations face in its implementation. The third chapter provides a detailed overview of the applied methodology and describes the specifics of the LDA approach used. The fourth chapter presents the results of the analysis, along with a thorough interpretation of the identified research themes. Finally, the fifth chapter summarizes the key conclusions of the research, outlines the limitations of the study, and offers recommendations for future scientific research in this field.

2. THEORETICAL BACKGROUND

Although globalization enables cross-border business operations, it also brings risks such as supply delays, price fluctuations, and inaccurate forecasts (Abay et al., 2024; Amico & Cigolini, 2023). A particular challenge arises in situations where supply cannot be fully utilized, while demand uncertainty makes inventory management critical, often leading to unnecessary cost increases throughout the supply chain (Kim & Shin, 2024; Qin & Liu, 2024).

Effective demand planning requires consensus among various teams: sales creates plans by customer, marketing plans at the brand and promotional level, while data scientist teams use statistical models and artificial intelligence (Qin & Liu, 2024; Wibowo, 2024). Nevertheless, human judgment remains essential, particularly in uncertain situations where experts are better at detecting negative market signals that statistical models cannot always capture (Fahimnia et al., 2023; Wibowo, 2024).

The success of this integration depends on six key coordination mechanisms: the process itself, organizational structure, tools and data, performance management (KPIs), strategic

alignment, and culture and leadership (Goh & Eldridge, 2024; Tuomikangas & Kaipia, 2014). These mechanisms encompass the "hard side" (procedures and data) and the "soft side" (trust and collaboration), whereby it has been shown that the transformation of people and culture requires considerably more time than the implementation of software solutions themselves (Amico & Cigolini, 2023; Pereira et al., 2020; Tuomikangas & Kaipia, 2014).

Contemporary S&OP processes are supported by specialized software such as SAP IBP, Oracle S&OP Cloud, Logility, and Manhattan, which enable what-if simulations and plan optimization (Pereira et al., 2020; Samouche et al., 2020). However, many companies continue to struggle with collecting raw data from ERP systems and processing it into a format that would support effective real-time decision-making (Amico & Cigolini, 2023; Seeling et al., 2021).

3. RESEARCH METHODOLOGY

In order to identify the dominant research themes in the field of Sales & Operations Planning (S&OP), the method of Latent Dirichlet Allocation (LDA) was applied, which represents a standard approach for extracting latent thematic structures from large textual datasets. This method enables the modeling of documents as probabilistic combinations of topics, while the topics themselves are defined as probability distributions over a set of words.

The empirical foundation of the research was formed on the basis of bibliographic data retrieved from the Scopus database. The analysis was conducted on the abstracts of scientific papers, with standard text preprocessing previously performed, including tokenization, stop-word removal, and lemmatization, in order to ensure consistency of the input corpus.

Following data preparation, a term frequency matrix (bag-of-words representation) was constructed, which served as the input for the LDA model.

The number of topics was determined through an iterative approach, taking into account the interpretability of the obtained results and the coherence of the topics. The final model encompasses five thematic units, which proved to be the optimal solution in the context of the analyzed dataset.

Model parameter estimation was carried out using Gibbs sampling, yielding two key matrices: the word distribution matrix per topic and the topic distribution matrix per document. For the visualization of results, the PyLDAvis tool was

used, enabling additional interpretation of the interrelationships between the identified topics.

The dataset collected from the Scopus database includes 434 scientific articles published between 1938 and 2026. Most of the publications appeared after 2014, which shows that research interest in the S&OP area has increased significantly in recent years. During the data preparation phase, 8 papers were removed because they did not contain abstracts. Therefore, the final dataset used for the LDA analysis consisted of 426 documents.

The analysis of publication trends shows a clear growth in the number of studies, especially from 2018 onward. More than 45% of all analyzed papers were published in the period from 2018 to 2025. This indicates that S&OP has become an important and highly discussed research topic, particularly due to the influence of digital transformation and recent supply chain challenges.

4. RESEARCH RESULTS

The application of the LDA model resulted in the identification of five dominant topics in the field of Sales & Operations Planning, defined on the basis of the most frequently occurring terms within each topic.

The first topic (Topic 1) includes terms such as supply, chain, research, process, planning, and management, which indicate the general conceptual framework of S&OP as an integrated supply chain management process.

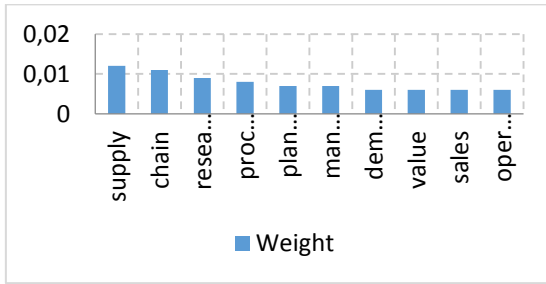
This topic mainly reflects the theoretical and research-oriented side of the discipline, with particular attention given to coordination between sales and operations activities across the value chain.

The results suggest that a large portion of the literature is focused on explaining the role of S&OP in improving organizational alignment and supporting more effective decision-making within supply chain management.

This topic is the most represented in the analyzed dataset and covers around 38% of the total corpus. Such result is in line with previous studies from the wider field of supply chain management, where S&OP is often described as an important coordination mechanism between strategic planning and operational activities.

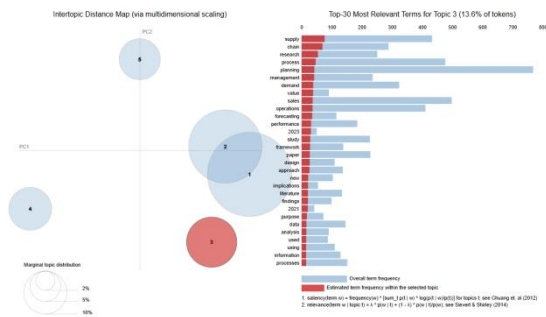
The frequent appearance of terms like research and management also indicates that many papers within this topic are mainly theoretical or review-oriented. In most cases, the authors focus on explaining the concept of S&OP and defining its main characteristics, scope, and role within modern supply chain management.

Figure 1. Topic 1: key terms



Source: Authors of research

Figure 2. Top 30 Most relevant Terms for Topic 1



Source: Authors of research

The second topic (Topic 2) is defined by terms such as performance, demand, sales, and manufacturing, which indicate that the main research focus is related to performance measurement and operational efficiency within the S&OP process.

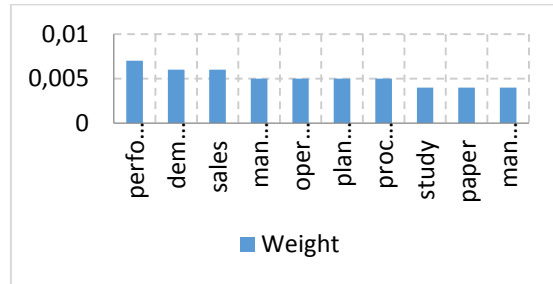
Most of the papers included in this topic analyze how planning activities influence business results and manufacturing performance. The studies particularly emphasize the relationship between demand planning, sales coordination, and production efficiency, as well as their impact on overall organizational performance.

The emphasis on performance measurement in this topic points to one important issue that is often mentioned in the literature.

Although many companies have implemented S&OP practices, there is still a relatively small number of empirical studies that clearly confirm the direct influence of S&OP on overall company performance.

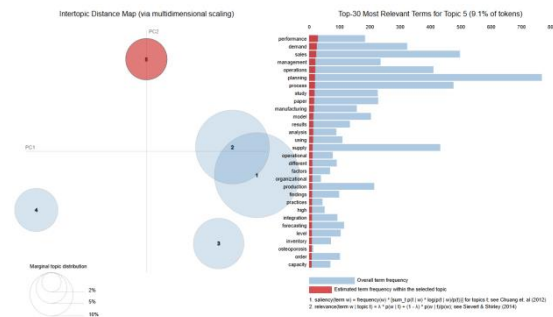
The strong presence of manufacturing-related terms indicates that studies connected with performance aspects of S&OP are mostly conducted in production-oriented environments. In such systems, the effects of planning quality can be more easily observed through operational indicators such as inventory levels, lead times, and utilization of production capacity.

Figure 3. Topic 2: key terms



Source: Authors of research

Figure 4. Top 30 Most relevant Terms for Topic 2



Source: Authors of research

The third topic (Topic 3) includes terms such as planning, process, sales, and operations, together with concepts like business and study, which indicates the important role of S&OP as an organizational business process. This topic mainly emphasizes the integration of different business functions and the strategic importance of planning activities within organizations.

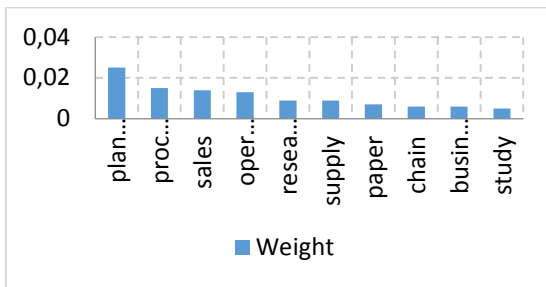
The analyzed studies often focus on how coordination between departments can improve decision-making, organizational alignment, and overall business performance.

The papers included in this cluster often discuss the well-known five-step S&OP process, which consists of data collection, demand planning, supply planning, pre-S&OP meetings, and executive review. In addition, many studies analyze the organizational roles and responsibilities connected with each phase of the process.

The presence of the term business highlights the cross-functional character of S&OP.

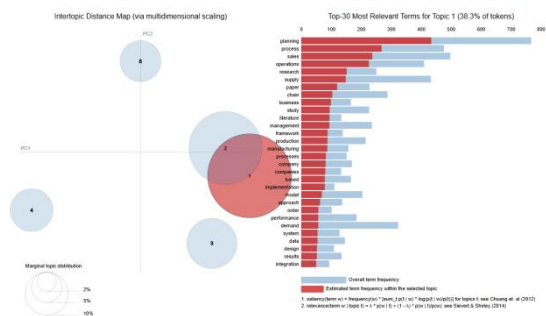
This means that S&OP is not limited only to supply chain activities, but also involves other important business functions such as finance, marketing, and top management in the decision-making process.

Figure 5. Topic 3: key terms



Source: Authors of research

Figure 6. Top 30 Most relevant Terms for Topic 3



Source: Authors of research

The fourth topic (Topic 4) contains terms such as system, model, information, forecasting, and data, which clearly point to the technological and analytical dimension of the S&OP process.

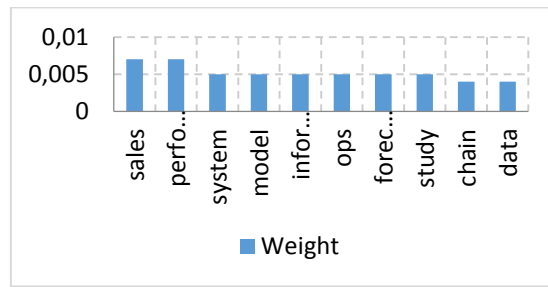
The studies within this topic are mainly focused on modeling approaches, information systems, and the use of analytical methods in demand planning and operational decision-making.

Particular attention is given to the role of digital technologies and data analysis in improving forecasting accuracy and supporting more efficient planning processes.

The technological and analytical aspects represented in this topic are especially important in the context of recent developments in artificial intelligence and advanced planning technologies. The studies within this cluster increasingly focus on the role of tools such as SAP IBP, Oracle S&OP Cloud, and machine learning algorithms in changing and improving traditional S&OP processes.

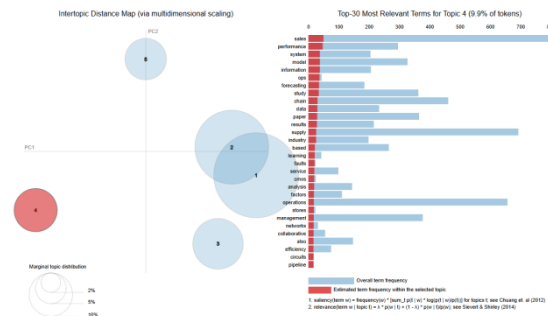
The frequent appearance of terms like forecasting and data confirms that forecast precision and high-quality data are considered among the key factors for successful S&OP implementation and execution. Many authors emphasize that modern analytical tools can significantly improve planning reliability and decision-making quality within supply chain operations.

Figure 7. Topic 4: key terms



Source: Authors of research

Figure 8. Top 30 Most relevant Terms for Topic 4



Source: Authors of research

The fifth topic (Topic 5) is centered around terms such as planning, demand, supply, production, and company, which highlights the operational side of the S&OP process.

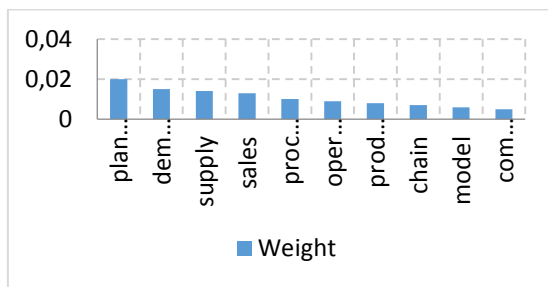
The main focus of this topic is on balancing supply and demand, as well as managing production capacities at the organizational level. The analyzed studies often examine how companies coordinate production planning with market demand in order to improve operational efficiency and reduce costs. Special attention is given to production capacity management, inventory optimization, and maintaining stable supply chain performance under changing market conditions.

The operational aspect of this topic is closely connected with the main purpose of S&OP, which is to achieve balance between supply and demand at the aggregate planning level.

The goal of such coordination is to optimize production volumes, inventory levels, and capacity requirements. Studies within this cluster often discuss practical problems caused by mismatches between supply and demand.

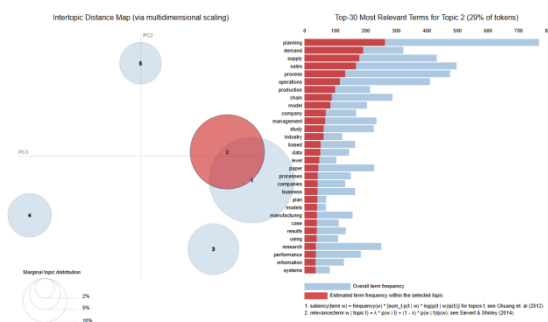
These issues include excess inventory, product shortages, and inefficient use of production capacity. Such problems are recognized as important factors that directly influence supply chain costs and the overall level of customer service.

Figure 9. Topic 5: key terms



Source: Authors of research

Figure 10. Top 30 Most relevant Terms for Topic 5



Source: Authors of research

The visualization of topics presented in the figures 2,4,6,8 and 10 provides additional insight into the mutual distance and relative representation of the topics. Based on the layout in the two-dimensional space, it can be concluded that the topics are interconnected, yet sufficiently differentiated to represent distinct aspects of S&OP research. The first topic stands out in particular, accounting for the largest share of the total corpus (approximately 38%), which confirms its central significance in the analyzed literature.

Furthermore, the analysis of term distributions indicates a strong connection between planning, management, and performance, which is consistent with the fundamental function of S&OP as a mechanism for aligning strategic and operational goals. A growing significance of analytical and informational components is also observed, reflecting contemporary trends in digitalization and the application of advanced methods in planning.

Based on the obtained results, it can be concluded that research in the field of S&OP clusters around several key directions: (1) conceptual-theoretical development, (2) performance improvement, (3) process integration, (4) technological support, and (5) operational planning. This structure provides a foundation for further research and the identification of potential directions for the development of this discipline.

CONCLUSION

Sales and Operations Planning represents a field that is in a constant state of development, both in practice and in the scientific literature. In order to identify the dominant research directions in this field, an analysis of a corpus of scientific abstracts retrieved from the Scopus database was conducted using the Latent Dirichlet Allocation method.

The results of the analysis revealed five thematic units that comprehensively reflect the research landscape of S&OP. The identified topics encompass the conceptual-theoretical framework of supply chain management, performance measurement and operational efficiency, process integration of business functions, the technological and analytical dimension of planning, as well as operational management of the supply-demand balance. This structure confirms that researchers approach S&OP from various angles, ranging from strategic and organizational to technological and quantitative, which contributes to the richness and heterogeneity of the available literature.

In addition to the identification of topics, the analysis also highlighted the interconnections between certain research directions, particularly between process integration and technological support, which may serve as a basis for defining future research questions. The dominance of the topic relating to the general supply chain management framework is especially notable, accounting for approximately 38% of the total corpus, which clearly speaks to its central place in the literature.

The limitation of the conducted study lies in the exclusive use of a single scientific database, which may affect the comprehensiveness of the analyzed corpus. In future research, the authors plan to expand the data sources, as well as to conduct a deeper investigation of one of the identified topics through a targeted empirical or theoretical study.

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