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LITERATURE REVIEW

Beyond S&OP implementation: A maturity model and meta-framework for assessing and managing evolution paths

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ABSTRACT

Goal: The purpose of this paper is to present an S&OP meta-framework that combines specific S&OP tools and an original S&OP maturity model as an approach to reduce uncertainty and increase commitment in the S&OP implementation process.

Design / Methodology / Approach: A systematic review led to the development of a six-pillar S&OP tool framework. Then, a maturity model and an S&OP implementation meta-framework, were defined for managing the introduction and evolution of S&OP dimensions.

Results: The S&OP maturity model provides a structured model for identifing critical gaps in the S&OP process. Furthermore, the S&OP meta-framework - combining Action Research (AR), Kotter's 8 steps, and agile project management approaches - provides an holistic implementation guide for promoting large-scale transformation in S&OP implementation efforts.

Limitations of the investigation: The S&OP maturity model and implementation system are new empirical contributions to the literature and have not been validated in this article.

Practical implications: This work provides a set of tools to address specific S&OP environments; a maturity model to diagnose the S&OP process; and an S&OP implementation framework to reduce uncertainty and increase commitment in the change process.

Originality / Value: This article fills a literature gap of necessary S&OP implementation practices, contributing to: (1) an S&OP tools framework, (2) an S&OP maturity model based on evolutionary boundaries correlated to the presence of specific tools, processes and metrics, and (3) an S&OP implementation meta-framework, raising awareness in under researched S&OP dimensions for more oriented research and practices needed to promote sustainable change.

Keywords: Sales and Operations Planning, S&OP, S&OP Implementation, S&OP Maturity Model, S&OP Meta-framework.

1 INTRODUCTION

Plunged into high levels of global competition and economic uncertainties, companies are striving even harder to find a positioning in a tight profit margin environment. Competitive advantage and operational performance are two intrinsic correlated pillars. The strong link between manufacturing strategy, valuable resources and overall organization performance is well established in different contexts (Schroeder et al., 2002; Machuca et al., 2011; Nason and Wiklund, 2018). Therefore, functional capabilities combined with the efficient allocation of assets and resources can dictate the long-term success of enterprises.

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The Sales and Operations Planning (S&OP) process occupies a key place in SCM, receiving a growing number of publications in the last decade (Thomé et al., 2012; Tuomikangas and Kaipia, 2014; Kristensen and Jonsson, 2018). The purpose of the tool is to balance demand and supply chain capabilities in a cross-function and integrated planning process to maximize profit (Thomé et al., 2014; Wagner et al., 2014) by: (i) coordinating the decision-making stages of procurement, production, marketing, sales and finance departments into a reactive demand-driven global plan, and (ii) influencing positively the core drivers of supply chain management as: forecast accuracy, service level, capacity utilization and inventory level (Kristensen and Jonsson, 2018).

Despite the broadness of S&OP literature branches, gaps still can be identified between industry and academic research (Noroozi and Wikner, 2017). As several authors recognize the possible benefits of additional in-depth empirical research (Rexhausen et al., 2012; Thomé et al., 2014; Tuomikangas and Kaipia, 2014; Kristensen and Jonsson, 2018). With these gaps in mind, we have identified a research opportunity for identifying specific tools deployed in different S&OP contexts, as well as the relationship of these tools with the S&OP maturity levels and dimensions of organizations, and how this evolutionary transitioning process could be implemented into a comprehensive and prescriptive meta-framework.

The purpose of this study is, through a review of the literature, to develop an S&OP maturity model and implementation meta-framework to manage the evolution stages of the implementation process. It serves as a roadmap to support the implementation efforts of the S&OP process, in the context of a medium-size automotive company, located in southern Brazil. This research provides not only insights into the specific aforementioned context, but also a broader view for researchers and practitioners, especially to test different S&OP development scenarios. Therefore, this research is relevant by addressing these gaps. First by conducting a systematic review to identify the main tools used in S&OP. Second, by developing an S&OP maturity model, to highlight the choices that a particular company needs to make in order to evolve from a reactive stage to a world-class S&OP stage in each dimension. Finally, by proposing a meta-framework of how to increase the S&OP implementation success, considering the elements that support the maturity model, such as an organizational learning process, change management and project management.

This paper is structured in five parts, as follows. After the introduction, a systematic review of the S&OP is covered in Session 2, presenting a framework with a set of tools for the S&OP implementation and metrics for measuring the process performance. Session 3 establishes the S&OP maturity evaluation model based on the review insights. Afterwards, Session 4 synthesizes the proposed meta-framework for the S&OP implementation, finishing with the conclusions in Session 5.

2 METHODS

The procedures were adopted according to the guidelines outlined in the works of Denyer and Tranfield (2009) and Cooper (2010) for the different stages of the process. A five-step model was followed including: (i) formulation of the problem, (ii) location of studies, (iii) selection and evaluation of studies, (iv) synthesis of results, and (v) literature analysis and conclusions. This approach aims to provide a transparent and replicable scientific research to contribute with an unbiased work to the S&OP literature.

2.1 Formulating the Problem

The focus of this research is associated with the lack of works providing an integrated set of tools for implementing S&OP. In this sense, a synthesis of the literature could help practitioners with a roadmap of specific tools for the different maturity levels of organizations that are willing to adopt or improve the process. Therefore, the main motivation behind this review is to contribute with a framework of tools for the implementation of the Sales and

Operations Planning process, reaching deeper layers of conceptual applications to provide a guideline that supports its practical application.

To identify the variables of interest within the scope of this systematic review, two research questions were defined:

a) Research question 1: What are the main tools used in S&OP?

b) Research question 2: How can these tools be synthesized in an S&OP framework?

Those questions allow a clear conceptual definition of the variables related to the research purpose, beginning with an overview of the S&OP concepts, the initial question assesses the main limitations of the current literature. Subsequently, narrowing the focus of the research, questions 2 substantiates the potential for synthesizing the results.

2.2 Location of Studies

Six data sources were selected for the location of studies: EBSCO (Academic Search Ultimate, Business Source Ultimate), Emerald, ScienceDirect, Scopus, Taylor & Francis, and Web of Science. These databases selected are often used in most S&OP studies and ensure a wide coverage of the scientific literature in the spheres of operations management, social sciences and industrial studies, including peer-reviewed articles (Thomé et al., 2012; Noroozi and Wikner, 2017; Kristensen and Jonsson, 2018). Keywords were selected based on the definition of the research problem, in pseudocode: “Sales and Operations Planning” OR “S&OP” AND “Implementation” AND “Tools”. The search was performed in the end of January of 2021, without any year limit defined.

A manual search was also performed to capture sources outside the selected databases, using the same terms and period in a broad search of several key operations management and supply chain journals, highlighted in the works of Thomé et al. (2012) and Tuomikangas and Kaipia (2014). The searched journals were *Journal of Business Forecasting* (JBF), *Supply Chain Management Review* (SCMR), *Journal of Operations Management* (JOM), *International Journal of Production Economics* (IJPE) and *International Journal of Production Research* (IJPR).

2.3 Selection and Evaluation of Studies

The study selection and evaluation stage requires a clear definition of the inclusion and exclusion criteria of articles to provide a congruent judgment of the relevance of each finding. In this review, the exclusion criteria were defined as follows: a) Duplicates; b) Availability: not full papers; c) Relevancy: articles do not adequately address the S&OP implementation construct; d) Methodology: poorly defined methods or lack of clear evidence in empirical publications.

The initial database search found 1180 papers, which were evaluated based on the exclusion criteria. First, 211 duplicates were excluded from the results, followed by a reading of all abstracts, leading to the removal of 709 articles that were not relevant or available, resulting in 260 articles selected for full-text reading. A manual search added 30 publications to those previously selected. After reading the full text of the selected articles, 208 papers were excluded from the process. Thus, they remained 82 after the application of the selection criteria. The whole review process is illustrated in Figure 1.

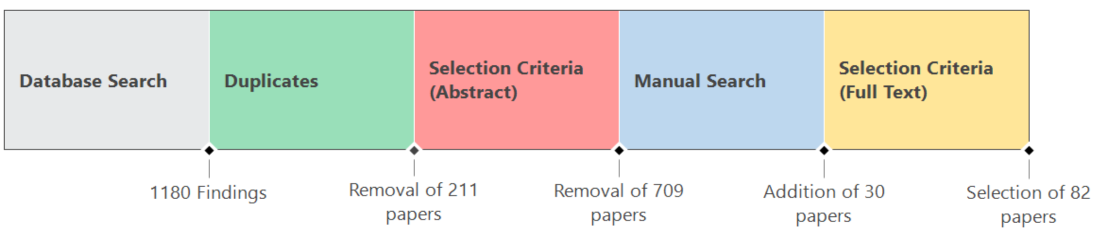


Figure 1 – Study Selection Process

Of the 208 articles excluded from reading the full text due to the defined criteria, most have only superficial information or brief quotes, not S&OP as the focus of the study. A representative number of articles illustrates only general theoretical definitions of the topic. The others, given the scope of the review, lacked acceptable methodological procedures or satisfactory evidence.

3 RESULTS

The 82 articles selected in the systematic review are listed in Table 1, combined with their journals and citation index provided by Scopus. The findings highlight the growth and relevance of the topic in publications in recent years, consistent with the results recently found by Kristensen and Jonsson (2018).

Table 1 – Papers Selected

Author(s)	Journal
Sato and Tsai (2004)	International Journal of Production Research
Chen and Chen (2005)	Computers & Operations Research
Wikner and Rudberg (2005)	International Journal of Logistics Research and Applications
Collin and Lorenzin (2006)	International Journal of Physical Distribution & Logistics Management
Grimson and Pyke (2007)	International Journal of Logistics Management
Feng et al. (2008)	International Journal of Production Economics
Thomas et al. (2008)	Journal of Decision Systems
Mooraj et al. (2009)	AMR Research
Nakano (2009)	International Journal of Physical Distribution & Logistics Management
Rudberg and Thulin (2009)	Production Planning & Control
Chen-Ritzo et al. (2010)	European Journal of Operational Research
Feng et al. (2010)	International Journal of Production Research
Ivert and Jonsson (2010)	Industrial Management & Data Systems
Lebreton et al. (2010)	International Journal of Production Research
Voluntary Interindustry Commerce Solutions (2010)	Voluntary Interindustry Commerce Solutions
Feng et al. (2011)	International Journal of Production Research
Figueiredo et al. (2011)	Journal of Operations and Supply Chain Management
Hahn and Kuhn (2011)	Journal of the Operational Research Society
Oliva and Watson (2011)	Journal of Operations Management
Sodhi and Tang (2011)	Journal of the Operational Research Society
Hahn and Kuhn (2012a)	International Journal of Production Economics
Hahn and Kuhn (2012b)	International Journal of Production Economics
Kelleher (2012)	Journal of Business Forecasting
O'Marah (2012)	SCM World
Olhager and Johansson (2012)	Journal of Engineering and Technology Management
Wang et al. (2012)	International Journal of Computer Integrated Manufacturing
Feng et al. (2013)	Production and Operations Management
Jonsson et al. (2013)	Supply Chain Management: An International Journal
Ivert and Jonsson (2014)	International Journal of Operations & Production Management
Li and Thorstenson (2014)	International Journal of Production Research
Lim et al. (2014)	International Journal of Production Economics
Rappold and Yoho (2014)	International Journal of Production Economics
Wagner et al. (2014)	Business Horizons
Calfa et al. (2015)	Industrial & Engineering Chemistry Research
Chen, Lai and Xiao (2015)	Management Science
Goh and Eldridge (2015)	Journal of Physical Distribution & Logistics
Jonsson and Ivert (2015)	International Journal of Production Economics
Rostami-Tabar et al. (2015)	International Journal of Production Economics
Taşkin et al. (2015)	Interfaces, Articles in Advance
Doering and Suresh (2016)	Journal of Supply Chain Management
Hübner (2016)	International Journal of Retail & Distribution Management

Table 1 – Continued...

Author(s)	Journal
Hulthén et al. (2016)	International Journal of Physical Distribution & Logistics Management
Negahban and Smith (2016)	International Journal of Production Research
Noroozi and Wikner (2016)	Production & Manufacturing Research
Omar et al. (2016)	Computational Intelligence and Neuroscience
Shimizu et al. (2016)	Journal of Advanced Mechanical Design, Systems, and Manufacturing
Wochner et al. (2016)	International Journal of Production Economics
Albrecht and Steinrücke (2017)	International Journal of Production Research
Cassettari et al. (2017)	Foresight
Danese et al. (2017)	International Journal of Production Research
Kaipia et al. (2017)	Journal of Operations Management
Lalami et al. (2017)	International Journal of Production Research
Lim et al. (2017)	Computers & Industrial Engineering
Nemati et al. (2017)	Computers & Chemical Engineering
Pedroso et al. (2017)	Production
Ali et al. (2018)	Operations Research Perspectives
Ambrose et al. (2018)	Journal of Business Research
Anderson and Jonsson (2018)	International Journal of Physical Distribution & Logistics Management
Darmawan et al. (2018)	International Journal of Production Research
Dreyer et al. (2018)	International Journal of Physical Distribution & Logistics Management
Nemati and Alavidoost (2018)	Soft Computing
Vereecke et al. (2018)	International Journal of Operations & Production Management
Wery et al. (2018)	Computers in Industry
Ali et al. (2019)	INFOR: Information Systems and Operational Research
Ávila et al. (2019)	52nd CIRP Conference on Manufacturing Systems
Bagni and Marçola (2019)	Gestão & Produção
Darmawan et al. (2019)	Applied Mathematical Modelling
Fildes et al. (2019)	International Journal of Forecasting
Mahadevan (2019)	International Journal of Productivity and Performance Management
Abolghasemi et al. (2020)	International Journal of Production Economics
Aiassi et al. (2020)	Simulation Modelling Practice and Theory
Albrecht and Steinrücke (2020)	Flexible Services and Manufacturing Journal
Alfieri et al. (2020)	Computers & Industrial Engineering
Gholami-Zanjani et al. (2020)	International Journal of Production Research
Oger et al. (2020)	Enterprise Information Systems
Santos et al. (2020)	International Journal of System Dynamics Applications
Schlegel et al. (2020)	International Journal of Physical Distribution & Logistics Management
Steenbergen and Mes (2020)	Decision Support Systems
Stentoft et al. (2020)	International Journal of Physical Distribution & Logistics Management
Torkaman et al. (2020)	Computers and Operations Research
Wolfshorndl et al. (2020)	Global Journal of Flexible Systems Management
Fildes and Goodwin (2021)	International Journal of Forecasting

Despite 53 different journals identified, 33% of the findings are concentrated in three journals - *International Journal of Production Economics* (IJPE), *International Journal of Production Research* (IJPR) and *International Journal of Physical Distribution & Logistics Management* (IJPDLM).

3.1 LITERATURE ANALYSIS

This section presents the conclusions of each article selected in the systematic review to answer the defined research questions. Exploring the tools identified in each specific context of study to synthesize the data found during this systematic review process. Subsequently, the categories used for the classification of the S&OP pillars are presented in a S&OP framework.

The first category of the review refers to the tools used in a wide range of works selected in the literature. The data collected on this topic represent the main variable of this research. From the results, it is identified that the S&OP literature has a significant number of tools already established in several publications. These findings corroborate with the growing maturity of the theme in practical and academic contexts, and complete the first research question proposed, presenting the specific tools used in a diverse number of S&OP publications in the literature.

To answer the second proposed research question ("How can these tools be synthesized in an S&OP framework?"), six pillars were empirically defined to summarize the review: Demand Management, Forecasting, Human Resources, New Product Introduction, Supply Chain Management and Tactical Planning. These criteria were established based on the reviewed data, exploring the distribution of topics behind each work selected in the literature. For the synthesis purpose, Table 2 was created to group the tools identified by each defined pillar.

Table 2 – Literature Findings

Pillar	Tools	Author(s)
Demand Management	· Business Assumptions Package (BAP) · Control mode decoupling point (CMDP) · Customer order decoupling point (CODP) · Demand Management Organization (DMO) · Discretization decoupling point (DDP) · Electronic Data interchange (EDI) · Genetic Algorithm (GA) · Kriging Metamodels · Linear Programming (LP) · Nested Booking Limits (NBL) · Point-of-sales (PoS) · Simulated Annealing (SA) · Simulation-optimization · Stochastic Programming	Wikner and Rudberg (2005), Oliva and Watson (2011), Sodhi and Tang (2011), Chen et al. (2015), Noroozi and Wikner (2016), Kaipia et al. (2017), Ali et al. (2018), Darmawan et al. (2018), Dreyer et al. (2018), Ali et al. (2019), Darmawan et al. (2019)
Forecasting	· Autoregressive Integrated Moving Average (ARIMA) · Backpropagation Neural Network (BPNN) · Big Data · Collaborative Planning, Forecasting and Replenishment (CPFR) · DemandForest · Exponential Smoothing · Forecasting Management Competence (FMC) · Forecasting support system (FSS) · Forecasting Systematic Events (FSE) · IT Systems · Single Exponential Smoothing (SES) · Stochastic Multi Source Forecasting Model (SMS-FM)	Collin and Lorenzin (2006), Nakano (2009), Voluntary Interindustry Commerce Solutions (2010), Feng et al. (2011), Kelleher (2012), Rostami-Tabar et al. (2015), Doering and Suresh (2016), Omar et al. (2016), Cassettari et al. (2017), Fildes et al. (2019), Abolghasemi et al. (2020), Steenbergen and Mes (2020), Fildes and Goodwin (2021)
Human Resources	· Maturity model · Myers–Briggs Type Indicator (MBTI) · Superordinate Identity Teams	Grimson and Pyke (2007), Mooraj et al. (2009), O'Marah (2012), Wagner et al. (2014), Goh and Eldridge (2015), Hulthén et al. (2016), Danese et al. (2017), Pedroso et al. (2017), Ambrose et al. (2018), Vereecke et al. (2018), Bagni and Marçola (2019), Stentoft et al. (2020)
New Product Introduction	· IT Systems · Mixed-integer Linear Programming (MILP) · Monte Carlo Simulation · Point-of-sales (PoS) · Simulation-optimization	Goh and Eldridge (2015), Negahban and Smith (2016), Wochner et al. (2016), Kaipia et al. (2017), Wery et al. (2018)

Table 2 – Continued...

Pillar	Tools	Author(s)
Supply Chain Management	· Big Data · Contact Manufacturing Shipment Schedule (CMSS) · Decision Support System (DSS) · Fuzzy Mixed-integer linear programming (f-MILP) · Hybrid Heuristics · IT Systems · Linear Programming (LP) · Mixed-integer Linear Programming (MILP) · Mixed-integer nonlinear programming (MINLP) · Mixed-integer Programming (MIP) · Reverse Collaboration Framework (RCF) · Simulation-optimization · Stochastic Programming · System Dynamics (SD) · Warehouse Management System (WMS)	Feng et al. (2008), Feng et al. (2010), Lebreton et al. (2010), Hahn and Kuhn (2011; 2012a; 2012b), Jonsson et al. (2013), Lim et al. (2014), Goh and Eldridge (2015), Hübner (2016), Shimizu et al. (2016), Lim et al. (2017), Nemati et al. (2017), Nemati and Alavidoost (2018), Ávila et al. (2019), Mahadevan (2019), Aiassi et al. (2020), Gholami-Zanjani et al. (2020), Oger et al. (2020), Santos et al (2020), Schlegel et al. (2020)
Tactical Planning	· Advanced Planning and Scheduling (APS) · Agile Production Planning and Control System (APPCS) · Decision Support System (DSS) · Dynamic Programming · Fuzzy Mixed-integer linear programming (f-MILP) · Hybrid Heuristics · IT Systems · Linear Programming (LP) · Long-term capacity management framework · Master Production Schedule (MPS) · Mixed-integer Linear Programming (MILP) · Mixed-integer nonlinear programming (MINLP) · Mixed-integer Programming (MIP) · Optimization models · Rough Cut Capacity Planning (RCCP) · Simulation-optimization · Stochastic Programming · Tabu Search	Sato and Tsai (2004), Chen and Chen (2005), Feng et al. (2008), Thomas et al. (2008), Rudberg and Thulin (2009), Chen-Ritzo et al. (2010), Ivert and Jonsson (2010), Figueiredo et al. (2011), Feng et al. (2011), Oliva and Watson (2011), Olhager and Johansson (2012), Wang et al. (2012), Feng et al. (2013), Jonsson et al. (2013), Ivert and Jonsson (2014), Li and Thorstenson (2014), Rappold and Yoho (2014), Calfa et al. (2015), Goh and Eldridge (2015), Jonsson and Ivert (2015), Taşkin et al. (2015), Albrecht and Steinrücke (2017), Lalami et al. (2017), Nemati et al. (2017), Darmawan et al. (2018), Dreyer et al. (2018), Nemati and Alavidoost (2018), Albrecht and Steinrücke (2020), Alfieri et al. (2020), Torkaman et al. (2020), Wolfshorndl et al. (2020)

As we can conclude based on the results, most of the tools found in the S&OP literature are concentrated in the Tactical Planning pillar. Demand Management, Supply Chain Management and Forecasting follow the ranking of publications. New Product Introduction and Human Resources were the pillars with the fewest tools found in the reviewed articles. Although the proposed techniques are highly complex, these results illustrate a gap to be filled by the literature.

3.1.1 S&OP Framework

To summarize the results and fill in the last research question, in Figure 2, we present a S&OP framework as a structured model to synthesize the S&OP pillars. The framework was created based on the data obtained through the review process. The model provides a conceptual view of the overall S&OP basis, highlighting the main S&OP pillars that are essential for the effectiveness of the process.

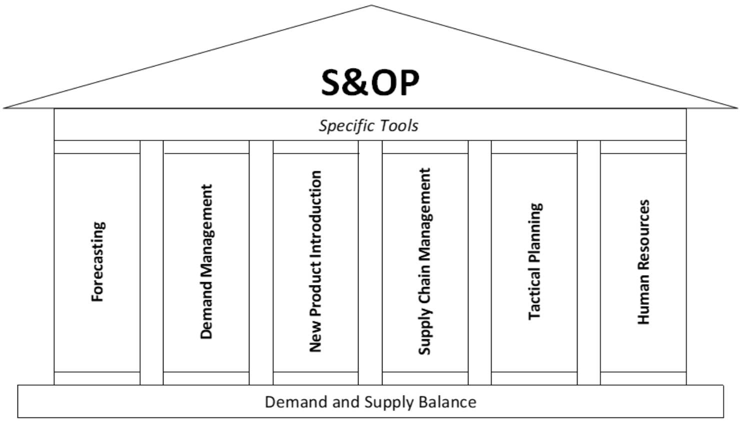


Figure 2 – S&OP Framework

The framework depicts how the pillars of a wide range of tools in different business spheres are key to support the S&OP process in a synergistic way. Forecasting, Demand Management and New Product Introduction techniques provide projections as inputs for assessing and planning future market demand scenarios. Supply Chain Management and Tactical Planning are the pillars linked to the operational aspect, unfolding the demand projections into feasible plans. And finally, the Human Resources pillar brings all the elements together, integrating the decision-making process through different business departments in a holistic results-driven way. Combining these multidisciplinary practices and tools from all the pillars identified, the S&OP process is able to reach its full potential, providing deep integration and collaboration for any organization.

4 DEBATES

As the results of the systematic review highlighted, the S&OP literature provides several maturity models that vary from different approaches, contexts, and publication dates. Despite some similarities in the paths and dimensions of evolution as noted by Danese et al. (2017), in general, the definition of the S&OP dimensions is not well explored in detail in the current models available. To discuss the actual structure used, Table 3 was designed to depict the stages and S&OP dimensions used in the selected models through the systematic review process.

Table 3 – S&OP Maturity Models

Author(s)	Stages	Dimensions
Grimson and Pyke (2007)	1-5	· Meetings & Collaboration · Organization · Measurements · Information Technology · S&OP Plan Integration
Mooraj et al. (2009)	1-4	· Balance · Goal · Ownership · Metrics
O'Marah (2012)	1-10	· Depth of S&OP into supply, demand, and product management · Breadth of S&OP's internal and external alignment, and information visibility
Wagner et al. (2014)	0-5	· Process Effectiveness · Process Efficiency · People & Organization · Information Technology
Goh and Eldridge (2015)	1-5	· Meetings and Collaboration · Organization · Measurements · Information technology · S&OP Plan integration

Table 3 – Continued...

Danese et al. (2017)	1-5	· People and organization
		· Process and methodologies
		· Information technology
		· Performance measurement
Pedroso et al. (2017)	1-5	· Tools
		· Processes
Vereecke et al. (2018)	1-5	· Data
		· Method
		· System
		· Performance
		· Organization
		· People

Several dimensions were adopted throughout the development of S&OP maturity models, however, there are no clear scopes and boundaries identified for the dimension's impact on the S&OP process. Although recent models have improved, their S&OP dimensions are still mainly composed of broad topics, which are unable to provide tangible gaps to organizations that may need to address them at specific implementation steps. This characteristic could be valuable in environments with a lower level of maturity and knowledge of the S&OP process, allowing a more in-depth assessment.

4.1 S&OP MATURITY MODEL

To fill this gap, we developed an S&OP maturity model in order to improve the existing models in the literature, with a deeper structure of the S&OP dimensions. To this end, the findings of the systematic review, were introduced, using the six pillars (Human Resources, Demand Management, Forecasting, New Product Introduction, Tactical Planning and Supply Chain Management) as the basis of the model. Similar to most of the studies analyzed, five maturity stages were adopted, in which S&OP tools were classified based on the insights obtained from the review data. The classification logic set boundaries of evolution from one stage to another based on the presence of tools, processes and metrics. Assessment questions were also created for each topic to assist practitioners during the evaluation of each specific point. The model, presented in Table 4, allows the identification of gaps in the S&OP pillars and provides a roadmap of actions for the transition of stages. In addition, it serves as a reference between different industries and organizations for the S&OP performance and the implementation success factors.

In general, the expected behavior at each maturity stage, as illustrated in Figure 3, can be summarized as the following characteristics. For companies positioned in stage 1, the lack of collaboration in the planning process, as well as the absence of defined tools and metrics are the main characteristics. Typically, organizations at this stage represent only reactive responses and are not able to forecast demand and operations scenarios. The decision-making process is mainly empirical and human judgment dictates most of the actions. Stage 2 represents organizations that have some integration in their planning activities. For this stage, manual procedures are perceived for the management of planning tasks and non-specific tools without objectives are noted in the process. Some metrics are measured; however, they are generally interpreted in isolation from other KPIs. Stage 3 begins to represent a more robust planning environment. At this level, established procedures and events are identified, depicting collaboration and synergy with the different departments. Market scenarios are forecasted, and decisions are made through consensus projections. Specific tools and metrics are used to assist in the planning and monitoring of results. In the two most advanced stages, the use of IT and advanced technologies is clearly noted. Stage 4 brings the introduction of optimization tools combined with programming techniques to improve the planning and decision-making process. This stage also presents the internal integration of the KPIs, as well as continuous improvement actions to improve the organization's performance. In the last stage, advanced simulation techniques, combined with real-time data and global supply chain integration, represent the pinnacle of the demand and supply balancing process for optimal performance and agility.

Table 4 – Proposed S&OP Maturity Model

#	Pillar	Assessment Question(s)	Scoring Criteria				
			1 - Undefined	**2 - Reactive**	**3 - Integrated**	**4 - Optimized**	**5 - World Class**
1	**Human Resources**						
1.1	**S&OP Team**	*Does your company have a specific team to ensure the capacity to meet future demand?*	• There is no team to plan demand and supply operations • No collaboration between departments	• There is an informal team for the decision-making process • Occasionally meetings to plan demand and supply matches	• A formal S&OP team is defined • Clear roles and defined stakeholders • Scheduled routine meetings	• All of Stage 3 + • Superordinate Identity teams • Involvement of executive management in the process	• All of Stage 4 + • Involvement of external stakeholders in the planning process • The global plan is shared with the entire supply chain
1.2	**S&OP Performance**	*How do you evaluate the S&OP performance in your organization?*	• No method is used to evaluate the S&OP process	• Functional metrics are monitored in isolation, but the overall performance of S&OP is not known	• Specific KPIs and KBIs are defined and shared with stakeholders to measure the process effectiveness	• All of Stage 3 + • Maturity models are used to assess the maturity of the process • Action plans are established for the continuous improvement of S&OP dimensions	• All of Stage 4 + • S&OP performance is linked to external supply chain partners
2	**Demand Management**						
2.1	**Demand Planning**	*How do you deal with demand uncertainties?* *How do you manage orders in your production planning system?* *How do you define order due dates?*	• Reactive planning process • There are no defined constraints for establishing order due dates	• Informal demand planning process • Order due dates are defined based on human judgment and rough constraints	• Centralized planning process • Definition of capacity limitations and bottlenecks • Frozen windows and decoupling points established Applicable tools: • BAP • DMO • CODP • NBL	• All of Stage 3+ • Programming tools are used to manage demand • Feasible delivery plans are generated Applicable tools: • LP • MILP • Kriging metamodels • Heuristics	• All of Stage 4 + • Sophisticated simulation models are used • Computation time is monitored Applicable tools: • Simulation-optimization • Stochastic Programming

Table 4 - Continued...

#	Pillar	Assessment Question(s)	Scoring Criteria				
			1 - Undefined	**2 - Reactive**	**3 - Integrated**	**4 - Optimized**	**5 - World Class**
2.2	**Orders Receipt**	*How do you receive purchasing orders from your clients?*	• Manual process for receiving orders	• Order receipt is electronically but a manual process is performed to input into the ERP system	• Order receipt is fully integrated with the ERP system Applicable tools: • Electronic Data Interchange (EDI)	• All of Stage 3 + • Order receipt is integrated with MRP / production schedules (MPS)	• All of Stage 4 + • Integration of customer information in real time Applicable tools: • Vendor Managed Inventory (VMI) • Point-of-sales (PoS) • Efficient Customer Response (ECR)
3	**Forecasting**						
3.1	**Forecasting Process**	*How is the forecasting process in your organization?*	• No forecasting process exists	• Informal forecasting process • Forecasts are generated based on human judgment only	• Formal forecasting process established • Scheduled routinely meetings • Integration with marketing (promotions), qualitative variables and new products introduction plans	• All of Stage 3 + • Statistical forecasting techniques are combined with human judgment Applicable tools: • ARIMA • Big data • Exponential Smoothing • Neural Network • Stochastic Programming • IT systems	• All of Stage 4 + • External supply chain collaboration in joint forecasting activities Applicable tools: • Collaborative Planning, Forecasting and Replenishment (CPFR)
3.2	**Forecast Accuracy**	*How do you monitor your forecast accuracy?*	• Forecast accuracy is not tracked	• Forecast accuracy is monitored but only shared upon request	• Forecast accuracy is tracked and shared across the organization	• All of Stage 3 + • Forecast accuracy is linked to other metrics (inventory costs, service level, capacity utilization, profit, ...)	• All of Stage 4 + • Forecasting accuracy is linked to external supply-chain metrics

Table 4 - Continued...

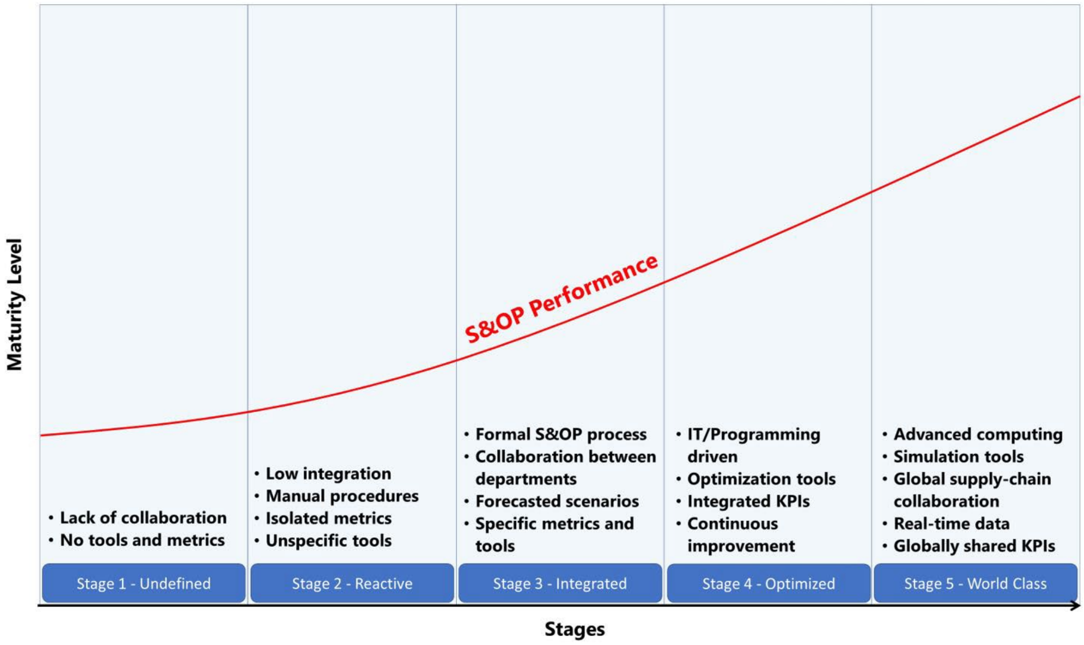
#	Pillar	Assessment Question(s)	Scoring Criteria				
			1 - Undefined	**2 - Reactive**	**3 - Integrated**	**4 - Optimized**	**5 - World Class**
4	**New Product Introduction**						
4.1	**NPI Strategies**	*How do you plan to introduce new products in your production?* *How is the demand ramp-up process managed in your organization?*	• There is no new product introduction plan or process	• There are informal NPI plans, but the strategy is not documented	• Formal NPI plan is defined • Demand is forecasted for new launches • Production constraints are assessed at the development phases	• All of Stage 3 + • Programming tools are used to plan the demand ramp-up process Applicable tools: • MILP • Monte Carlo Simulation • Simulation-optimization	• All of Stage 4 + • Integration of customer information in real time Applicable tools: • Vendor Managed Inventory (VMI) • Point-of-sales (PoS) • Efficient Customer Response (ECR)
5	**Supply Chain Management**						
5.1	**Inventory Replenishment**	*How do you plan your inventory replenishment process?*	• Manual process to plan the inventory replenishment cycle (spreadsheets)	• Automated planning system • Reorder point (ROP) defined for each SKU • Historical data available Applicable tools: • IT Systems	• All of Stage 2 + • Centralized integrated supply chain planning • Inventory is adjusted based on demand projections • Service level and logistical costs are monitored	• All of Stage 3 + • Programming techniques are used to plan inventory replenishment Applicable tools: • MILP • MINLP • MIP • Heuristics	• All of Stage 4 + • Sophisticated simulation models are used • Computation time is monitored Applicable tools: • Simulation-optimization • System Dynamics (SD) • Stochastic Programming
5.2	**Safety Stocks**	*How do you determine safety stock levels?*	• No metrics or rules are documented to establish safety stocks	• Safety stocks are determined based on historical data • Parameters are established for product families	• Service level and lead times are defined and updated regularly • Documented strategies at the SKU level • Automated planning system	• All of Stage 3 + • Programming techniques are used • Forecasts accuracy and deviations are taken into account when determining safety stock levels	• All of Stage 4 + • Sophisticated simulation models are used • Computation time is monitored Applicable tools:

Table 4 - Continued...

#	Pillar	Assessment Question(s)	Scoring Criteria				
			1 - Undefined	2 - Reactive	3 - Integrated	4 - Optimized	5 - World Class
					Applicable tools: • IT Systems	Applicable tools: • LP • MILP	• Simulation-optimization • Stochastic Programming
5.3	Inventory Control	*How do you control your inventory?* *Do you track the accuracy of your inventory?*	• Open access storage areas • Inventory control is disaggregated • Inventory accuracy is not tracked	• Centralized stock areas • Storage locations defined for each SKU • ERP integration	• All of Stage 2 + • First in first out (FIFO) plan • Documented process for managing expiration dates • Inventory accuracy is monitored	• All of Stage 3 + • Automated planning system • Storage constraints are set Applicable tools: • WMS	• All of Stage 4 + • Real-time data is available Applicable tools: • RFID
6	Tactical Planning						
6.1	Capacity Planning	*How do you plan and quantify your production capacity?* *How do you assess the forecasted demand scenarios in your production constraints?* *How do you identify when the projected demand exceeds the production capacity?*	• No capacity planning is carried out • Production orders are released to the production site without any capacity assessment	• Capacity is measured only for critical processes by units • Manual process for planning production capacity (spreadsheet)	• Capacity is measured and planned for all resources • Manufacturing cycle times and routings are updated regularly • Capacity utilization is monitored Applicable tools: • Rough Cut Capacity Planning (RCCP) • IT Systems	• All of Stage 3 + • Programming techniques are used to generate feasible capacity plans Applicable tools: • LP • MILP • MIP • Heuristics	• All of Stage 4 + • Sophisticated simulation models are used • Computation time is monitored Applicable tools: • Simulation-optimization • Stochastic programming
6.2	Scheduling	*How do you schedule your production orders?* *How do you minimize your production timespan?*	• No production schedule is defined	• Production schedule is defined based on human judgment only • Manual process to develop schedule (spread sheet) • No documented scheduling rules	• Master production schedule is integrated with ERP system • Scheduling rules are applied and documented	• All of Stage 3 + • Programming techniques are used to generate feasible schedules • Planning efficiency is monitored	• All of Stage 4 + • Advanced Planning Systems are used • Production execution is monitored in real time • Computation time is monitored

Table 4 - Continued...

#	Pillar	Assessment Question(s)	Scoring Criteria				
			1 - Undefined	**2 - Reactive**	**3 - Integrated**	**4 - Optimized**	**5 - World Class**
					Applicable tools: • Master Production Schedule (MPS) • IT Systems	Applicable tools: • MILP • MIP • Stochastic Programming • Heuristics	Applicable tools: • Advanced Planning and Scheduling (APS) systems • Manufacturing Execution Systems (MES)
6.3	**Lot-Sizing**	*How do you define your production lot-sizes?* *How do you handle low volume orders?*	• No metrics or rules are documented for lot-sizing	• Lot-sizes are defined based only on human judgment • Manual process and data review (spreadsheet)	• Lot-sizing approaches are documented • Constraints are defined and updated regularly • ERP integration	• All of Stage 3 + • Programming techniques are used to stablish lot sizes Applicable tools: • DSS • MILP • Heuristics	• All of Stage 4 + • Sophisticated simulation models are used. • Computation time is monitored Applicable tools: • Simulation-optimization • Stochastic Programming



The five stages presented in the S&OP maturity model should be assessed individually for each S&OP pillar, as organizations may depict different maturity levels throughout their systems. Therefore, it is important that practitioners be able to differentiate the results for each pillar rather than to get an average of the organization's overall maturity in order to establish feasible action plans targeted to the steps necessary to improve each S&OP pillar and hence the organization's overall maturity. Moreover, a critical level was defined based on the proposed maturity scale. Pillars with a score below 3 are considered critical, as this level represents a minimum formalization of processes and application of tools, therefore actions must be defined in the evaluation process. It is also important to address that the maturity level should always be dictated by the auditor's perception and based on the evidence available in each context. In the next section, an approach to implementing this maturity model is discussed.

4.2 S&OP IMPLEMENTATION META-FRAMEWORK

The evolution in the stages of the S&OP maturity model requires an implementation framework. The complexity of the S&OP implementation requires an organizational learning curve, demanding actions that reduce the project uncertainty and increase the team commitment. This set of actions is understood from a strategic level meta-framework.

The general idea of this approach is that the S&OP Maturity Model can provide viable roadmaps for the process development, by linking all the implementation levels through the integration of the S&OP pillars, presented in Figure 2, and the specific tools into a structured path for assessing and managing the S&OP implementation steps in an iterative way. The model guides these implementation stages, identifying gaps in each dimension and unfolding actions to adopt S&OP best practices and metrics related to any specific maturity level context that practitioners may face. The meta-framework encapsulates the S&OP Maturity Model with other specific frameworks, critical to promoting sustainable change. This meta-framework (Figure 4) aims to guide researchers and practitioners on the process of implementing S&OP. Six integrated dimensions structure the Meta-Framework, providing the critical knowledge and required practices to advance the stages of implementation.

The Action Research (AR) method provides the general approach to the process, as the first dimension. AR is based on the proposition that generalized solutions may not be suitable for all contexts, therefore its purpose is to find appropriate solutions for the specific dynamics of each context (Stringer, 2014). This method involves a process in which four main steps are developed: diagnostic, planning action, taking action and evaluating action (Coghlan and Brannick, 2005). The use of AR is considered valuable in Operations Management (OM), as noted by Coughlan and Coghlan (2002). There is always a need for conceptually-based collaborative work among managers and researchers around relevant operational issues faced by organizations. Therefore, the approach is particularly important as it provides an organizational learning process when dealing with practical implementation challenges, where management interventions find scientific support. Thus, it can be argued that without AR, the S&OP implementation process could be strictly empirical and based on trial and error, without the creation of explicit knowledge and the systematization of learning.

The S&OP Tools application is the second dimension and includes the S&OP Maturity Model and Tools approach. It provides the specific S&OP resources and metrics to be implemented. Initially, the S&OP Maturity Model is applied as a diagnostic tool, enabling the company to understand the current S&OP level and the gaps in which to implement the appropriate actions. Subsequently, S&OP tools are enablers in supporting the phases of planning and taking action, while the S&OP KPIs provide metrics to assess progress in implementation. The AR method alone is compromised without the integration of this set of tools and metrics, which may end up demanding more time and increasing the project risk.

The Change Management Process is the third dimension and has proven the approach to developing commitment to implementation. S&OP implementation is a change process that demands participation and commitment from the cross-functional team. It is essential to create an environment and climate to promote and sustain change. Only AR and the S&OP Maturity Model with isolated tools are not enough to promote change, especially in environments with inadequate implementation conditions. To address this third dimension, the authors propose to use Kotter (1995) 8-step change method (sense of urgency, guiding team, vision of change, communication for buy-in, empowerment to remove obstacles, creation of quick wins, change consolidation and incorporation). Kotter`s steps play an important role in integrating the process. Without theoretical support for change management, the implementation process can be compromised by the lack of an appropriate change process.

Project Management tools provide control and feedback for the process, constituting the fourth dimension. Traditional Project Management guidelines as PMI (2017) Body of Knowledge (PMBOK) and Agile frameworks support a hybrid approach. Allocating resources to establish and maintain the direction and assertiveness of the project throughout its course. The specific activities of the best project management practices are addressed in this dimension, such as defining the project scope, developing the project charter, identifying and planning the stakeholders, creating the project plan, defining methods for managing and monitoring the project work, conducting sprint reviews, implementing risks responses and other forms of control. Without these practices, failures in planning, execution and control might affect the success level of the implementation project. Thus, their relationship with the meta-framework should be view as a supporting role, assisting and providing the means to manage the proper path of implementation evolution.

Cross integration, through meetings and events to foster collaboration and the development of the environment for alignment, is the fifth dimension. This means holding meetings and events such as awareness, training and alignment workshops; project sprint reviews; S&OP meetings and executive feedback reviews to create the project vision and sustain stakeholders' engagement through the process. This dimension plays a crucial role in the S&OP implementation as it addresses a gap previously identified in the Human Resources pillar. Generally, cross-integration aims to enhance education and create a transparent change environment that is highly required in any implementation context.

Milestones, which signal achievements and drivers towards the specific implementation mission, are the sixth dimension. For each implementation phase, the process requires specific milestones or gates. The first milestone in the diagnostic phase is the initial assessment of the system's maturity, which allows the understanding of the system gaps that need to be addressed throughout the following steps. After assessing the system maturity, it is necessary to promote executive engagement to support the process and create a sense of urgency in the organization. Afterwards, the definition of the multidisciplinary S&OP team, as well as the realization of alignment workshops to educate and establish the project's vision for stakeholders are the next milestones to support the planning phase. Next, in the action-taking phase, the implementation of S&OP tools based on the maturity model gaps and the establishment of S&OP meetings are fundamental to the progress of the implementation, improving processes, creating new routines and increasing the overall organization knowledge and effectiveness. To finalize, defining and tracking specific S&OP KPIs and the final maturity assessment of the system - considering practices such as lessons learnt, stakeholders' feedback and project ROI - ends the cycle, highlighting the tangible gains incorporated into the organization and evidencing further gaps to be addressed in new improvement cycles. These key achievements are crucial to create a momentum for change in the organization. Without them, managers may face more difficulties in what needs to be done to move forward in a first implementation process.

The S&OP Meta-Framework serves as a general roadmap, providing guidelines to support S&OP implementations. It accelerates the learning curve, providing a prescriptive process and considering the necessary adaptations to the contextual factors of organizations. Therefore, the Meta-Framework is presented as a system approach, where all the essential parts are crucial for the successful implementation. Managers must take these elements into account in S&OP implementation environments.

This meta-framework was created by the authors based on insights obtained during the implementation of the S&OP process in an automotive company, located in southern Brazil. First, a system diagnosis was performed using the maturity model presented in Table 4. Followed by the deployment of the S&OP tools and metrics, unfolded from the action plan established based on the initial maturity level of the company. The S&OP maturity reassessment, using the same model, was carried out at the end of the project to assess the maturity gains obtained for the system, as well as to define the new actions to be carried out later. This S&OP implementation was highly effective in the studied context, as per the results, analyzed for 9 months, presented in the work of Rampon Neto (2020). These overall results and conclusions led to the empirical creation of the meta-framework presented in this work.

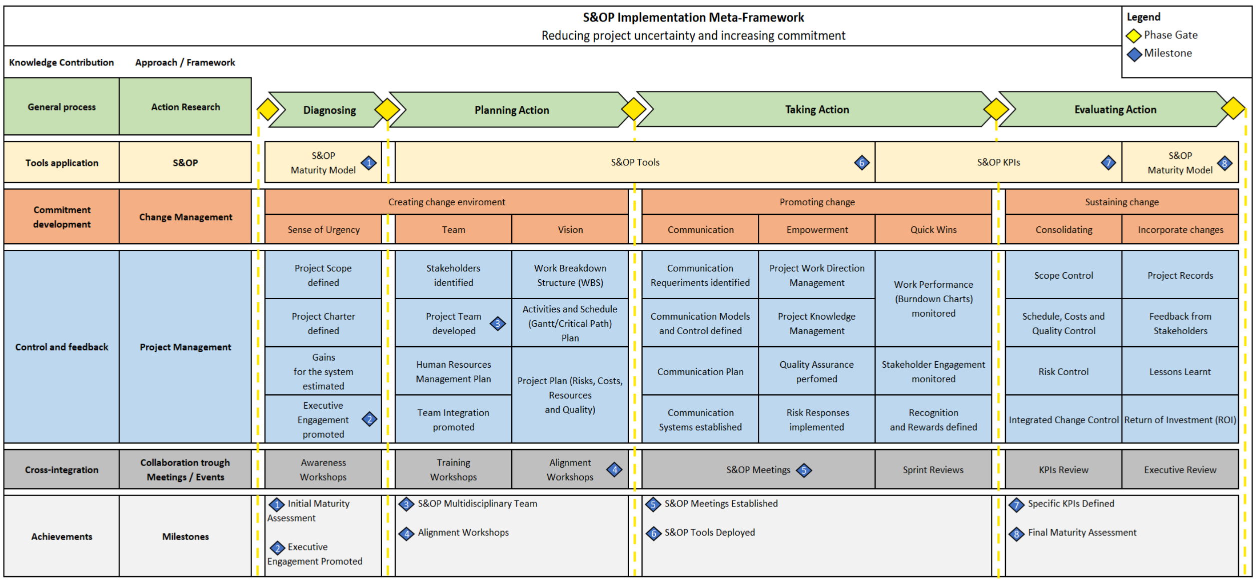


Figure 4 – S&OP Implementation Meta-framework

5 CONCLUSIONS

This research developed an S&OP Implementation Meta-Framework, based on an original S&OP Maturity Model. A systematic literature review created the synthesis of the specific tools implemented in the S&OP process. The results present a wide set of tools established in different fields and applications. Based on the findings, a framework of S&OP tools presents the distribution of results in six labeled pillars: Demand Management, Forecasting, Human Resources, New Product Introduction, Supply Chain Management and Tactical Planning. The observations of the relevant elements emphasize the strong trend in the topics of Tactical Planning, Demand Management and Forecasting. In general, the findings indicate a high level of maturity when addressing specific implementation tools in a wide range of different contexts analyzed. However, gaps are still identified in some branches of the literature. Mainly, the low contribution of tools dedicated to the Human Resources pillar, exposing a weakness in an intrinsic variable of any system: people.

Furthermore, an S&OP maturity model was developed based on the pillars and tools identified through the systematic review process. The model presents specific S&OP dimensions and establishes a classification logic based on the presence of tools, business process and metrics at each S&OP stage. The overall purpose of the maturity model is to support the assessment of the S&OP maturity gaps and to define a roadmap of actions for the S&OP evolution. Afterwards, an implementation meta-framework was built to depict the process relationships and the resources needed to promote substantial change in organizations. Combining S&OP tools, AR method, Kotter`s 8 steps of change and project management tools, the meta-framework provides a holistic guide to promoting large-scale transformation in S&OP implementation efforts.

Three significant contributions are identified in this study. First, the S&OP tools framework, which presents a categorization of the tools and their correlation with specific metrics and pillars. The other contribution is the maturity assessment model, which provides a structured model to identify the organization`s maturity levels and critical gaps in the S&OP process. Finally, the S&OP implementation meta-framework, which combines all the elements together in a comprehensive change method, providing contributions, insights and benchmarks for the success of the process.

For professionals, this work provides a set of tools that address specific contexts and metrics; a maturity model to diagnose the S&OP process in-depth; and an implementation framework to reduce uncertainty and increase commitment to the S&OP implementation as a change process. For academics, the synthesis provides an overview of the current body of knowledge and trends in the S&OP literature, highlighting under-researched areas of the S&OP process, as well as the implementation challenges and system relationships to be explored further.

Limitations and suggestion for future research are clearly identified. The S&OP maturity model as well as the implementation system are new contributions to the literature and have not been validated in this article. Therefore, the dimensions of S&OP maturity and implementation stages must be adapted by practitioners according to the peculiarities of each system under study. It is also important to mention that the present implementation method will be reported in a future article. Then, the complete case study of the S&OP implementation system, will be fully described, as well as the results obtained in an automotive company located in southern Brazil. As a suggestion for future research, a cross-industry survey to validate the S&OP maturity model and the implementation system is valuable for exploring the method effects in different environments. The evolution of tools dedicated to the human resources pillar within the S&OP process is also a suggestion for future research to fill this gap previously mentioned. Furthermore, the exploration of advanced technologies from Industry 4.0, such as big data, artificial intelligence (AI), Internet of Things (IoT) and other digital solutions in the S&OP process is another suggestion for a new line of research.

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