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JOÃO RAMPON NETO

SALES AND OPERATIONS PLANNING IMPLEMENTATION: A STUDY IN AN AUTOMOTIVE COMPANY

BENTO GONÇALVES

2020

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Master thesis presented to the Programa de Pós-Graduação em Engenharia de Produção of the Universidade de Caxias do Sul, as partial fulfillment of the requirements for the degree of Mestre em Engenharia de Produção.

Advisor Prof. Dr. Paulo Fernando Pinto Barcellos

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To God, for always keeping me from falling.

To my family and friends, for coping with my long hours devoted to this achievement, I cannot express how much this gave me strength to carry on.

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To the members of the defense committee, for all the valuable suggestions to improve this research.

"When we are no longer able to change a situation, we are challenged to change ourselves."

Viktor E. Frankl

RESUMO

Este trabalho tem como objetivo desenvolver e implementar uma sistemática de Sales and Operations Planning (S&OP) em uma empresa do ramo automotivo localizada no sul do Brasil. Inicialmente, uma revisão sistemática da literatura foi realizada em seis base de dados: EBSCO, Emerald, ScienceDirect, Scopus, Taylor & Francis e Web of Science, cobrindo dez anos de publicações. Na revisão, 368 artigos foram analisados, dos quais 42 artigos foram selecionados. Os resultados evidenciaram as principais ferramentas utilizadas em um amplo escopo de aplicações, bem como as métricas utilizadas para medir o impacto em cada contexto estudado. Seis pilares foram definidos para sintetizar as ferramentas: gestão da demanda, previsão, recursos humanos, introdução de novos produtos, gerenciamento da cadeia de suprimentos e planejamento tático. Um framework para a implementação do S&OP foi elaborado, fornecendo uma visão do corpo de conhecimento e profundidade das aplicações em cada pilar específico. Posteriormente, com base nas informações da revisão, uma sistemática para a implementação do S&OP foi criada em uma sequência de seis etapas: avaliação da maturidade, desenvolvimento da equipe, planejamento da demanda, planejamento de suprimentos, planejamento operacional e avaliação de KPIs. Os resultados foram analisados sete meses após o início do projeto, apresentando reduções de 18.42% nos custos dos estoques, aumento de 3% do nível de serviço desejado pela empresa e crescimento de 40% na acuracidade das previsões no período. Melhorias no nível de maturidade da organização também foram identificadas em comparação ao seu estado inicial.

Palavras-chave: Sales and Operations Planning. S&OP Implementation. Supply Chain Management.

ABSTRACT

This research aims to develop and implement a systematic for the Sales and Operations Planning (S&OP) in an automotive company located in southern Brazil. Inititaly, a systematic review was performed in six databases: EBSCO, Emerald, ScienceDirect, Scopus, Taylor & Francis e Web of Science, covering the ten years of publications. In the review, 368 articles were analyzed, in which 42 articles were selected. The results highlight the main tools used in a broad scope of applications, as well as the metrics for measuring the impact in each studied context. Six pillars were defined to synthesize the tools: demand management, forecasting, human resources, new product introduction, supply chain management and tactical planning. A framework for the S&OP implementation was developed, providing a view of the body of knowledge and depth of applications in each specific pillar. Afterwards, based on the review insights, a S&OP implementation systematic was created in a six-step sequency: maturity evaluation, team development, demand planning, supply planning, operational planning and KPIs evaluation. Results were evaluated seven months after the project go-live, depicting a reduction of 18.42% in inventory costs, 3% growth in the desired service level by the company, and a 40% increase in forecast acurracy in the period. Improvements in the organization's maturity level were also identified in comparison to its initial stage.

Keywords: Sales and Operations Planning. S&OP Implementation. Supply Chain Management.

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LIST OF ACRONYMS

APP	Aggregate Production Planning
APS	Advanced Planning and Scheduling
AR	Action Research
ARIMA	Autoregressive Integrated Moving Average
BAP	Business Assumptions Package
BPNN	Backpropagation Neural Network
CMSS	Contact Manufacturing Shipment Schedule
CPFR	Collaborative Planning, Forecasting and Replenishment
DMO	Demand Management Organization
DOE	Design of Experiments
DSS	Decision Support System
EDI	Electronic Data Interchange
ERP	Enterprise Resource Planning
EVA	Economic Value Added
FIFO	First In First Out
FMC	Forecasting Management Competence
FSS	Forecasting Support System
IoT	Internet of Things
KPIs	Key Performance Indicators
LP	Linear Programming
MAD	Mean Absolute Deviation
MILP	Mixed-integer Linear Programming
MIP	Mixed-integer Programming
MPS	Master Production Schedule
MRP	Manufacturing Resources Planning
MTBF	Mean Time Between Failures
MTTR	Mean Time to Repair
NBL	Nested Booking Limits
NPD	New Product Development
NPI	New product Introduction
OEE	Overall equipment effectiveness

O&M	Original Equipment's Manufacturer
OM	Operations Management
PoS	Point-of-sales
R&D	Research and Development
RCCP	Rough Cut Capacity Planning
RCF	Reverse Collaboration Framework
ROA	Return on Assets
S&OP	Sales and Operations Planning
SCM	Supply Chain Management
SES	Single Exponential Smoothing
SKUs	Stock Keeping Units
WMS	Warehouse Management System

SUMMARY

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, Bates and Juntilla, 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.

Superior operational performance might arise from a broad range of factors; however, the role of supply chain management (SCM) is one of the most sustainable edges (Li et al., 2006). Organizations around the world are moving toward a holistic view of operations and logistics chains, enhancing customer and supplier integration to leverage long-term performance (Huo et al., 2014). This insight is leading companies to search for efficient ways to manage materials and information flows to eliminate non-value adding activities for achieving higher levels of profit.

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, Sousa and Carmo, 2014; Wagner, Ullrich and Transchel, 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).

This study is structured in five parts, as follows. After the introduction, contextualization, justification, research question and objectives, a systematic review of the S&OP is presented in Chapter 2, providing a framework of a set of tools for the S&OP implementation. Chapter 3 establishes a method for the case study application, defining the S&OP implementation steps in the automotive company under study. The evaluation of the impacts, as well as the research findings are discussed in Chapter 4, finishing with the conclusions in Chapter 5.

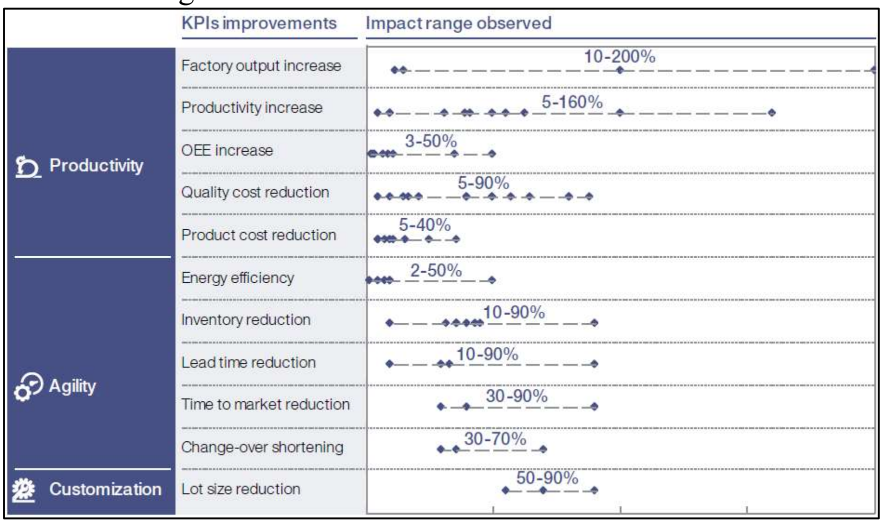
1.1 CONTEXTUALIZATION

The S&OP theme emerged from the early practices of aggregate production planning (APP) in the pioneer work of Holt, Modigliani, Muth and Simon back in 1950s, to manufacturing resources planning (MRP II) in the mid-1980s, transitioning into an integrated business planning process that aligns different pillars of organization's supply chains (Thomé et al., 2012a). From an intrinsic need of firm's adaptation to rapidly changing conditions, the risen of S&OP resulted in major improvements in the traditional production planning and control paradigms (Olhager, 2013).

Recently, the World Economic Forum in collaboration with McKinsey & Company, published a paper assessing the Fourth Industrial Revolution, identifying, as the authors called, the beacons of technology and innovation in manufacturing. The work scanned more than 1000 global leading companies, looking to find and differentiate the factories that embraced the three megatrends of production transformation: connectivity, intelligence and flexible automation, to provide insights to the path of successful scale implementation (WEF, 2019).

The so-called "lighthouses" organizations have taken the Fourth Industrial Revolution to the heart, altering their operational practices, and engaging in an accelerated continuous improvement journey to develop new technologies and capabilities to achieve better operational and financial results. The research findings of the top cases are demonstrated in Figure 1, highlighting the leverage of productivity, agility, and customization as operational competitiveness pillars through measuring the impact range of several key performance indicators (KPIs) in lighthouses factories.

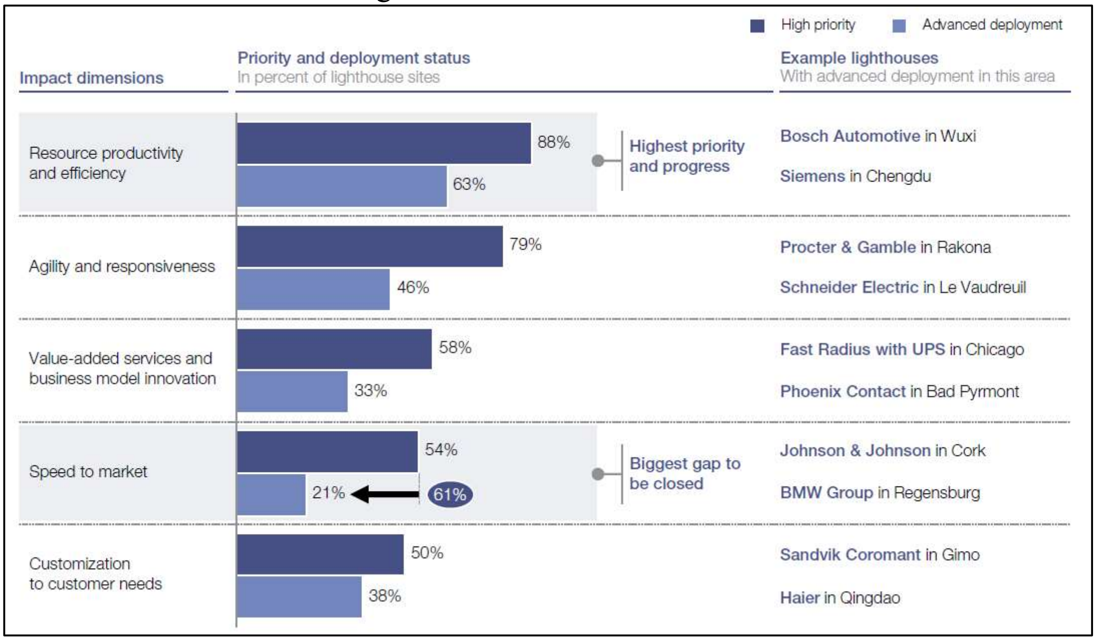
Figure 1 – Fourth Industrial Revolution KPIs



Source: World Economic Forum and McKinsey & Company (2019)

This transformation is attributed to two distinct yet complementary routes to scale of the manufacturing pioneers: (i) innovate the production system, expanding competitive advantage through operational excellence and (ii) innovate the end-to-end value chain, offering new or improved value propositions to customers with more customization, smaller lot sizes and significantly shorter lead times, changing the economics of operations. Within these paths, the authors identified specific value-creation differentiators and core capabilities to scaling up the implementation journey, as the main ones: big data decision-making, IoT architecture, capability-building, and workforce engagement. The data gathered from the survey also revealed gaps between aspirations and achievements in different business drivers on the ongoing transformation process of a variety of lighthouses (Figure 2), indicating room for improvement.

Figure 2 – Global Benchmarks



Source: World Economic Forum and McKinsey & Company (2019)

As depicts in Figure 2, despite the major advances in global manufacturing productivity, efficiency and responsiveness, some business drivers are still behind, as for example, the speed to market pillar, showing only a 21% deployment status, while having a 54% priority dimension. These conclusions allow the placement of S&OP in the epicenter of the technological changes in the Fourth Industrial Revolution, highlighting the potential of the tool to improve additional business dimensions in synergy with other value-creation differentiators and core capabilities.

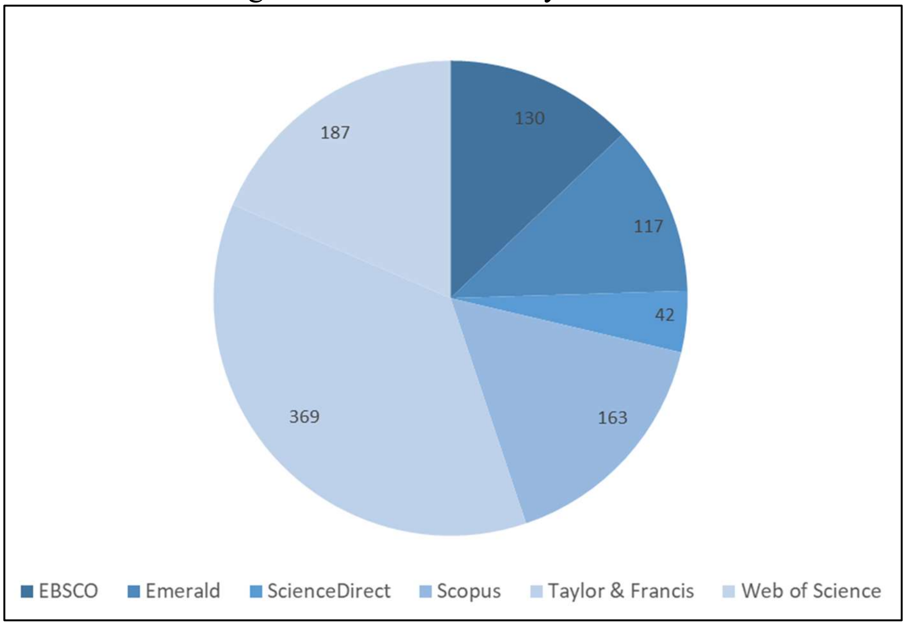
1.2 JUSTIFICATION

The justification of this study is presented in this section, approached in two topics: theoretical and practical.

1.2.1 Theoretical Justification

For the initial evaluation of richness and trends of S&OP literature awareness, six databases were selected: EBSCO (Academic Search Premier, SocINDEX, Library, Information Science & Technology Abstracts with Full Text and Information Science & Technology Abstracts), Emerald, ScienceDirect, Scopus, Taylor & Francis, and Web of Science contemplating the majority of scientific journals on this field (Kristensen and Jonsson, 2018). The search keywords selected were: "Sales and Operations Planning" OR "S&OP", and the time span chosen was from 2004 to 2018. This search protocol returned a total of 821 articles, distributed on the five selected databases as depicts in Figure 3.

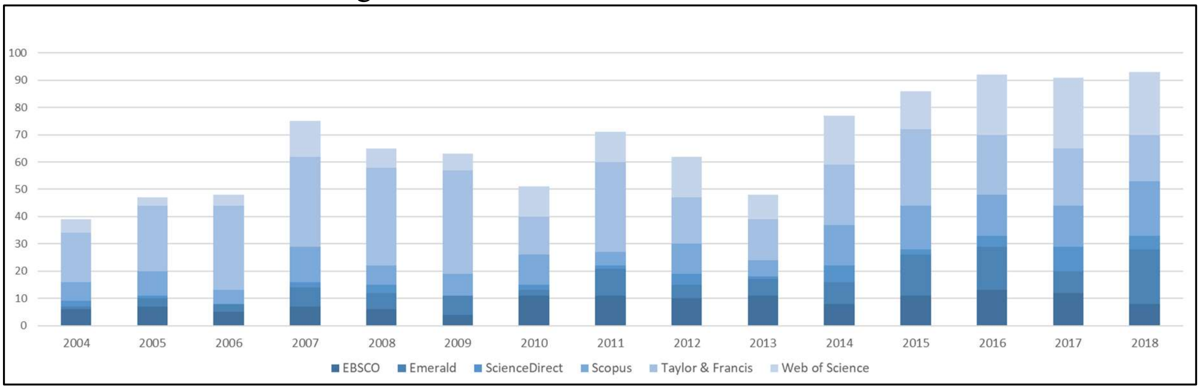
Figure 3 – Publications by Database



Source: Created by the author (2019)

For a better visualization of the trends and density of the literature publications through the time, Figure 4 was built, illustrating a break-down of the raw finds of each database by year.

Figure 4 – Publications x Year x Database



Source: Created by the author (2019)

As evidenced by the growing number of papers, there is an upward trend of publications in the S&OP literature, demonstrating the relevancy and development of the theme in recent years. This growing tendency is reflected in both academic and practitioner fields, with the higher rate of publications happening after 2010 (Tuomikangas and Kaipia, 2014; Kristensen and Jonsson, 2018). Conjointly, is perceived a solid body of knowledge provided by several relevant works, indicating a high level of maturity on the topic.

In the synthetization of the main concepts, three significant literature reviews provide insights into the main aspects of the S&OP theme. The work of Thomé et al. (2012b) contributes with an integrated S&OP framework, embracing contexts, variables, outcomes and performance metrics of the process, aiding practitioners, and researchers with a better understanding of the S&OP role. On the same realm, Tuomikangas and Kaipia (2014) structured a coordination Sales and Operations Planning framework, consisting of six mechanism: process, organization, tools and data, performance management, strategic alignment and culture and leadership, to emphasize the S&OP tactical correlation between strategy and operations planning, as well as the importance of leadership and culture mindset. More recently, Noroozi and Wikner (2017) developed an integrative framework, contemplating the supply chain context and introducing actors in both vertical and horizontal integrations directions, complementing the two works previously mentioned.

The implementation benefits on organization's performance were assessed by several research, demonstrating the S&OP positive impacts on different ranges of operational performance. From a large sample of organizations across the world, Thomé, Sousa and Carmo (2014), developed a survey-based study, evaluating the impact of the S&OP practices in distinctive markets and company sizes, showing the key influence on manufacturing performance in terms of quality, flexibility and delivery of the methodology. Similarly, relevant empirical case studies as: Ivert and Jonsson (2010), Oliva and Watson (2011), Nemati, Madhoshi and Ghadikolaei (2017), and other deriving from mathematical modeling approaches (Feng, D'Amours and Beauregard, 2008; Chen-Ritzo et al., 2010; Hahn and Kuhn, 2012a; Lim, Alpan and Penz, 2017) endorse the positive effects upon organizations performance.

Rich sources concerning S&OP maturity models can also be found in the literature. Grimson and Pyke (2007), improving Lapide (2005) model, provided a five stages framework for S&OP integration, highlighting business process that can enable integration effectiveness. Wagner, Ullrich and Transchel (2014) contributed with a multi-method research developing a holistic S&OP maturity model which can provide a detailed map of improvements needs for a better organizational alignment. Danese, Molinaro and Romano (2017), in a detailed three case-study comparison, investigated the paths and dimensions evolution of different stages transitions in S&OP implementation, presenting a maturity framework and guidelines addressing the execution and stakeholder engagement in the process. Recently, Vereecke et al., (2018), developed a specific six-dimension demand planning maturity assessment model, proposing a tool to refine the evaluation of a critical pillar within the S&OP process.

Despite the broadness of S&OP literature branches aforesaid, 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, Pibernik and Kaiser, 2012; Thomé, Sousa and Carmo, 2014; Tuomikangas and Kaipia, 2014; Kristensen and Jonsson, 2018). In this context, a lack of studies that provide a set of specific tools for the S&OP implementation is identified. Under those circumstances, this study aims to fill this gap, by presenting a framework, in Chapter 2, with a toolset for the S&OP implementation.

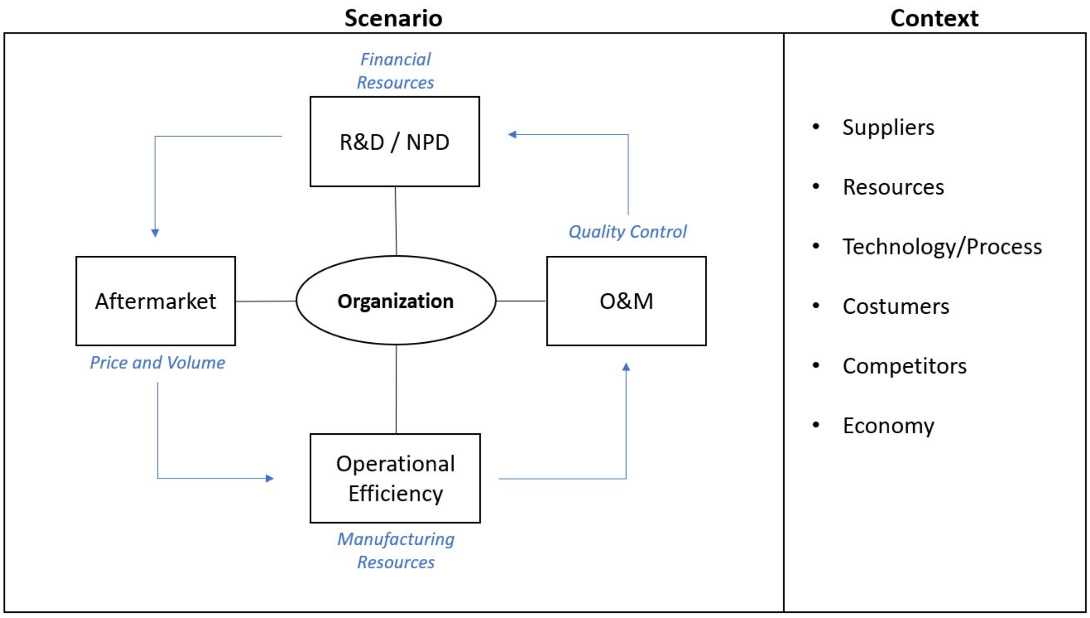
1.2.2 Practical Justification

The medium-sized company under study is a components supplier for the automotive industry, specifically for heavy vehicles (buses, coaches, trailers, and agricultural tractors). Its market-share is balanced between the aftermarket and the Original Equipment's Manufacturer (O&M), currently having a product portfolio divided in approximately 60 and 40 per cent, respectively.

Positioned in two niches with distinctive demands, the organization requires a high degree of technology and quality control in its production system to be able to meet the customers' requirement levels. Also, in a different perspective, requires flexibility, productiveness and, mainly, efficiency to assure the order-winning criteria of the aftermarket. Hence, the company needs a hybrid strategic position in this market context.

To compete in the aftermarket, the firm has a large product portfolio with a short delivery time. Due to this manufacturing strategy, the organization displays high levels of inventory in its manufacturing process. Conversely, the company also depends upon the intrinsic renew and launch of products to capture new demands and business opportunities of clients and markets in potential. The Research and Development (R&D) department is extreme valuable in the current context, being the New Product Development (NPD) one of the organization's main business drivers.

Figure 5 – Strategic Context Framework



Source: Adapted from Thomé et al. (2012b)

The company`s strategic context aforesaid is portrayed in Figure 5. A trade-off concerning the company's positioning can be identified in the presented context. In one market, the organization needs investments in tools and new technologies, requiring cash flow in the development, validation and launch of new products. Conversely, requires financial resources to the manufacturing and supply chain effectiveness, thus raising challenges in the resource allocation to meet both markets drivers. In this context, this work also aims to implement the Sales and Operations Planning process, seeking to provide higher cash flow availability, maintaining the desired service level by the market, with the lowest use possible of its resources, leveraging the operational performance of the firm under study (Thomé, Sousa and Carmo, 2014; Wagner, Ullrich and Transchel, 2014).

1.3 RESEARCH QUESTION

Through the contextualization and justification presented, the research question is defined as: How to implement a Sales and Operations Planning (S&OP) systematic in an automotive company?

1.4 OBJECTIVES

In this section, the general and specific objectives of this study are presented.

1.4.1 General Objective

The general objective of this study is to develop a systematic for the implementation of the S&OP process in an automotive company.

1.4.2 Specific Objectives

To achieve the general objective, the specific ones are derived as:

a) identify a set of tools for the S&OP implementation;
b) create a systematic for the implementation of the S&OP;
c) implement the Sales and Operations Planning process in the organization;
d) evaluate the results of the Sales and Operations Planning implementation in the researched environment.

2 LITERATURE REVIEW

A systematic literature review of Sales and Operations Planning is presented in this chapter, addressing the gap previously mentioned of specific tools and frameworks for S&OP implementation. The process is described in detail in Section 2.1, including the main definitions of the procedures selected. Section 2.2 shows the synthetization of the findings, followed by the literature analysis and discussions in Section 2.3.

2.1 SYSTEMATIC REVIEW PROCEDURES

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) synthetization 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.

2.1.1 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, presenting 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, three research questions were defined:

a) Research question 1: What are the main tools applied in implementing S&OP?
b) Research question 2: Can these tools be integrated into different applications contexts?
c) Research question 3: How can these tools be synthesized in an implementation framework?

These questions allow a clear conceptual definition of the variables related to the research purpose, beginning with an overview of the S&OP implementations concepts, the initial question assesses the main limitations of the current literature. Subsequently, narrowing the focus of the research, questions 2 and 3 substantiate the potential for synthesizing the results, to avoid a general conclusion, incongruent with possible peculiarities in theoretical and practical contexts.

2.1.2 Location of Studies

Six data sources were selected for the location of studies: EBSCO (Academic Search Premier, SocINDEX, Library, Information Science & Technology Abstracts with Full Text and Information Science & Technology Abstracts), Emerald, ScienceDirect, Scopus, Taylor & Francis, and Web of Science, covering most of the scientific journals in the field. 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 period was from 2009 to May of 2019, covering ten full years of publications and a fraction of 2019.

Gray literature was also taken into consideration, with a manual search 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 Kipia (2014). The professional journals searched were Journal of Business Forecasting (JBF) and Supply Chain Management Review (SCMR), and the academic journals were The Journal of Operations Management (JOM), International Journal of Production Economics (IJPE) and International Journal of Production Research (IJPR).

2.1.3 Selection and Evaluation of Studies

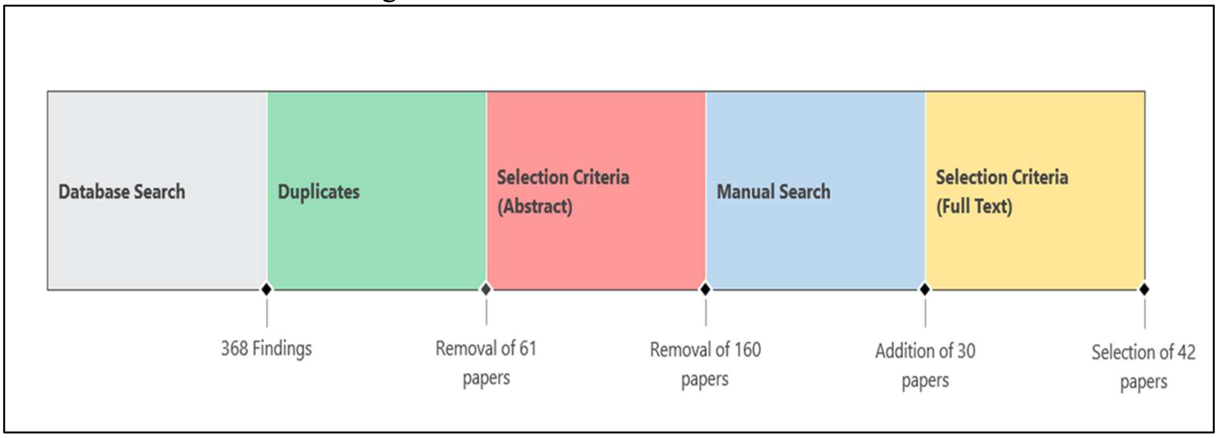
The study selection and evaluation stage require a clear definition of the inclusion and exclusion criteria of articles to provide a congruent judgment of the relevance of each finding. In this review, the exclusion criteria were defined as follows:

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 database search found 368 papers, which were evaluated based on the exclusion criteria. First, 61 duplicates were excluded from the results, followed by a reading of all abstracts, leading to the removal of 160 articles that were not relevant or available, resulting in 147 articles selected for full-text reading. The manual search added 30 publications to those previously selected. After reading the full text of the select articles, 135 papers were excluded from the process. Thus, 42 remained after the selection criteria were applied. This whole review process is illustrated in Figure 6.

Figure 6 – Selection of Studies Process



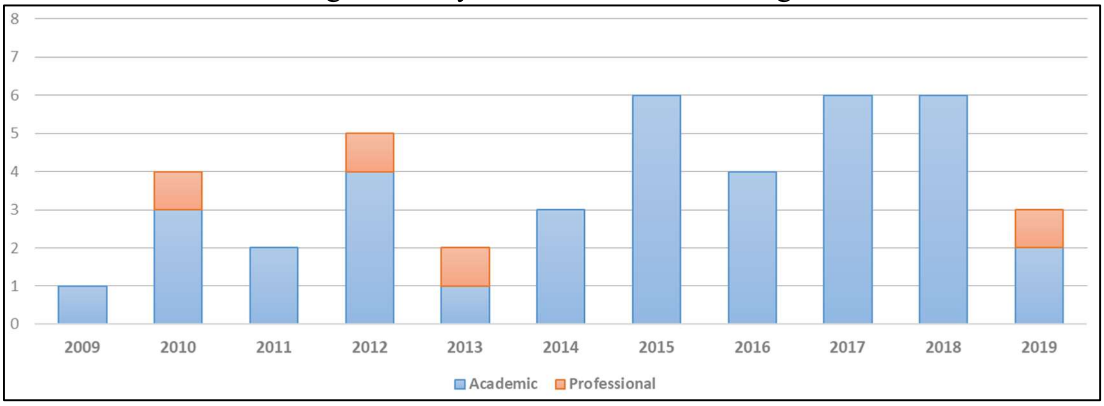
Source: Created by the author (2019)

Of the 135 articles excluded from reading the full text due to the defined criteria, most have only superficial information or brief citations, and not S&OP as the focus of study. A representative number of articles illustrate only general theoretical definitions of the topic. The others, fulfilling the scope of the review, proposing specific tools for implementing the S&OP process, lacked acceptable methodological procedures or satisfactory evidence.

2.2 RESULTS SUMMARY

The key findings of the literature review are presented in Fig. 7, categorizing the articles retrieved by journal type and year. Of the 42 articles, 38 are from academic sources and only 4 from professional publications. These results contradict the findings of Thomé et al. (2012) and Tuomikangas and Kipia (2014), which presented most articles from professional sources. The findings show the growth and relevance of the theme in academic publications in recent years, given the results found by Kristensen and Jonsson (2018).

Figure 7 – Systematic Review Findings



Source: Created by the author (2019)

The 42 final articles are listed in Table 1, combined with the publication journals and Scopus citation index. Despite 30 different journals identified, 31% of the findings are concentrated within 2 journals - International Journal of Production Economics (IJPE) and International Journal of Production Research (IJPR) - where, Oliva and Watson (2011), Hahn and Kuhn (2012a), and Ivert and Jonsson (2010) hold the highest number of citations (234 out of 549).

Table 1 – Papers Selected

Author(s)	Journal	Citations (Scopus)
Rudberg and Thulin (2009)	PPC	20
Chen-Ritzo et al. (2010)	EJOR	20
Feng, D`Amours and Beauregard (2010)	IJPR	27
Ivert and Jonsson (2010)	IMDS	44
VICS (2010)	VICS	0
Oliva and Watson (2011)	JOM	123
Sodhi and Tang (2011)	JORS	9
Hahn and Kuhn (2012a)	IJPE	67
Hahn and Kuhn (2012b)	IJPE	18
Kelleher (2012)	JBF	0
Olhager and Johansson (2012)	JETM	25
Wang, Hsieh and Hsu (2012)	IJCIM	13
Feng et al. (2013)	POM	16
Jonsson, Rudberg and Holmberg (2013)	SCM	17
Li and Thorstenson (2014)	IJPR	9
Lim, Alpan and Penz (2014)	IJPE	24
Rappold and Yoho (2014)	IJPE	7
Calfa et al. (2015)	IECR	7
Chen, Lai and Xiao (2015)	MS	19
Goh and Eldridge (2015)	JPDL	16
Jonsson and Ivert (2015)	IJPE	9
Rostami-Tabar et al. (2015)	IJPE	6
Taşkin et al. (2015)	IAA	0
Doering and Suresh (2016)	JSCM	3
Omar, Hoang and Liu (2016)	CIN	5
Shimizu, Sakagychi and Yoo (2016)	JAMDSM	3
Wochner et al. (2016)	IJPE	8
Albrecht and Steinrücke (2017)	IJPR	3

Danese, Molinaro and Romano (2017)	IJPR	3
Kaipia et al. (2017)	JOM	12
Lalami, Frein and Gayon (2017)	IJPR	3
Lim, Alpan and Penz (2017)	CIE	5
Nemati, Madhosi and Ghadikolaei (2017)	CCE	2
Ali et al. (2018)	ORP	0
Ambrose, Matthews and Rutherford (2018)	JBR	0
Darmawan, Wong and Thorstenson (2018)	IJPR	0
Dreyer et al. (2018)	IJPDLM	2
Vereeck et al. (2018)	IJOPM	0
Wery et al. (2018)	CI	1
Ali et al. (2019)	INFOR	0
Fildes, Goodwin and Önkal (2019)	IJF	3
Mahadevan (2019)	IJPPM	0

Source: Created by the author (2019).
CCE – Computers & Chemical Engineering; CI – Computers in Industry; CIE – Computers & Industrial Engineering; CIN – Computational Intelligence and Neuroscience; EJOR – European Journal of Operational Research; IAA – Interfaces, Articles in Advance; IECR – Industrial & Engineering Chemistry Research; IJCIM – International Journal of Computer Integrated Manufacturing; IJF – International Journal of Logistics Research and Applications; IJOPM – International Journal of Operations & Production Management; IJPDLM – International Journal of Physical Distribution & Logistics Management; IJPE - International Journal of Production Economics; IJPPM – International Journal of Productivity and Performance Management; IJPR – International Journal of Production Research; IMDS – Industrial Management & Data Systems; INFOR – INFOR: Information Systems and Operational Research; JAMDSM – Journal of Advanced Mechanical Design, Systems, and Manufacturing; JBF – Journal of Business Forecasting; JBR – Journal of Business Research; JETM – Journal of Engineering and Technology Management; JOM – Journal of Operations Management; JORS – Journal of the Operational Research Society; JPDL – Journal of Physical Distribution & Logistics; JSCM – Journal of Supply Chain Management; MS – Management Science; ORP – Operations Research Perspectives; POM – Production and Operations Management; PPC – Production Planning & Control; SCM – Supply Chain Management: An International Journal and VICS – Voluntary Interindustry Commerce Solutions.

2.3 LITERATURE ANALYSIS

The findings of each paper selected in the systematic review are presented in Table 2. The table depicts the author(s), tool(s), purpose, impact, and context of each study, summarizing the data found during the research. The categories used for classification, evaluation and construction of the S&OP implementation framework are explored in detail in the following subsections.

Table 2 – Literature Findings

Author(s)	Tool(s)	Purpose	Impact	Context
Rudberg and Thulin (2009)	Advanced Planning and Scheduling (APS)	Present findings from a case study of a supply chain redesign with the aid of APS.	Results demonstrate a total cost reduction of 13% with higher throughput levels, while inventory costs decreased by almost 50%. Service level and planning efficiency gains were also related.	European Farming and Food Industry
Chen-Ritzo et al. (2010)	Stochastic Programming	Deal with order configuration uncertainty in the process of matching demand and supply.	Significant benefits in profit and revenue (improvements of 25% in profit, 24% in revenue and 51% reduction in inventory holding costs).	Simulated Scenario
Feng, D`Amours and Beauregard (2010)	Simulation-optimization Mixed-integer Programming (MIP)	Evaluate the financial performances of SC-S&OP, SP-S&OP, and DP in a rolling planning environment. Comparing each planning model in a fixed and rolling horizon, as well as the impact of forecast inaccuracy on the financial performance of each model.	Results demonstrate that deterministic models are insufficient for decision support and performance evaluations in a real business environment, however, are important to theoretical studies. The models are limited to the fixed-horizon deterministic and a rolling horizon simulation procedure is required when addressing planning issues in practice and efforts should be made to reduce forecast bias.	Oriented Strand Board Industry
Ivert and Jonsson (2010)	Advanced Planning and Scheduling (APS)	Explore the benefits of APS systems in the S&OP process, structuring a framework for this integration.	Reliable demand plans, improved knowledge about the supply chain and made the planning activities more enjoyable. The use of APS resulted in a common and optimal supply plan and simplified planning activities.	Chemical Industry
VICS (2010)	Collaborative Planning, Forecasting and Replenishment (CPFR)	Link CPFR and S&OP to develop an integrated business plan to extend the supply chain coordination and create competitive advantage.	The collaboration model allowed the companies to improvements as sales grows up 12 % while overall inventory costs reduced to 5 % and improved on-time shipments. In addition, the companies continue to create relationships to efficient make decisions to increase flexibility and business predictability.	Home Appliances Industries - Lowe's Home and Whirlpool Corporation
Oliva and Watson (2011)	Demand Management Organization (DMO) Business Assumptions Package (BAP) Master Production Schedule (MPS) Electronic Data interchange (EDI)	Present a detailed case study of the implementation of a S&OP process in a supply chain, describing how individuals and functional areas are involved in the cross-functional decision-making process.	Improvements in forecasting accuracy from 58% to 88%. Inventory turns increased from 12 to 26 in the previous year, average on-hand inventory decreased from \$55M to \$23M and excess and obsolete costs decreased to zero.	Consumer Electronics
Sodhi and Tang (2011)	Stochastic Programming	Present a set of modelling choices that enables the use of stochastic programming in a practical extension of the S&OP process to deal with demand uncertainty, minimizing the weighted sum of the risk metrics associated.	Conclude that stochastic programming can be effective at least in the present setting of managing demand uncertainty in the demand-planning stage of the S&OP process.	Simulated Scenario

Hahn and Kuhn (2012a)	Stochastic Programming	Develop a framework for integrated value-based performance and risk optimization, applying robust optimization methods.	The proposed model performance showed an average EVA increase at constants low and robust levels of variation. Indicating that the scenario generation can be limit by the decision-maker to manage the practicability without compromising robustness in practical applications.	Simulated Scenario
Hahn and Kuhn (2012b)	Stochastic Programming	Develop a decision support framework for mid-term investment in capacity management from a value-based perspective.	The results confirmed the importance of asset utilization, the different approaches showed that capacity adjustments are aligned with negative scenarios, avoiding costly ide resources. The postponement approach, in general, improves the expected value creation in terms of EVA and restricts the impact of uncertainty.	Simulated Scenario
Kelleher (2012)	IT System	Analyze how the organization improved the global S&OP process by developing a process for better managing data, providing warnings about outliers, and forecast challenges.	Forecast accuracy improved from 88% to 92%, with the upper and lower limits narrowing from 90% to 94%. This led to the reduction of safety stocks and improvements of the just-in-time standards.	Clothing Industry
Olhager and Johansson (2012)	Long-term capacity management framework	Develop a framework for long-term capacity decision-making in integrated manufacturing and service operations.	The framework proposed created awareness for the managers addressing long-term capacity management in an integrated approach, combining a lead and a lag capacity strategy for different demand profiles and capacity requirements.	Industrial Turbines After-sales Service
Wang, Hsieh and Hsu (2012)	Mixed-integer Linear Programming (MILP)	Develop a planning framework to integrate the planning of demand, purchasing, production planning and distribution.	The authors concluded that the model provided feasible solutions and had flexibility enough to design scenarios to decision making.	Taiwan Television Manufacturer
Feng et al. (2013)	Stochastic Programming	Study the coordinated contract selection and capacity allocation problem with the objective to maximize the manufacturer's profitability, using a modeling approach based on stochastic programming, considering economic, market, supply, and system uncertainties.	The computational results show that the proposed approach provides realistic and robust solutions. The S&OP plans obtained from the stochastic programming model yield expected 11–15% profit improvements, on average, compared with that obtained by the simplified model.	Oriented Strand Board (OSB) Industry
Jonsson, Rudberg and Holmberg (2013)	IT System Advanced Planning and Scheduling (APS)	Analyze the effects of centralized supply chain planning at IKEA, exploring how the planning process, system and organization make up a centralized approach.	The process implemented increased the forecast accuracy, reduced safety stock levels, increased supply chain visibility and enhance hierarchical integration.	Home Furnishing Company
Li and Thorstenson (2014)	Mixed-integer Programming (MIP) Stochastic Programming	Explore the impact on profitability by design a procedure for joint stochastic lot-sizing and pricing problem with capacity constraints in a market environment characterized by demand uncertainty.	The results indicate that the multi-phase algorithms can solve the lot-sizing effectively, in all instances, the overall profit is improved in the stochastic approach from the deterministic methods.	Simulated Scenario

Lim, Alpan and Penz (2014)	Simulation-optimization	A planning model for reconciling sales and operations management with long procurement lead times to capture and understand the system dynamics.	The model suggests a significantly logistical cost reduction (about 8% cost reduction and 15% less delayed order and lost sales).	Automotive Industry
Rappold and Yoho (2014)	Stochastic Programming	A model to determine safety stocks levels that minimizes long run expected costs. The model proposition is to assess inventory investment requirements as a function of capacity investment, product mix, technology, demand volatility and customer service levels.	The modelling approach provided the expected cost associated with the increasing capacity utilization, which can be used to make tactical decisions. Allowing to set lower and upper cycle limits as well as capacity utilization to reduce the inventory size.	Simulated Scenario
Calfa et al. (2015)	Simulation-optimization	Propose two data-driven simulation-optimization approaches to account for production variability when generating a tactical production plan.	The simulation model yielded 97,92% expected overall service level and the bi-objective optimization framework showed a 98,60%.	Chemical Process Industry
Chen, Lai and Xiao (2015)	Simulation-optimization	Develop a model which provide an opportunity for the producer to collect a signal about the market conditions before the sales season for better production planning in managing contractual decisions.	In the model presented, the FC outperformed the MLC results. When demand and supply mismatch cost is large, the manufacturer wants a larger information-acquisition effort, leading to conflicted moral hazard effect over the adverse selection effect, implying the superiority of the FC model.	Simulated Scenario
Goh and Eldridge (2015)	IT System Master Production Schedule (MPS) Contact Manufacturing Shipment Schedule (CMSS)	Study the S&OP implementation practices, focusing in how to incorporate the supplier's inputs integration and the introduction of new products in organizations of Asia Pacific region.	The findings from the two cases showed significant improvements in the supply chains of both companies. Case 1 demonstrated a 67.2% of lead time reduction and Case 2 reduction of 30.4 % of total inventory.	Company A - manufacturer of fire protection systems Company B - software, hardware industry
Jonsson and Ivert (2015)	Master Production Schedule (MPS) Rough Cut Capacity Planning (RCCP) Advanced Planning and Scheduling (APS)	Investigate the impact of sophisticated MPS methods considering the effects of planning environment complexity.	The survey suggests that sophisticated MPS methods results in a direct positive impact of performance regardless the environment, reducing the negative impacts of complex environments and uncertainty.	Survey on Swedish Manufacturing Companies
Rostami-Tabar et al. (2015)	Autoregressive Integrated Moving Average (ARIMA) Single Exponential Smoothing (SES)	Analyze the case of a non-stationary process to evaluated if it is beneficial to use cross-sectional forecasting when departing from the stationary assumption.	Concluded that the variance of forecast error of the top-down to the bottom-up approach is equal to one for identical process parameters when compared at the aggregate level. However, the bottom-up approach is superior when demand forecasts at the SKU level when demand is nonstationary (and highly autocorrelated) and the top-down when they have the same patterns but are associated with different autocorrelation value.	Simulated Scenario
Taşkin et al. (2015)	Decision Support System (DSS) Mixed-integer Programming (MIP)	Develop a mathematical programming-based decision support system (DSS) to support the S&OP process.	Planning time decrease three hours, requiring approximately 30 minutes. Discrepancies between planned and realized operations decreased significantly as a result of the implementation. Inventory levels decrease approximately five percent for long lead time components.	Turkey Television Manufacturer

Doering and Suresh (2016)	Forecasting Management Competence (FMC)	Provide empirical validation to FMC as a higher-order construct based on four underlying sets of practices: internal integration, forecasting process quality, effective use of advanced systems, and evaluation of forecasting.	The authors found that improvements in forecast accuracy do not automatically translate into cost reduction and operational advantages. The FCS elements enhance are also dependent on nonforecasting processes.	Survey of United States contributing members of relevant LinkedIn forecast groups
Omar, Hoang and Liu (2016)	Backpropagation Neural Network (BPNN) Autoregressive Integrated Moving Average (ARIMA)	Develop a hybrid neural network model for sales forecasting based on the popularity of articles titles.	The model provided improvements in forecasting indicators (RMSE). The BPNNs approach has lower values than the ARIMA for most of the stores in our dataset. The Hybrid-POP performed better than the other methods, capturing linear and nonlinear patterns of the data.	Publishing Industry
Shimizu, Sakagychi and Yoo (2016)	Hybrid heuristics	Propose a hierarchical method that is possible to practically solve real world of the single depot VRPSPD problems in comparison with separate transportation and centralized network configuration.	The models delivered a well-approximated solution within an acceptable computation time even for large problems. Also, revealed a high performance for the variant approaches, special importance for real world applications.	Simulated Scenario
Wochner et al. (2016)	Mixed-integer Linear Programming (MILP)	Investigate the S&OP process for ramp-up and new product introduction, developing a MILP model for a new car model.	Results demonstrate that is necessary to determine the optimal sequence of trade-offs between lost sales costs, complexity and demand. The analysis also provides insights into rework quantities, when neglected, they influence other planning levels.	European Automotive Industry
Albrecht and Steinrücke (2017)	Mixed-integer Linear Programming (MILP)	Develop an optimization scheduling processes between sites of a 24/7 operating supply chain network.	High flexibility for material flow scheduling with an average computation time 68% lower than an equivalent model that could be applied.	German fresh food producer
Danese, Molinaro and Romano (2017)	Maturity model	Evaluate specifically maturity models and the transitions towards advanced stages. Investigating how the dimensions evolve and interact during the execution of the transition between two subsequent stages.	Confirmed that the transition to a more advanced stage requires a balanced action and performance on all areas: people and organization, process and methodologies, IT and performance measurement. Also, that managers should plan to redesign the performance measurement and organizational S&OP culture.	Company A - Perishable raw materials Company B - Construction Industry Company C - Chemical Industry
Kaipia et al. (2017)	Point-of-sales (PoS)	Evaluate the results from engagement in S&OP collaborative information sharing in a real-life setting of two product manufacturers and one retailer.	Forecast accuracy was improved by 7% and service level 2,6%. Furthermore, the context dependency was highlighted, identifying the main factors of demand and productions planning, indicating the effort to reduce lead time to react faster to forecast updates.	FoodCo is a supplier of food products ChemCo is a multinational supplier of techno-chemical products
Lalami, Frein and Gayon (2017)	Mixed-integer Linear Programming (MILP)	Propose a MILP model to determine the optimal production quantities over a planning horizon.	The simulation results helped to quantify the performance obtained in different scenarios. Showed that the increased in frozen horizon and planning periodicity improves the performance in terms of stability but worsen in terms of stock.	Powertrain Automotive Industry

Lim, Alpan and Penz (2017)	Simulation-optimization	Extend the research of Lim et al. (2014) model by introducing optimal policies for managing parts inventory and sales flexibility in the S&OP via a simulation-optimization approach.	The algorithms tested perform relatively well in terms of cost performance. For the static policies, the authors suggest using the CLS algorithms for better performance. In linear policies, the model choice should be carefully examined, where SA is the best option if computation time is not a priority followed by the RLS algorithm for logistics costs and computation time overall performance.	Automotive Industry
Nemati, Madhosi and Ghadikolaei (2017)	Mixed-integer Linear Programming (MILP)	Present a mathematical modeling approach to evaluate the benefits of the S&OP process, in three different approaches (FI-S&OP, PI-S&OP, and DP).	The results analysis demonstrated the superiority of the FI-S&OP approach over the PI-S&OP and DP approaches in all situations, with a solution gap of 0,32%, impacting on Production Cost, Shipping Cost, Purchase Cost and Inventory Cost of the organization.	Iranian dairy company
Ali et al. (2018)	Kriging Metamodels Linear Programming (LP) Nested booking limits (NBL)	Experiment different demand management approaches to analyze the behavior of an IDMP facing various sequences of order arrival and taking various market disturbances into account.	Results confirm that NBL approach can be a powerful tool to maximize revenues facing different environmental conditions.	Canadian Softwood Industry
Ambrose, Matthews and Rutherford (2018)	Superordinate Identity Teams	Analyze the emergent condition of superordinate identity as a cognitive state of mind which S&OP teams achieve higher levels of performance.	The authors identify that having a special team structure that delegates decision making authority is more likely to promote social identity, improving the S&OP performance.	Survey of medium to large-size manufacturing and service companies, from $125 million to $80 billion in annual revenues.
Darmawan, Wong and Thorstenson (2018)	Mixed-integer linear programming (MILP) Simulation-optimization	Investigate a refined modelling framework for generating sales and operations plans that integrate promotion and production planning decisions. Featuring a rich demand function that captures the dynamics and heterogeneity of consumer responses to promotions, without the mutual dependence of marketing and production factors.	Results show that different factors provided a better understanding on the importance of coordination and its main driving forces. The average improvement of the profit can be up to more than 40% with the use of the presented model. Also, the authors identified that coordinated approach tends to plan promotions during the low-demand season, while non-coordinated tends to schedule them during the high demand season.	Simulated Scenario
Dreyer et al. (2018)	IT Systems Rough Cut Capacity Planning (RCCP)	Explore the tactical planning process and integration mechanisms to enhance the S&OP process.	The organizational structure should improve functional plans involving suppliers and customers in the planning. Integrated IT solutions also may increase planning efficiency, but they do not ensure planning integration. Improves on demand management activities also would gradually be enhancing tactical planning.	Grocery retailing industry in Finland, Norway and the UK

Vereeck et al. (2018)	Maturity model	Propose a model assessing demand planning maturity and empirically validate it in an instrument-based survey.	The proposed model emphasizes the use of external sources of data in enterprises, indicating the organization potential for improvement of the demand planning process and track the progress over time. Results of the survey data set of 128 observations showed a relative low level of maturity in some areas and the positive relationship between demand planning and company size.	Western Europe companies of a wide range of sectors
Wery et al. (2018)	Simulation-optimization	Propose a multi-period simulation-optimization model that select/change plant configurations over time to accommodate new products demand without compromising profit.	The proposed simulation-optimization approach demonstrated a potential 1,35 % augmentation of sales value from the original scenario.	North America Wood Industry
Ali et al. (2019)	Linear Programming (LP) Nested Booking Limits (NBL)	Propose a mathematical model integrating S&OP and Revenue Management (RM).	Simulation results provide evidence of the value of integrating RM and S&OP, showing a better service level to high-priority customers and higher profit margin compared to common demand management practices.	Canadian Softwood Industry
Fildes, Goodwin and Önkal (2019)	Forecasting Support System (FSS)	Address in which diverse information is used by judgmental forecasters when predicting the effects of sales promotions in the typical organizational.	The results suggest that the provision of information relating to promotions can be detrimental to the forecast accuracy when it has either no or unknown diagnostic.	Academic students
Mahadevan (2019)	Reverse Collaboration Framework (RCF) Warehouse Management System (WMS) Master Production Schedule (MPS) IT Systems	Develop a conceptual framework to provide supply chain management visibility and information sharing in reverse logistics operations.	The proposed framework implementation reduced the number of man-hours taken in the reverse logistics operations from 65 to 52 days. This includes the reduction in data loading time of ten days and three days saved in the capacity-planning process and enabled real-time data visibility for the reverse supply chain planning process.	Consumer Electronics Company

Source: Created by the author (2019).

2.3.1 Tools

The first category of the review refers to the tools used in a wide range of works selected in the literature. The data gathered on this topic represents the main variable of this research. From the results, is identified that the S&OP literature has a significant number of tools already established in several publications. Those findings corroborate with the growing maturity of the theme in practical and academic contexts, and fill the first research question proposed, presenting specific tools used among a diverse number of S&OP publications in the last 10 years.

Table 3 – Tools Findings

Tool	Freq.	%	Author(s)
Stochastic Programming	7	11.3	Chen-Ritzo et al. (2010); Sodhi and Tang (2011); Hahn and Kuhn (2012a); Hahn and Kuhn (2012b); Feng et al. (2013); Li and Thorstenson (2014); Rappold and Yoho (2014)
Mixed-integer Linear Programming (MILP)	6	9.7	Wang, Hsieh and Hsu (2012); Wochner et al. (2016); Albrecht and Steinrücke (2017); Lalami, Frein and Gayon (2017); Nemati, Madhosi and Ghadikolaei (2017); Darmawan, Wong and Thorstenson (2018)
Simulation-optimization	6	9.7	Feng, D`Amours and Beauregard (2010); Lim, Alpan and Penz (2014); Calfa et al. (2015); Chen, Lai and Xiao (2015); Lim, Alpan and Penz (2017); Darmawan, Wong and Thorstenson (2018); Wery et al. (2018)
IT Systems	5	8.2	Kelleher (2012); Jonsson, Rudberg and Holmberg (2013); Goh and Eldridge (2015); Dreyer et al. (2018); Mahadevan (2019)
Advanced Planning and Scheduling (APS)	4	6.6	Rudberg and Thulin (2009); Kjellsdotter and Jonsson (2010); Jonsson, Rudberg and Holmberg (2013); Jonsson and Ivert (2015)
Master Production Schedule (MPS)	4	6.6	Oliva and Watson (2011); Goh and Eldridge (2015); Jonsson and Ivert (2015); Mahadevan (2019)
Mixed-integer Programming (MIP)	3	4.9	Feng, D`Amours and Beauregard (2010); Li and Thorstenson (2014); Taskin et al. (2015)
Autoregressive Integrated Moving Average (ARIMA)	2	3.3	Rostami-Tabar et al. (2015); Omar, Hoang and Liu (2016)
Linear Programming (LP)	2	3.3	Ali et al. (2018); Ali et al. (2019)
Maturity models	2	3.3	Danese, Molinaro and Romano (2017); Vereeck et al. (2018)
Nested Booking Limits (NBL)	2	3.3	Ali et al. (2018); Ali et al. (2019)
Rough Cut Capacity Planning (RCCP)	2	3.3	Jonsson and Ivert (2015); Dreyer et al. (2018)
Backpropagation Neural Network (BPNN)	1	1.6	Omar, Hoang and Liu (2016)
Business Assumptions Package (BAP)	1	1.6	Oliva and Watson (2011)
Collaborative Planning, Forecasting and Replenishment (CPFR)	1	1.6	VICS (2010)
Contact Manufacturing Shipment Schedule (CMSS)	1	1.6	Goh and Eldridge (2015)
Decision Support System (DSS)	1	1.6	Taskin et al. (2015)
Demand Management Organization (DMO)	1	1.6	Oliva and Watson (2011)
Electronic Data interchange (EDI)	1	1.6	Oliva and Watson (2011)
Forecasting Management Competence (FMC)	1	1.6	Doering and Suresh (2016)
Forecasting Support System (FSS)	1	1.6	Fildes, Goodwin and Önkal (2019)
Hybrid heuristics	1	1.6	Shimizu, Sakagychi and Yoo (2016)
Kriging metamodels	1	1.6	Ali et al. (2018)

Long-term capacity management framework	1	1.6	Olhager and Johansson (2012)
Point-of-sales (PoS)	1	1.6	Kaipia et al. (2017)
Reverse Collaboration Framework (RCF)	1	1.6	Mahadevan (2019)
Single Exponential Smoothing (SES)	1	1.6	Rostami-Tabar et al. (2015)
Superordinate Identity Teams	1	1.6	Ambrose, Matthews and Rutherford (2018)
Warehouse Management System (WMS)	1	1.6	Mahadevan (2019)
Total	62	100	-

Source: Created by the author (2019).

In Table 3, each tool identified in the systematic review is presented together with the frequency, percentage of usage, and the respective author(s). Of the distinct range of applications, the largest concentration of works present stochastic programming with 11.3%, followed by MILP and simulation-optimization models with 9.7% each. IT systems, APS and MPS follow the rank of applications.

2.3.2 Impact

The metrics behind each tool application were gathered to provide a contextualization of the general impact in each studied context. The evaluation metrics, correlated with the tools applied, are classified, and presented in Table 4. In the available data, it is possible to identify the KPIs and business drivers taken into consideration when assessing and acting on different practical issues.

Table 4 – Metrics Classification

Metric	Tool(s)	Author(s)
Financial		
Economic Value Added (EVA)	Stochastic Programming [**2**]	Hahn and Kuhn (2012a); Hahn and Kuhn (2012b)
Profit	Kriging Metamodels Linear Programming (LP) [**2**] Mixed-integer linear programming (MILP) [**2**] Nested booking limits (NBL) [**2**] Mixed integer programming (MIP) [**2**] Simulation-optimization [**3**] Superordinate Identity Teams Stochastic Programming [**3**]	Chen-Ritzo et al. (2010); Feng, D`Amours and Beauregard (2010); Feng et al. (2013); Li and Thorstenson (2014); Chen, Lai and Xiao (2015); Nemati, Madhosi and Ghadikolaei (2017); Ali et al. (2018); Ambrose, Matthews and Rutherford (2018); Darmawan, Wong and Thorstenson (2018); Ali et al. (2019)
Return on Assets (ROA)	Superordinate Identity Teams	Ambrose, Matthews and Rutherford (2018)
Revenue	Collaborative Planning, Forecasting and Replenishment (CPFR) Kriging Metamodels Linear Programming (LP) [**2**] Mixed-integer linear programming (MILP) [**2**] Mixed integer programming (MIP) Nested booking limits (NBL) [**2**] Simulation-optimization [**3**] Stochastic Programming Superordinate Identity Teams	Chen-Ritzo et al. (2010); Feng, D`Amours and Beauregard (2010); VICS (2010); Nemati, Madhosi and Ghadikolaei (2017); Ali et al. (2018); Ambrose, Matthews and Rutherford (2018); Darmawan, Wong and Thorstenson (2018); Wery et al. (2018); Ali et al. (2019)

Forecasting		
Forecast Accuracy	Autoregressive Integrated Moving Average (ARIMA) [**2**] Backpropagation Neural Network (BPNN) Business assumptions package (BAP) Contact Manufacturing Shipment Schedule (CMSS) Demand Management Organization (DMO) Electronic Data interchange (EDI) Forecasting Management Competence (FMC) Forecasting support system (FSS) IT Systems [**3**] Point-of-sales (PoS) Single Exponential Smoothing (SES) Superordinate Identity Teams	Oliva and Watson (2011); Kelleher (2012); Jonsson, Rudberg and Holmberg (2013); Goh and Eldridge (2015); Rostami-Tabar et al. (2015); Doering and Suresh (2016); Omar, Hoang and Liu (2016); Kaipia et al. (2017); Ambrose, Matthews and Rutherford (2018); Fildes, Goodwin and Önkal (2019)
Logistics		
Inventory Costs	Advanced Planning and Scheduling (APS) [**2**] Business assumptions package (BAP) Collaborative Planning, Forecasting and Replenishment (CPFR) Contact Manufacturing Shipment Schedule (CMSS) Decision Support System (DSS) Demand Management Organization (DMO) Electronic Data interchange (EDI) IT Systems [**3**] Kriging Metamodels Linear Programming (LP) Master Production Schedule (MPS) [**2**] Mixed-integer Linear Programming (MILP) [**2**] Mixed-integer Programming (MIP) Nested booking limits (NBL) Simulation-optimization [**2**] Stochastic Programming [**3**] Superordinate Identity Teams	Rudberg and Thulin (2009); Chen-Ritzo et al. (2010); VICS (2010); Oliva and Watson (2011); Sodhi and Tang (2011); Kelleher (2012); Jonsson, Rudberg and Holmberg (2013); Lim, Alpan and Penz (2014); Rappold and Yoho (2014); Goh and Eldridge (2015); Taşkin et al. (2015); Lim, Alpan and Penz (2017); Lalami, Frein and Gayon (2017); Nemati, Madhosi and Ghadikolaei (2017); Ali et al. (2018); Ambrose, Matthews and Rutherford (2018)
Inventory Turns	Advanced Planning and Scheduling (APS) Business assumptions package (BAP) Demand Management Organization (DMO) Electronic Data interchange (EDI) Master Production Schedule (MPS) [**2**] Rough Cut Capacity Planning (RCCP)	Oliva and Watson (2011); Jonsson and Ivert (2015)
Procurement Costs	Mixed-integer Linear Programming (MILP) Mixed-integer Programming (MIP) Simulation-optimization	Feng, D`Amours and Beauregard (2010); Nemati, Madhosi and Ghadikolaei (2017)
Service Level	Advanced Planning and Scheduling (APS) [**3**] Business assumptions package (BAP) Collaborative Planning, Forecasting and Replenishment (CPFR) Demand Management Organization (DMO) Electronic Data interchange (EDI) Forecasting Management Competence (FMC) IT System Kriging Metamodels Linear Programming (LP) [**2**] Master Production Schedule (MPS) [**2**] Mixed-integer linear programming (MILP) [**3**] Nested booking limits (NBL) [2] Point-of-sales (PoS) Rough Cut Capacity Planning (RCCP) Stochastic Programming [**2**] Simulation-optimization [**2**]	Rudberg and Thulin (2009); Chen-Ritzo et al. (2010); VICS (2010); Oliva and Watson (2011); Sodhi and Tang (2011); Jonsson, Rudberg and Holmberg (2013); Lim, Alpan and Penz (2014); Calfa et al. (2015); Jonsson and Ivert (2015); Doering and Suresh (2016); Wochner et al. (2016); Kaipia et al. (2017); Lalami, Frein and Gayon (2017); Nemati, Madhosi and Ghadikolaei (2017); Ali et al. (2018); Ambrose, Matthews and Rutherford (2018); Ali et al. (2019)
Transportation Costs	Hybrid heuristics Mixed-integer Programming (MIP) Mixed-integer Linear Programming (MILP) Simulation-optimization	Feng, D`Amours and Beauregard (2010); Shimizu, Sakagychi and Yoo (2016); Nemati, Madhosi and Ghadikolaei (2017); Ambrose, Matthews and Rutherford (2018)

Mathematical Models		
Computation Time	Hybrid heuristics Mixed-integer Linear Programming (MILP) [**2**] Mixed-integer Programming (MIP) Simulation-optimization [2] Stochastic Programming	Wang, Hsieh and Hsu (2012); Li and Thorstenson (2014); Calfa et al. (2015); Shimizu, Sakagychi and Yoo (2016); Albrecht and Steinrücke (2017); Lim, Alpan and Penz (2017)
Maturity		
Maturity Level	Maturity models	Danese, Molinaro and Romano (2017); Vereeck et al. (2018)
Operational		
Capacity Utilization	Long-term capacity management framework Mixed-integer Linear Programming (MILP) [**2**] Stochastic Programming	Olhager and Johansson (2012); Rappold and Yoho (2014); Wochner et al. (2016); Nemati, Madhosi and Ghadikolaei (2017)
Lead Time	Contact Manufacturing Shipment Schedule (CMSS) IT Systems [**2**] Master Production Schedule (MPS) [**2**] Reverse Collaboration Framework (RCF) Warehouse Management System (WMS)	Goh and Eldridge (2015); Mahadevan (2019)
Planning Efficiency	Advanced Planning and Scheduling (APS) [**4**] Collaborative Planning, Forecasting and Replenishment (CPFR) Decision Support System (DSS) IT Systems [**2**] Long-term capacity management framework Master Production Schedule (MPS) Mixed-integer Linear Programming (MILP) [**2**] Mixed-integer Programming (MIP) Rough Cut Capacity Planning (RCCP) [**2**]	Rudberg and Thulin (2009); Ivert and Jonsson (2010); VICS (2010); Olhager and Johansson (2012); Jonsson, Rudberg and Holmberg (2013); Jonsson and Ivert (2015); Taşkin et al. (2015); Wochner et al. (2016); Lalami, Frein and Gayon (2017); Dreyer et al. (2018)
Production Costs	Advanced Planning and Scheduling (APS) Forecasting Management Competence (FMC) Mixed-integer Linear Programming (MILP) [**2**] Mixed-integer Programming (MIP) Simulation-optimization [**2**] Stochastic Programming	Rudberg and Thulin (2009); Chen-Ritzo et al. (2010); Feng, D\`Amours and Beauregard (2010); Doering and Suresh (2016); Nemati, Madhosi and Ghadikolaei (2017); Darmawan, Wong and Thorstenson (2018)
Throughput	Advanced Planning and Scheduling (APS)	Rudberg and Thulin (2009)

Source: Created by the author (2019).

From Table 4, is identified that most tool-oriented publications lean toward logistical and operational metrics to assess systems gains, where service level, inventory costs, planning efficiency and forecast accuracy were the highest mentioned metrics. Interestingly, some works have addressed computing time as the main metric, highlighting a trend focused on the development of computational and programming models in this field. This general information can guide future academic and professional works developing or improving S&OP tools, providing the recognition of trade-offs in the decision-making process between desired tools, contexts, and outcomes.

2.3.3 Context

Contextual data from each publication applies to the second proposed research question, to provide insight in a wide range of tools and fields identified. In the second objective of this research, by providing an integration of the S&OP tools, no variables or peculiarities of specific contexts that restrict the interchangeability of the proposed applications were identified. The collected data in the publications has flexibility enough to be adapted to the needs of different industries and business types, despite the possible changes that professionals may face when addressing a current problem in a real situation, having a combined set of tools, present in Table 2, to rely on.

2.3.4 Pillars

To answer the third proposed research question ("How can these tools be synthesized into an implementation framework?"), six pillars were empirically defined to synthesize the review: Demand Management, Forecasting, Human Resources, New Product Introduction, Supply Chain Management and Tactical Planning. These criteria were established based on the review data, exploring the distribution of topics behind each selected work in the literature. An extract from Table 2 is presented in Table 5, grouping the publications by each pillar.

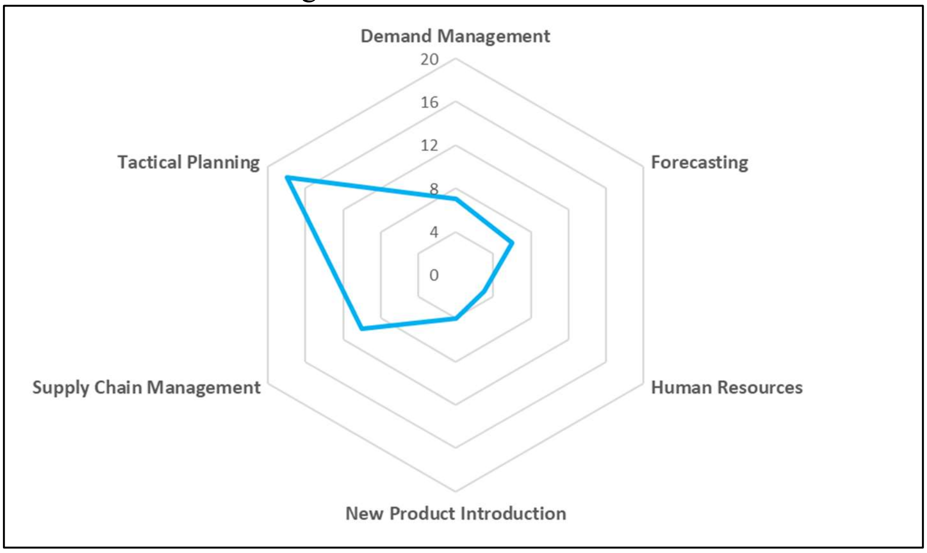
Table 5 – Findings by Pillars

Pillar	Author(s)
Demand Management	Oliva and Watson (2011); Sodhi and Tang (2011); Chen, Lai and Xiao (2015); Kaipia et al. (2017); Ali et al. (2018); Darmawan, Wong and Thorstenson (2018); Ali et al. (2019)
Forecasting	VICS (2010); Kelleher (2012); Rostami-Tabar et al. (2015); Doering and Suresh (2016); Omar, Hoang and Liu (2016); Fildes, Goodwin and Önkal (2019)
Human Resources	Danese, Molinaro and Romano (2017); Ambrose, Matthews and Rutherford (2018); Vereeck et al. (2018)
New Product Introduction	Goh and Eldridge (2015); Wochner et al. (2016); Kaipia et al. (2017); Wery et al. (2018)
Supply Chain Management	Feng, D`Amours and Beauregard (2010); Hahn and Kuhn (2012a); Hahn and Kuhn (2012b); Wang, Hsieh and Hsu (2012); Jonsson, Rudberg and Holmberg (2013); Lim, Alpan and Penz (2014); Rappold and Yoho (2014); Shimizu, Sakagychi and Yoo (2016); Lim, Alpan and Penz (2017); Mahadevan (2019)
Tactical Planning	Rudberg and Thulin (2009); Chen-Ritzo et al. (2010); Ivert and Jonsson (2010); Oliva and Watson (2011); Olhager and Johansson (2012); Feng et al. (2013); Jonsson, Rudberg and Holmberg (2013); Li and Thorstenson (2014); Calfa et al. (2015); Goh and Eldridge (2015); Jonsson and Ivert (2015); Taşkin et al. (2015); Albrecht and Steinrücke (2017); Lalami, Frein and Gayon (2017); Nemati, Madhosi and Ghadikolaei (2017); Darmawan, Wong and Thorstenson (2018); Dreyer et al. (2018)

Source: Created by the author (2019).

The distribution of the findings by pillar is illustrated in Figure 8. As the chart shows, most of the tools found in the S&OP literature are concentrated on the Tactical Planning pillar. Supply Chain Management, Demand Management and Forecasting follow the ranking of publications.

Figure 8 – Tools Distribution



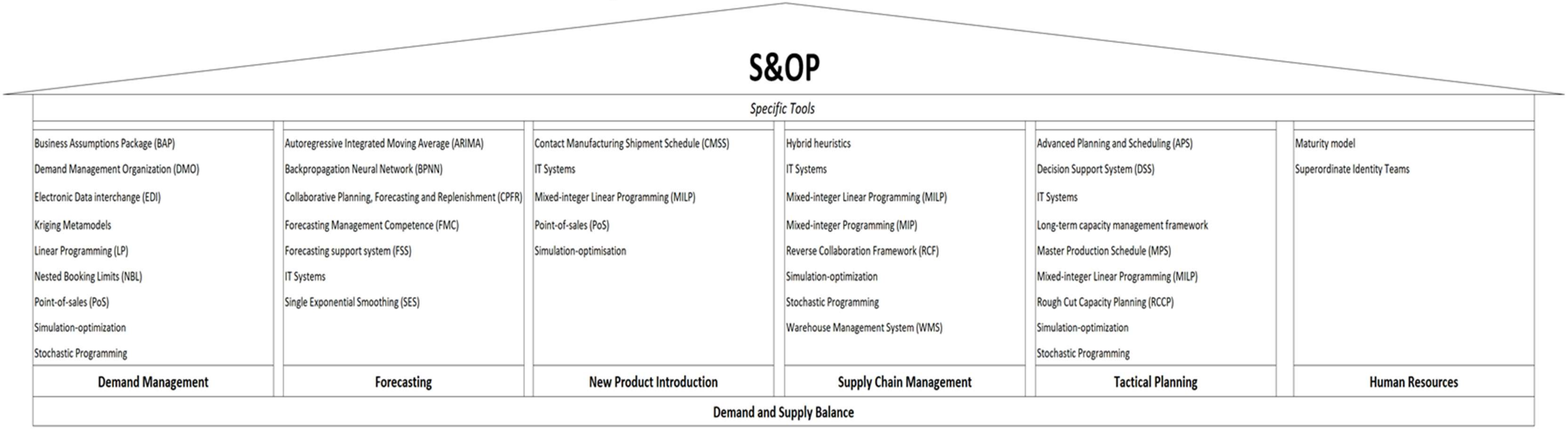
Source: Created by the author (2019)

New Product Introduction and Human Resources were the pillars with the least number of tools found in the reviewed articles. Despite showing a high complexity of the proposed techniques, these general results illustrate a gap to be assessed by the literature. For the definition, Forecasting and Demand Management were interpreted as two different topics due to the representative number of works that approach forecasting specifically as an autonomous subject. The distribution presented in Figure 8 provides a visualization of focus and trend in the S&OP literature.

2.3.5 S&OP Tools Framework

To summarize the results and fill in the last research question, a framework is presented in Figure 9 as a structured model to synthesize all findings. The distribution was based on the data gathered in Table 2, using the pillars of section 2.3.4 as the main classification criteria. The final framework provides a conceptual foundation of S&OP tools, contributing with a field-tested set of applicable solutions for academics and practitioners interested in developing or improving the overall S&OP field.

Figure 9 – S&OP Tools Framework



Source: Created by the author (2019)

2.4 SYSTEMATIC REVIEW CONCLUSIONS

This systematic review analyzed an extant number of three hundred and sixty-eight papers with the aim of creating a synthesized literature of specific tools in implementing S&OP. The categorization of the 42 selected articles provided an overview of the current state and focus of academic and professional publications in recent years. The results indicate the practical need for sophisticated tools to leverage the decision-making process in complex contexts.

The results present a broad set of tools and models established across a different range of fields and applications. Based on them, a S&OP tool framework has been proposed, presenting the distribution of the results across six pillars labeled as: Demand Management, Forecasting, Human Resources, New Product Introduction, Supply Chain Management and Tactical Planning. Observations of the relevant elements emphasize the strong trend of Tactical Planning and Demand Management/Forecasting topics. Results that are congruent with the purpose behind the S&OP methodology.

Insights and a benchmarking can be derived from the results presented in this article for both professionals and academic researchers. For professionals, the information provides a set of tools that address specific contexts and impacts behind each application. This provides a shortcut when choosing a solution to a problem in a real scenario, offering the flexibility to look for any wanted metric or pillar to select a specific tool. For academics, the synthesis provides a view of the current body of knowledge and trends in the literature, highlighting under-researched areas of the S&OP.

In general, the findings indicate a high level of topic maturity when addressing specific implementation tools in a wide range of different contexts analyzed. However, gaps can still be identified in certain branches of the literature. Mainly, the low contribution of dedicated tools to the Human Resources pillar, exposing a weakness in an intrinsic variable of any system: people. In this regard, further research is proposed to raise awareness of the role of human resources in Sales and Operations Planning.

3 METHOD

This chapter describes the methods adopted for this study. First, the research method is presented, explaining the overall approach, characteristics and procedures selected. Afterwards, the work method is described, breaking down the steps defined for the implementation of the Sales and Operations Planning process in the automotive company under study.

3.1 RESEARCH METHOD

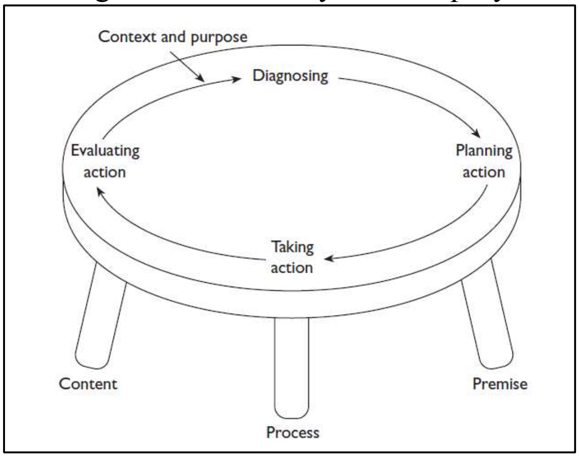
This study is classified as an action research (AR), which can be described as a systematic approach that enables people to find effective solutions to problems they face in their everyday lives. It is grounded in the proposition that generalized solutions may not fit all contexts, so its real purpose is to find an appropriate solution for context specific dynamics. Therefore, the approach uses cycles of investigation to reveal solutions to problems in each situation, providing means to increase the work effectiveness (STRINGER, 2014).

The use of AR is considered valuable in the Operations Management (OM) field, Coughlan and Coghlan (2002) justified that there is always a need for conceptually-based collaborative work among managers and researchers around relevant operational issues faced by organizations. The authors also point several major characteristics of the AR approach, though four stand out:

(1) Action researchers are not merely observing, they are actively takin action.
(2) AR always involves two goals: solve a problem and contribute to science.
(3) AR is interactive as the researchers may face a series of unpredictable events and be able to adapt.
(4) AR is fundamentally about change.

For the AR implementation, Coghlan and Brannick (2005) propose a three steps cycle: (i) pre-step – for understanding the context and purpose; (ii) main steps – diagnosing, planning action, taking action and evaluating action; and (iii) a meta-step to monitoring each cycle. This overall approach is illustrated by the authors in Figure 10.

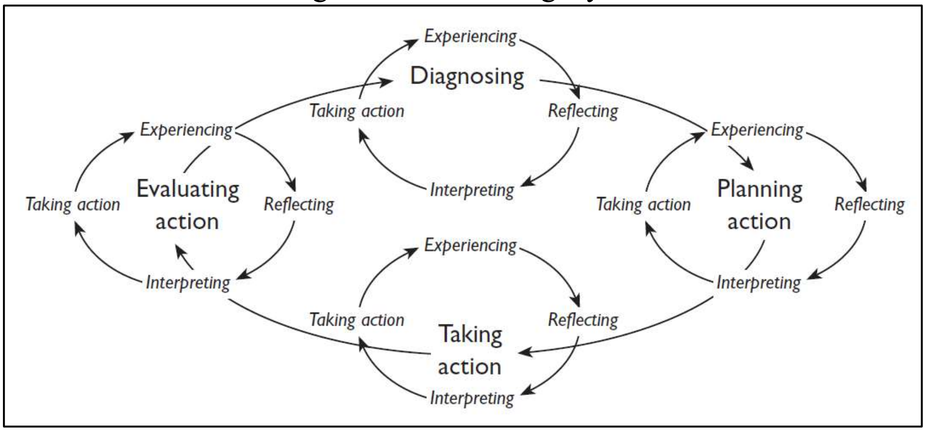
Figure 10 – Meta Cycle of Inquiry



Source: Coghlan and Brannick (2005)

Learning in action is one of the most important aspects for an action researcher engaged in any field of work. For Coghlan and Brannick (2005), the practical knowledge should always be aimed by researchers, since, the critical feature of AR is how you can learn about yourself and how you can shape the quality of your moment-to-moment actions. The authors present a four activities cycle for learning during an action research: Experiencing, Reflecting, Interpreting and Taking Action, incorporated to each main step of the implementation to guarantee the practical learning in each phase, as depict in Figure 11.

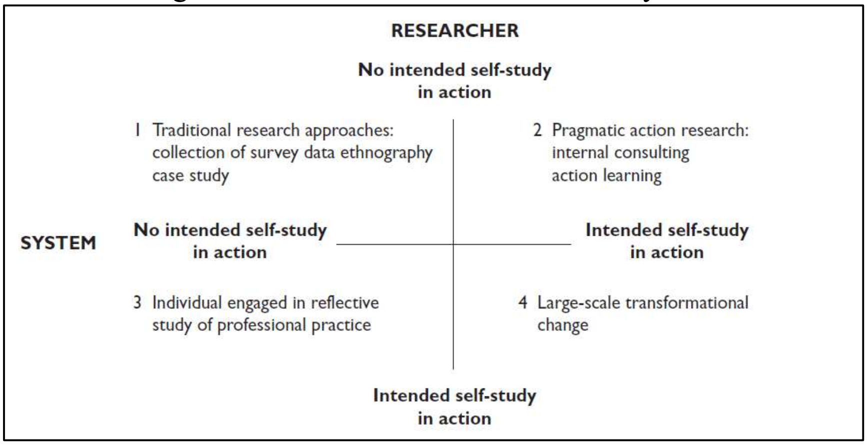
Figure 11 – Learning Cycle



Source: Coghlan and Brannick (2005)

Action Research in organizations is a complex process due to its several distinctive elements. Coghlan and Brannick (2005) develop a framework for outlining four different forms that a research can take, depending on the system and the researcher commitment to learning in action. As the central topic of their book, this framework illustrates how members may undertake action research in and on their organizations.

Figure 12 – Focus of Researcher and System

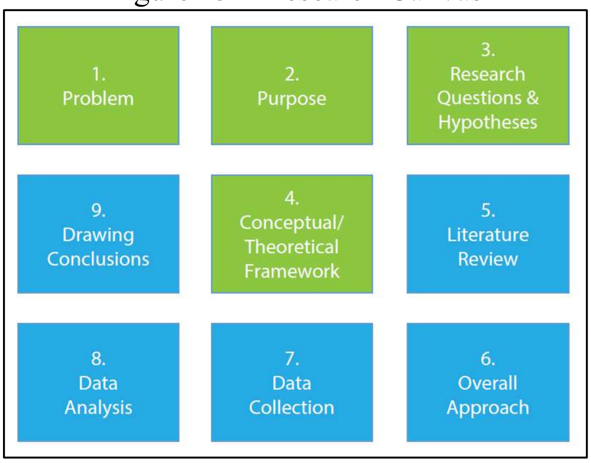


Source: Coghlan and Brannick (2005)

Figure 12 presents the four quadrants framework proposed by Coghlan and Brannick (2005) to classify any given research. Each quadrant reflects the outcome depending on the focus reflected by the system and researcher commitment. In this classification, this research is located at the fourth quadrant, meaning that both, the company (system) and the researcher are engaged in intended self-study in action seeking to promote a large-scale transformational change.

Complementary, the writing structure of this thesis was established based on the guidelines of Latham (2016). The method presented by the author, provides a consistent logic process for designing the "big picture" of studies. The two groups' structure presented to organize all necessary components is depicted in Figure 13. The "T" includes the problem, purpose, research questions and conceptual framework (green cells) and the "U" foundation includes the literature review, overall approach, data collection, data analysis, and drawing conclusions (blue cells).

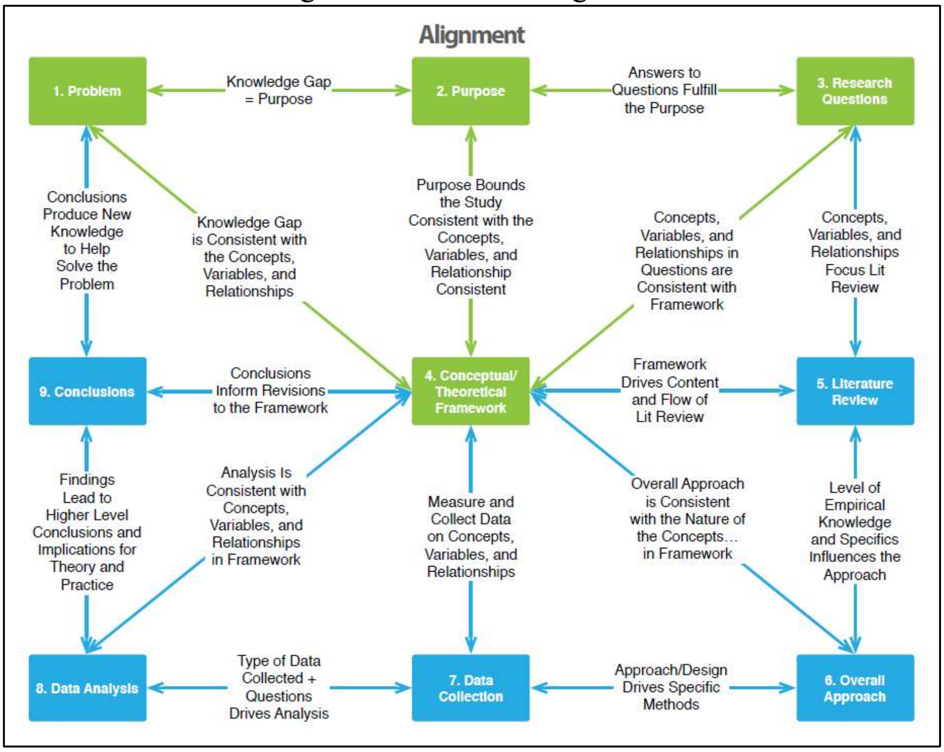
Figure 13 – Research Canvas



Source: Latham (2016)

To promote a consistent alignment between all components, Latham (2016) also reveals a framework unfolding the linkage between the nine steps proposed. This framework, presented in Figure 14, presents the correlation between all components in the research methodology proposed.

Figure 14 – Canvas Alignment



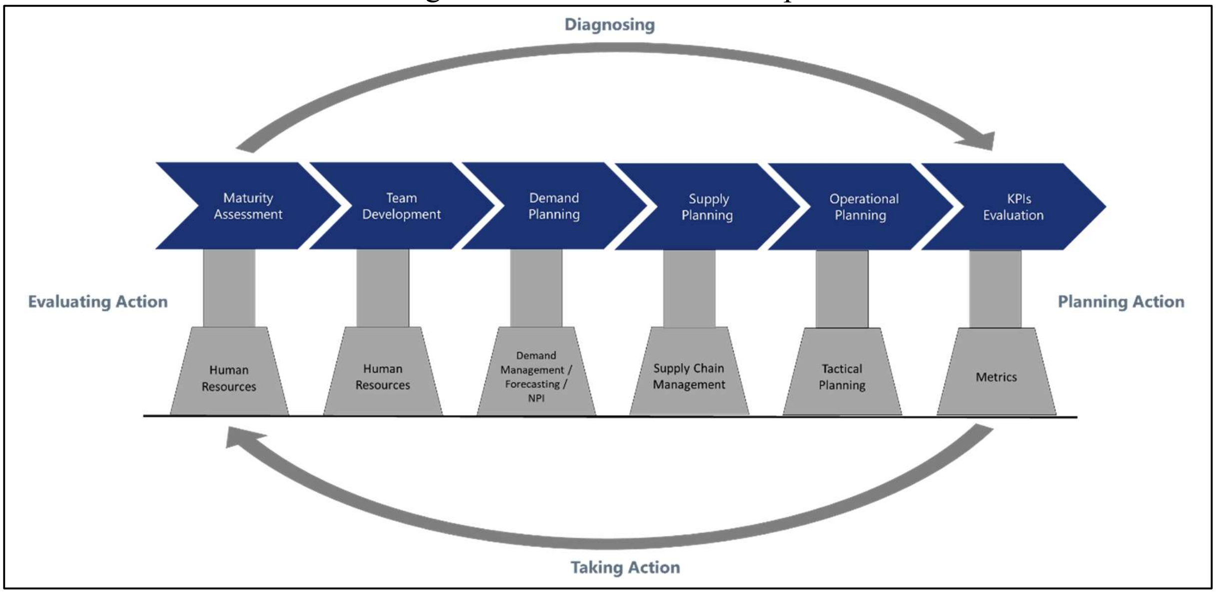
Source: Latham (2016)

Latham (2016) explains that if any adjustment is necessary, it becomes simpler in a brief canvas format than to achieve alignment in a more comprehensive structure. Hence, the methodology is designed to allow the researcher to pivot easier when changes are required without leaving inconsistencies between the components.

3.2 WORK METHOD

As Latham's (2016) presents, the overall approach should be correlated with the literature review, the conceptual framework and to be looking into the further steps of data collection and data analysis. Also, it must be based on the research problem, purpose, and questions for defining the most appropriate research strategy. In this logic, this research work method was defined in alignment with those steps, using the findings from the literature review, from the conceptual framework (Figure 5), together with the research purpose and questions presented in chapter 2. The proposed method for the S&OP implementation is presented in Figure 15, portraying the 6 main steps sustained by each pillar from the framework presented in Figure 9. The AR meta cycle of inquiry steps by Coghlan and Brannick (2005) is also integrated into the method deployment, forcing the retro feedback learning cycle for enhancing the practical learning in each phase.

Figure 15 – Work Method Steps



Source: Created by the author (2019)

The initial step of the S&OP implementation is the maturity assessment of the organization`s demand and supply balancing process. This kick-off activity provides a context evaluation of the company`s resources strengths and weakness. In this phase, a maturity model was created based on the models from Danese, Molinaro and Romano (2017) and Vereeck et al. (2018), incorporating the pillars from the S&OP framework presented in Figure 9. The model exhibits a classification score for each S&OP pillar, highlighting gaps for taking corrective or improvement actions during the S&OP implementation stages.

With the maturity level and the critical gaps identified, the next step is developing a highly performance multidisciplinary team, engaged in achieving a culture and mindset shift throughout the organization. The goal is defining the stakeholder’s responsibilities for each organization’s department within the S&OP process. In this task, the superordinate identity S&OP team structure and the relevant process influencers proposed by Ambrose, Matthews and Rutherford (2018) were adopted to guarantee the highest positive impact possible in the S&OP performance.

Afterwards, the third step is to build a structured demand planning process in the organization. In this phase, demand management and new product introduction tools are integrated with forecasting techniques to enhance the comprehensive of data and variables inputs. This step seeks to consolidate the statistical forecasts with the qualitative perception from key S&OP stakeholders to increase the forecast accuracy and planning efficiency in the decisions-making deployment. The tools considered to aid this implementation step are mainly integration mechanisms as BAP, FMC and FSS (Oliva and Watson 2011; Doering and Suresh 2016; Fildes, Goodwin and Önkal 2019) combined with statistical approaches as Rostami-Tabar et al. (2015) to mitigate the outputs uncertainties.

The two next steps address the supply and operational planning of the organization. These steps consist mainly of the forecast deployment into the company's supply chain and operational management pillars, providing scenarios for managers to make decisions in the operational, tactical, and strategic levels. This phase addresses several supply chain variables as inventory replenishment, safety stocks levels and warehouse management, combined with manufacturing planning aspects, as capacity, scheduling, and lot-sizing techniques to improve the firm's operational results. Several tools presented in the S&OP tools framework in Figure 9 are estimated to foment this phase, although, their selection is dictated by the current maturity level of the organization.

The KPIs evaluation step closes the process cycle by providing managers with the implication and results obtained from the proposed S&OP systematic. The metrics found in the systematic review, presented in Figure 4, are used as a benchmarking for the performance tracking. Historical data availability and company's maturity level are also taken into consideration when defining those KPIs.

4 RESULTS

This chapter presents the development of the implementation method, proposed in Figure 15, in the researched environment. The first section approaches the data collection phase throughout several implementation steps. Subsequently, an analysis of the collected data is performed to evaluate the initial results obtained in consistency with the variables and relationships of the system. Finally, the conclusions and implications for theoretical and practical environments are drawn in the last section.

4.1 DATA COLLECTION

Based on the guidelines of Latham`s (2016) framework, this section approaches the data collection phase of this research. From the case description in section 1.2.2 and the strategic context framework presented in Figure 5, the S&OP implementation steps were deployed among the company`s current variables, as detailed in the following sub-sections.

4.1.1 Maturity Assessment

In the first step, a maturity model was developed to identify the initial state (as-is) of the S&OP process in the organization. The purpose of this model is to provide a clear roadmap of actions to close critical gaps within the S&OP pillars, and a benchmark among different industries and organizations for the S&OP implementation success factors. The model was created based on the recent works of Danese, Molinaro and Romano (2017) and Vereeck et al. (2018).

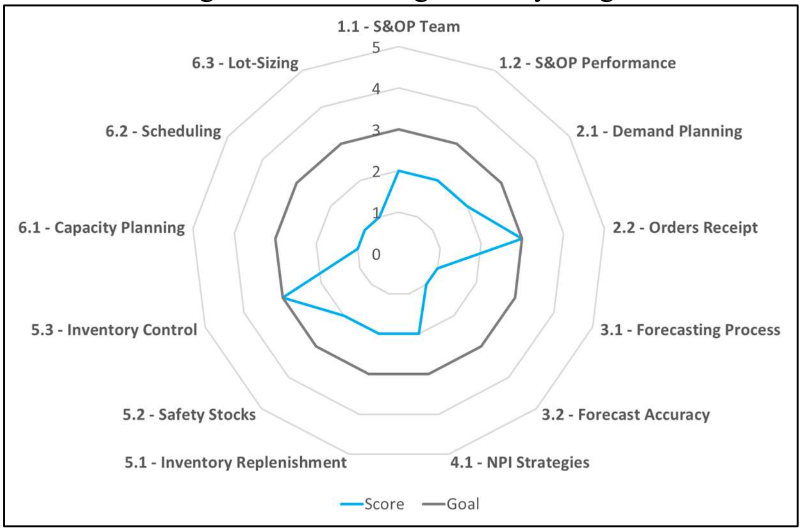
From Danese, Molinaro and Romano (2017) model, the transition dynamics of one stage to another was adopted to identify the steps and actions for each stage evolution. In their model, the authors propose four S&OP dimensions: People and organization, Process and methodologies, Information Technology and Performance measurements, and five maturity stages: ‘No S&OP process’, ‘Reactive’, ‘Standard’, ‘Advanced’ and ‘Proactive’ to represent the growth path from companies with no planning process to the most advanced ones.

From Vereeck et al. (2018), the higher focus on demand planning and forecasting as the main inputs of the S&OP process was the major influencer. The authors propose six dimensions measured by 33 practices: Data management, The use of forecasting methods, Management of the forecasting system, Performance management, The forecasting organization, People management. They also adopted a five maturity stages using a uniform Likert scale to measure each practice, ranging from ‘Never’ or ‘does not exist’ to ‘Always’ or ‘Definitely exists’. The general implications and results from both works can be seen in detail in the literature analysis presented in section 2.3.

Despite both model present improvements from previous works in the literature, their S&OP dimensions are mainly composed by broad topics. In this sense, the proposed model aims to improve this condition, with a solid S&OP dimensions structure with in-depth practices. For that, the systematic review findings, presented in chapter 2, were introduced, using the six pillars depicted in Figure 9: Human Resources, Demand Management, Forecasting, New Product Introduction, Tactical Planning and Supply Chain Management as the model foundation. A five maturity stages was used, in which the S&OP tools were classified based on the insights obtained from the literature review. The final S&OP maturity assessment model can be seen fully in Annex A. The classification logic sets boundaries from one stage to another based on the presence of each tool, facilitating the S&OP maturity evaluation in a correlated way. Assessment questions were created for each topic to aid practitioners during the assessment. A critical level was defined based on the maturity scale proposed. Topics with a score below 3 are considered critical since this level represents a minimum process formalization and tools application, and hence an action must be defined to fulfill the gap. The general maturity evidence required for each level should be dictated by the auditor’s perception to classify the company’s score in each pillar.

After the model conception, an assessment audit was performed in the company to understand the current maturity level. The process was conducted by the action researcher and took approximately 2 days to be finished. Several participants from different departments were involved to capture the current state of the process in detail. The company’s starting maturity stage is depicted in Figure 16.

Figure 16 – Starting Maturity Stage



Source: Created by the author (2020)

The initial maturity evaluation process brought a view of the company current strengths and weakness in each S&OP pillar. As depicted in Figure 16, overall, the organization has a low maturity level in several topics of the demand and supply balancing process. In the **Human Resources** pillar the lack of a formal structured S&OP team as well as no executive engagement in the planning process are the main shortcomings of the current state. S&OP performance and maturity level are not known by the organization, only isolated functional metrics are monitored. Furthermore, within the **Demand Management** pillar, there is not a formal S&OP planning process established. Some collaboration between departments is demonstrated, however only informal meetings happen without a defined schedule to plan demand and supply operations. In the same pillar, the company presented an online order receipt system integrated into the ERP system for managing receiving orders. In **Forecasting**, the lack of a structured process is the main gap identified. Sales projections are generated based only on historical demand moving averages, calculate automatic by the ERP system. Forecast accuracy is also not tracked. In the **New Product Introduction** pillar, due to be positioned in the automotive market, the company presented a solid methodology for developing new products. An annual NPI plan with projected demand is defined, however no evaluation of operational constrains is performed for a holistic capacity view. In regards of the **Supply Chain Management**, the company has an automated inventory replenishment process controlled via the ERP system, however no projections of future demands are integrated into the planning. Safety stocks are calculated based on linear historical demand patterns, without defined service levels and lead times. The company scored 3 in inventory control since it has a centralized warehouse system with ERP integration and a FIFO plan documented. The **Tactical Planning** pillar showed the lowest score, with several gaps identified, as the lack of capacity planning and scheduling techniques. An infinite MRP logic is used for generating production orders, which are released to the production site without a defined production schedule. Production lot-sizes are parameterized into the ERP system; however, they are based only on human judgment, therefore lot-sizing approaches are not documented.

After the maturity evaluation process, an action plan was defined in Table 6. Due to several gaps had been identified, only topics with scores below 3 were addressed in the implementation stage, leaving two topics: order receipt and inventory control for a second improvement transition stage when the overall maturity level of the organization rises.

Table 6 – Action Plan

Topic	Current Stage	Actions	Future Stage
1.1 – S&OP Team	**Score 2** • Company does not have a formal S&OP team • Only an informal team to make the decisions exists • Lack of executive management engagement in the process	• Create a S&OP multidisciplinary team • Define roles and responsibilities • Promote executive management engagement in the process	**Score 3** • Formal S&OP team • Clear roles and stakeholders defined • Executive management engagement in the process
1.2 – S&OP Performance	**Score 2** • Company does not have any method to evaluate the performance of the planning process • Isolate metrics are tracked but with no integration into the planning process • S&OP performance and maturity level is not known	• Define specific metrics to track the planning process performance • Establish feedback meetings with stakeholders to share the KPIs • Introduce the S&OP Maturity Model	**Score 3** • Specific KPIs are defined and shared with S&OP stakeholders
2.1 - Demand Planning	**Score 2** • Only an informal decentralized demand planning process exists • No routine scheduled meeting • Low collaboration between departments • Market and operational variables are not clearly defined	• Create a formal demand planning process • Establish meetings schedule • Define specific business assumptions and variables	**Score 3** • Formal demand planning process • Routinely scheduled meetings • Defined variables and business assumptions
3.1 - Forecasting Process	**Score 1** • Sales projections are generated based only on ERP historical values (moving average)	• Create a forecasting process • Integrate quantitative projections with qualitative marketing information • Introduce sophisticated forecasting statistical techniques	**Score 3** • Formal forecasting process • Integration with marketing qualitative variables
3.2 – Forecast Accuracy	**Score 1** • Forecast accuracy is not tracked in the organization	• Create a forecast accuracy indicator	**Score 3** • Forecast accuracy is tracked and shared in the organization
4.1 - NPI Strategies	**Score 2** • Organization has a formal annual NPI plan defined • Demand is projected in the early stages of development however operational constrains are not assessed	• Integrate the NPI plan into the S&OP cycle to evaluate NPI forecasts with the operational constrains	**Score 3** • Formal NPI plan is shared • Demand is forecasted for the new launches • Production constrains are evaluated in the development phases
5.1 - Inventory Replenishment	**Score 2** • Company has an automated inventory replenishment ROP in the ERP system	• Establish an integrated supply chain planning • Integrate sales forecasts into the planning system	**Score 3** • Integrated supply chain planning

	• Inventory levels are calculate based only on historical values (moving average) • Sales projections are not assessed in the planning process		• Inventory is adjusted based on demand projections
5.2 - Safety Stocks	**Score 2** • Safety stocks are determined based on historical data (moving average) • Linear parameters are defined in the ERP system (stock coverage in days) • Lead times and service level are not defined	• Define service levels and lead times for each SKU • Introduce forecasts accuracy and statistical deviations for safety stock calculation	**Score 3** • Service level and lead times are defined and updated regularly • Documented strategies at SKU level
6.1 - Capacity Planning	**Score 1** • No capacity planning is performed • Infinite MRP capacity logic is used for generating orders	• Implement RCCP tool • Track capacity utilization	**Score 3** • Rough Cut Capacity Planning (RCCP) is used • Capacity Utilization is monitored
6.2 - Scheduling	**Score 1** • No production schedule is defined • Workers decide the production sequence by their own judgment • Lack of scheduling rules	• Implement MPS • Define scheduling rules	**Score 3** • Master Production Schedule (MPS) is defined • Scheduling rules are applied and documented
6.3 - Lot-Sizing	**Score 2** • Lot-sizes are parameterized into the ERP system • Production batches are defined by human judgment	• Establish lot-sizing approaches • Define and update production constrains for calculation	**Score 3** • Lot-sizing approaches are documented • Constrains are defined and updated regularly

Source: Danese, Molinaro and Romano (2017)

To facilitate readers following the actions implementation, Table 7 was created to portray the location of each action by section of this chapter.

Table 7 – Actions by Section

Topic	Actions	Section
1.1 – S&OP Team	• Create a S&OP multidisciplinary team • Define roles and responsibilities • Promote executive management engagement in the process	4.1.2 – Team Development
1.2 – S&OP Performance	• Define specific S&OP metrics to track the planning process performance • Establish feedback meetings with stakeholders to share the KPIs	4.2.1 – KPIs Evaluation
2.1 - Demand Planning	• Create a formal demand planning process • Establish meetings schedule • Define specific business assumptions and variables	4.1.3 – Demand Planning
3.1 - Forecasting Process	• Create a forecasting process • Integrate quantitative projections with qualitative marketing information • Introduce sophisticated forecasting statistical techniques	4.1.3 – Demand Planning
3.2 – Forecast Accuracy	• Create a forecast accuracy indicator	4.2.1 – KPIs Evaluation
4.1 - NPI Strategies	• Integrate the NPI plan into the S&OP cycle to evaluate NPI forecasts with the operational constrains	4.1.3 – Demand Planning
5.1 - Inventory Replenishment	• Establish an integrated supply chain planning • Integrate sales forecasts into the planning system	4.1.4 – Supply Planning

5.2 - Safety Stocks	• Define service levels and lead times for each SKU • Introduce forecasts accuracy and statistical deviations for safety stock calculation	4.1.4 – Supply Planning
6.1 - Capacity Planning	• Implement RCCP tool • Track capacity utilization	4.1.5 – Operational Planning
6.2 - Scheduling	• Implement MPS • Define scheduling rules	4.1.5 – Operational Planning
6.3 - Lot-Sizing	• Establish lot-sizing approaches • Define and update production constrains for calculation	4.1.5 – Operational Planning

Source: Created by the author (2020).

The following sections present the implementation method steps in relation to the action plan unfolded from the initial maturity evaluation of the company.

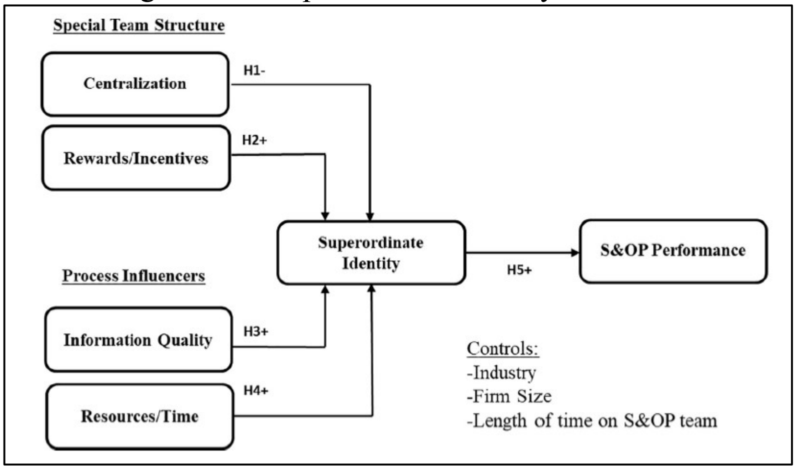
4.1.2 Team Development

The second implementation step was to develop a S&OP team in the organization. The main purpose of this step was to create a multidisciplinary team to promote a mindset shift in the company, since several gaps within the S&OP process were identified in the maturity evaluation. For defining this team structure, the superordinate team identity proposed by Ambrose, Matthews and Rutherford (2018) was adopted. The authors defined four main variables in the S&OP performance:

- Centralization – having a negative impact associate to the performance, inhibiting the exchange of ideas, autonomy, and hence lowering the collaboration levels among the stakeholders.
- Reward/Incentives – S&OP contributors will obtain superordinate identity when they are rewarded on collective goals extended beyond functional metrics.
- Information quality – appropriate information, both in content and form, shared between the S&OP team leads to higher levels of team identification.
- Resources/Time – Lack of resources and time will negatively impact in obtaining team identity. Proper training, education, as well as mandatory meeting attendance are key success factors for S&OP teams' performance.

Furthermore, the outcome association between the superordinate identity structure and S&OP antecedent variables, as depicted in the framework in Figure 17, was measured in a cross-sectional survey. The results supported all hypotheses, meaning that the superordinate identity structure, with a fully committed and unified team, will have a positive impact on S&OP results.

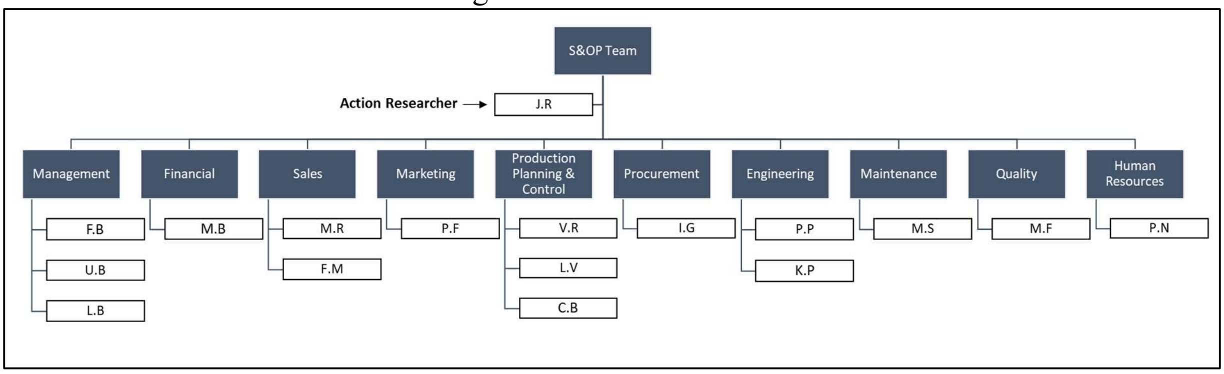
Figure 17 – Superordinate Identity Structure



Source: Ambrose, Matthews and Rutherford (2018)

Following the special team structure by Ambrose, Matthews and Rutherford (2018), a S&OP team was established in the organization. The complete team organization chart is presented in Figure 18.

Figure 18 – S&OP Team



Source: Created by the author (2020)

The goal to create a team with higher levels of identification started with the stakeholders definition. As depicted in Figure 18, 17 stakeholders were selected by each department after the maturity evaluation was performed. The team structure was established together with the management board of the company to promote engagement in the S&OP process. To avoid centralization, the action researcher acted as the process mediator to conduct the methodology throughout the early stages of implementation, and particularly, to enhance the exchange of ideas among departments, building a decentralized decision-making process. Collective goals were defined for tracking the overall process and to reward the team performance. The specific metrics are explored later in section 4.2.1.

After the team structure was defined, workshops were conducted to educate the stakeholders. The training introduced the main concepts, variables of integration, and the role of each department into the planning system. The emphasis was in the information quality and time management as the key factors for the S&OP team performance.

4.1.3 Demand Planning

With the S&OP team defined, the next step was to implement a demand planning process in the organization. For that, specific business assumptions were defined as inputs of the planning process, for transferring the responsibility to stakeholders to provide quality information during the process. The variables, depicted in Table 8, were later introduced throughout different stages of the S&OP process.

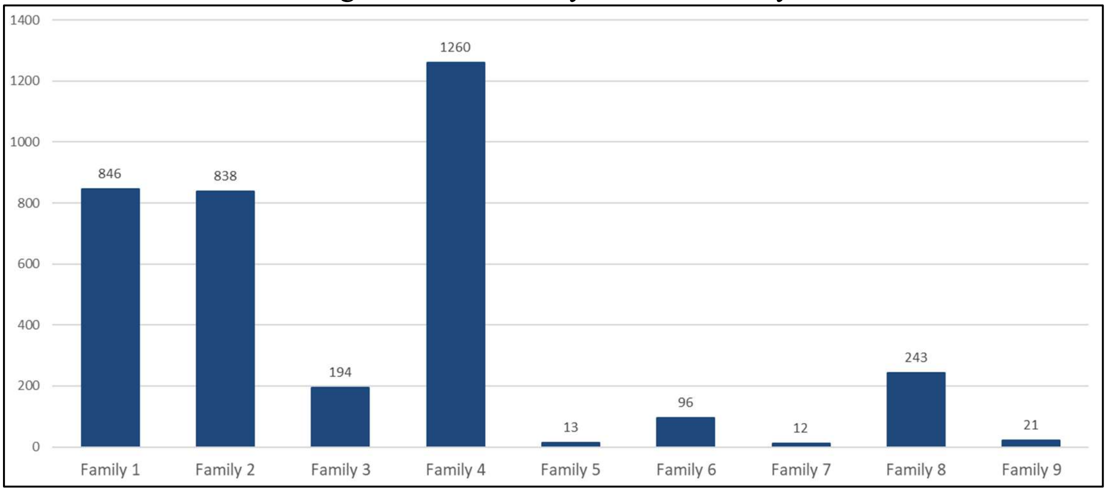
Table 8 – Business Assumption Package

Assumptions	**Responsible**
Business plan	Management
Financial budgets	Financial
MTBF and MTTR	Maintenance
NPI plan	Engineering
OEE	Production Planning and Control
Procurement lead times	Procurement
Promotion campaigns	Marketing
Qualitative market analysis	Sales
Scrap rates	Quality
Service levels	Management
Workforce levels	Human Resources

Source: Created by the author (2020).

Next, historical data was gathered to support the demand planning phase and introduction of statistical forecasting techniques. Sales and product information since 2015 were extracted from the ERP system to unfold the demand evaluation. The SKUs were aggregated into 9 product families, as presented in Figure 19, to provide a cluster visualization of each product group.

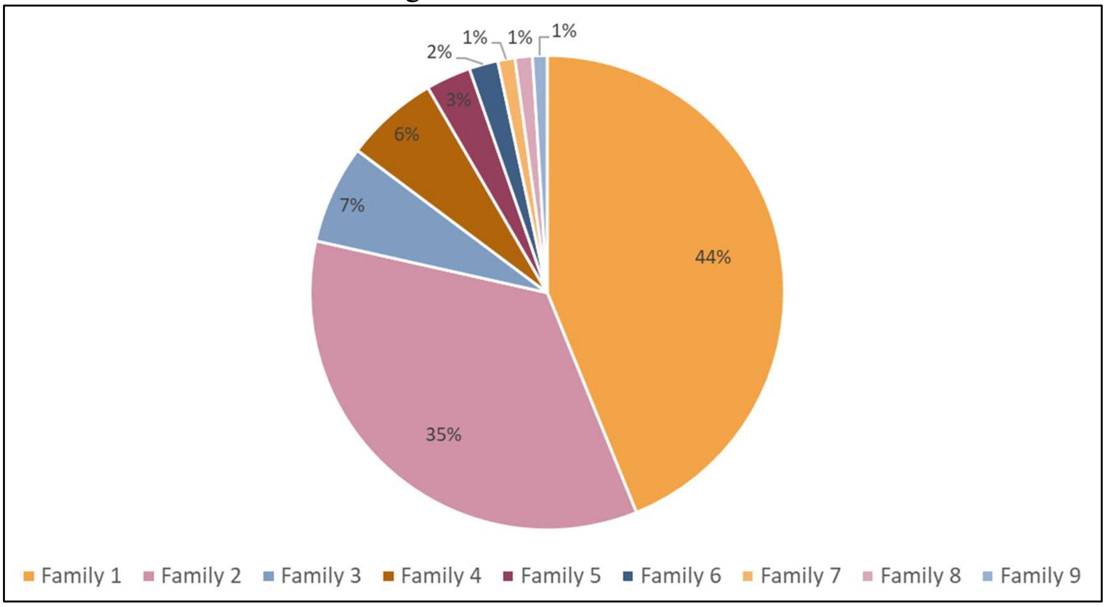
Figure 19 – SKUs by Product Family



Source: Created by the author (2020)

The revenue share of product families was also constructed to provide a classification of each product group relevance in the company's financial results. The family's contribution share is presented in Figure 20.

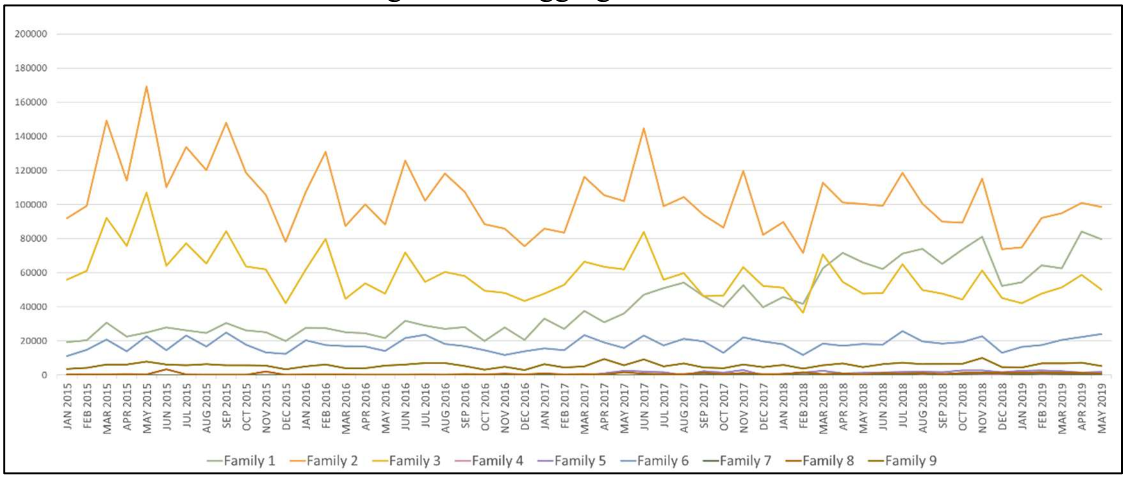
Figure 20 – Revenue Share



Source: Created by the author (2020)

Subsequently, sales time series of SKUs were organized in a database. The data was aggregated and plotted for a macro trend visualization as depicted in Figure 21.

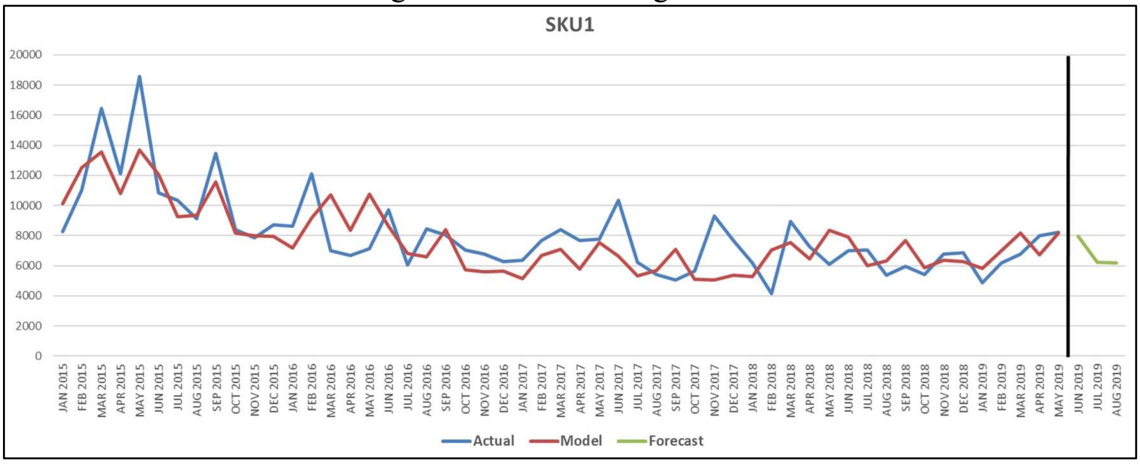
Figure 21 – Aggregate Demand



Source: Created by the author (2020)

Afterwards, forecasting models were applied at the SKU level to generate statistical sales projections. Several forecasting techniques as Exponential Smoothing, Holt-Winters and ARIMA were tested for each product time series. Figure 22 illustrates a forecast model adjustments and projections for a given product.

Figure 22 – Forecasting Models



Source: Created by the author (2020)

Finally, monthly demand planning meetings were established and conducted by the S&OP leader (action researcher), with the goal to create a consensus forecast that integrates demand management, forecasting and NPI inputs. In the meeting format, the statistical forecasts were presented to the stakeholders, followed by a brainstorming session with the evaluation of promotions, qualitative market analysis and NPI ramp-up plans. The process resulted in a sales plan which was deployed into the supply and operational planning stages, explored in the next sections.

4.1.4 Supply Planning

After the formalization of the forecast plan, the supply planning phase was unfolded. The first task of this stage was to establish service levels for each SKU to determine the inventory levels of the system. An assessment of contributions margins, life cycles, order winning criteria and specific business drivers of each product was performed combined with the forecasts generated. Moreover, statistical forecast deviations were compiled for establishing safety stocks levels, as depicted in Table 9.

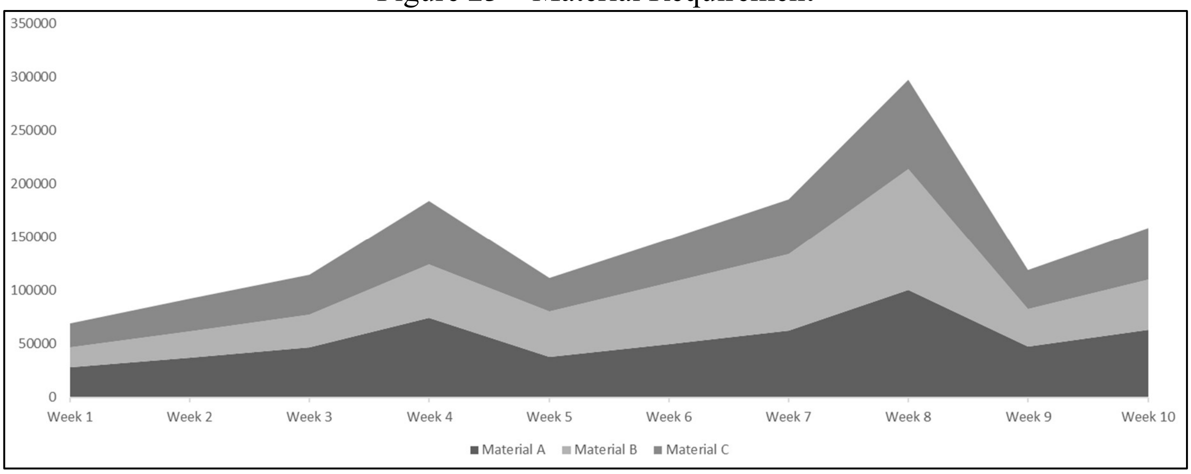
Table 9 – Service Level Agreement

SKU	Family	Service Level	Safety Stock
SKU 1	3	95%	285
SKU 2	2	95%	165
SKU 3	5	95%	92
SKU 4	1	95%	128
SKU 5	2	95%	367
…	…	…	…

Source: Created by the author (2020).

The following step, after the service levels agreement, was to plan the material requirements to meet the targeted inventory levels. The stock profiles of each SKU were inputted into the company`s ERP system for generating an MRP calculation based on the forecast for the planned period. As a result, a detailed bill of material demand aggregation was generated, allowing the inventory replenishment planning. An illustration of material requirement plan is presented in Figure 23.

Figure 23 – Material Requirement



Source: Created by the author (2020)

Those steps granted the formalization of the supply plan for the forecasted period, allowing the kick-start of the operational planning, presented in the next section, to meet the production and inventory levels predicted.

4.1.5 Operational Planning

In the next step, the operational planning phase started. Forecast outputs were evaluated among firmed orders and stocks levels of the system for the development of an MPS for the period. Lot-sizing rules were established for each SKU where several variables as changeover times, inventory holding, and unit costs were reviewed for the calculation. Table 10 depicts the MPS for a SKU in a forecast period.

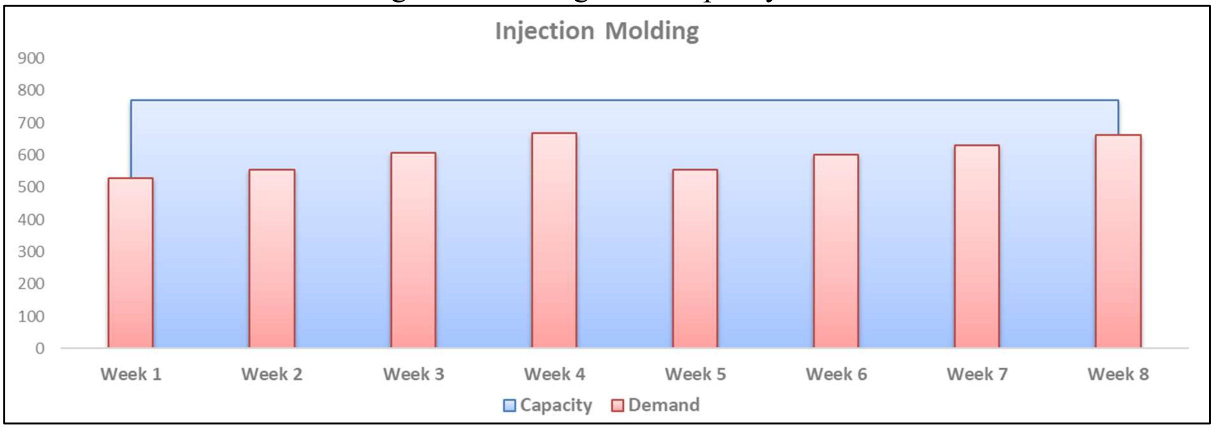
Table 10 – Master Production Schedule

	Planning Horizon							
SKU 1	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Opening Stock	1284	2204	2214	4266	1897	1517	2182	2743
Forecast		1580	1758	3959	380	925	1029	2318
Orders	671							
Safety Stock	285	285	285	285	285	285	285	285
MPS	1590*	1590*	3810	1590*		1590*	1590*	
Final Stock	614	624	456	307	1517	592	1153	425

Source: Created by the author (2020).
*Economic Order Quantity (EOQ)

The following step, after the frozen MPS horizon, was the introduction of the RCCP tool for a capacity evaluation of the manufacturing resources of the company. Several variables were collected to enhance the analysis, as production shifts, workforce levels, scrap rates, OEE, MTBF and MTTR to determine the availability and capacity utilization of each production resources within the planned period, as illustrated in Figure 24.

Figure 24 – Rough Cut Capacity Plan



Source: Created by the author (2020)

Finally, the operational plan was established to act upon bottlenecks and supply constrains identified in the capacity evaluation performed. An executive decision-making meeting was set afterwards to balance the scenarios to formalize the global S&OP plan.

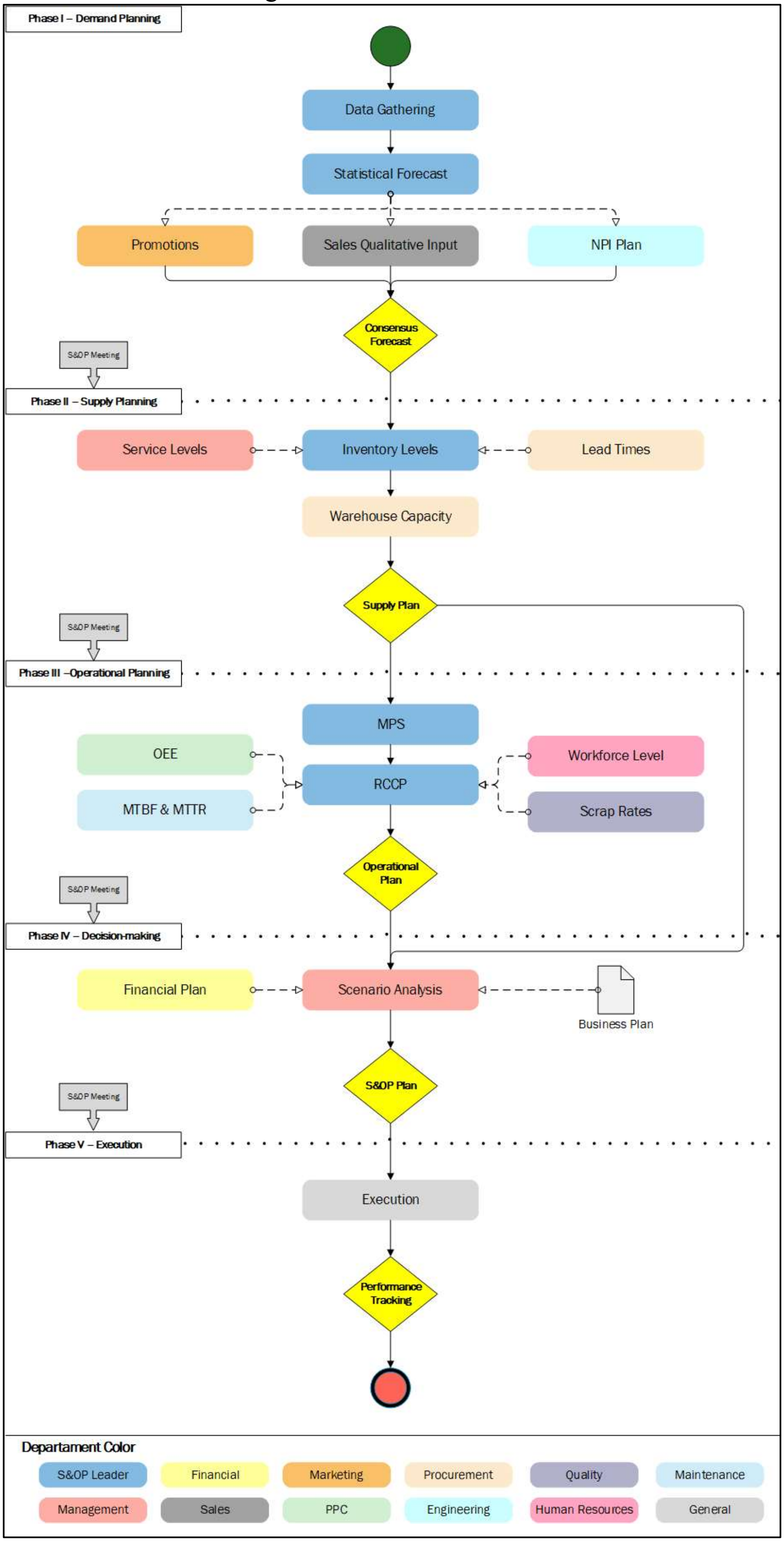
4.1.6 Decision-making

Integrating the demand, supply and operational plans, the next step was performing a managerial decision-making process to assess the outcomes generated in the S&OP planning stages. The purpose of this meeting is to analyze the impact of different scenarios in the financial plans of the company, as well as, the alignment with strategic business driver for core organization growth. As a result, a final global S&OP plan was established and shared throughout the organization for execution and performance tracking.

4.1.7 S&OP Process

The implementation steps were transformed into a cyclic S&OP process to establish a method for maintaining the developed S&OP culture alive in the organization. A workflow chart is presented in Figure 25, contemplating all the steps and tools involved in the planning process. The figure represents the information flow and department responsibilities throughout each stage of the process.

Figure 25 – S&OP Process



Source: Created by the author (2020)

The project started in May of 2019 and took 2 months for the implementation. After the project go-live, the workflow shown in Figure 25 was performed monthly in the organization. The results obtained are discussed in the following section.

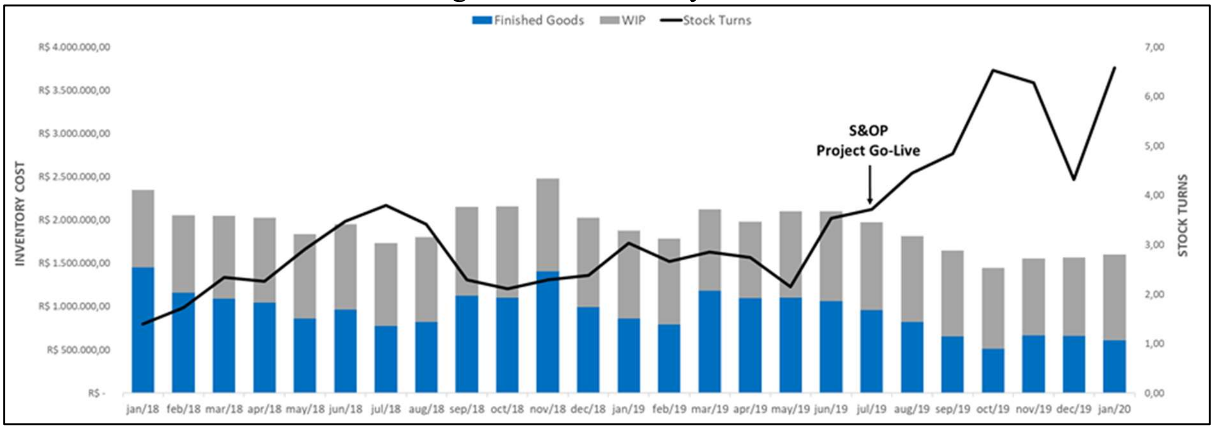
4.2 DATA ANALYSIS

This section approaches the data analysis phase of this research. The evaluation of the method results in the organization is performed in consistency with the core concepts, variables, and relationships of the system, with the purpose of driving conclusions based on the implications of theory and practice. The initial S&OP results are explored in detail in the following subsections.

4.2.1 KPIs Evaluation

Specific metrics were defined together with the S&OP stakeholders to track the performance of the planning process in the organization. For that, monthly meetings were created to assess the evolution of the S&OP throughout the tool development and in taking corrective actions when deviations occurred. The indicators were established based on the data available of the studied system.

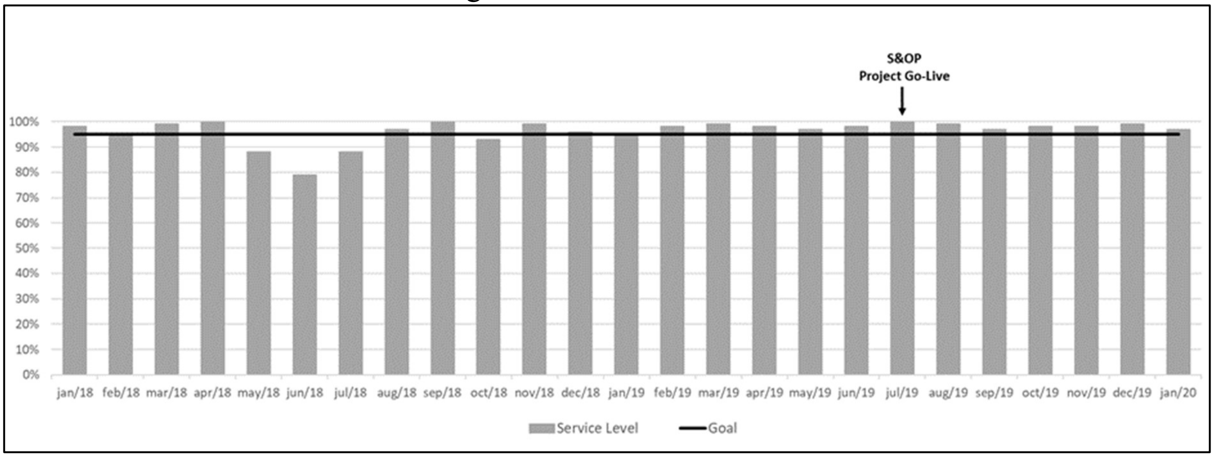
Figure 26 – Inventory Level



Source: Created by the author (2020)

The major KPIs defined to measure the efficiency of the S&OP process in the organization are twofold: inventory levels, presented in Figure 26, and service level of the system, depicted in Figure 27.

Figure 27 – Service Level



Source: Created by the author (2020)

Those two metrics combined present a comprehensive evaluation of the impact of the main goal of the methodology: to balance supply and demand with the lowest use of resource possible. As perceived from the S&OP project go-live, in July of 2019, a significant drop of inventory levels and hence increases of stock turns are depicted in the period, maintaining the desired service level target by the organization.

Table 11 – S&OP Initial Results

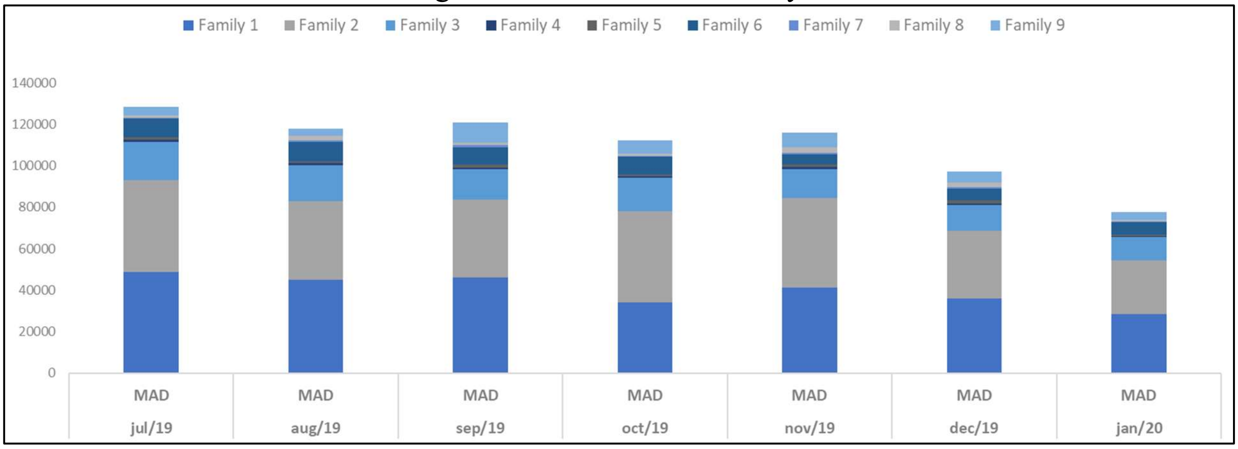
Monthly Average	Before S&OP	After S&OP
Inventory Costs	R$ 2.033.843,88	R$ 1.659.301,72
Stock Turns	2,63	5,25
Service Level	95%	98%

Source: Created by the author (2020).

The results are summarized in Table 11, portraying the before and after S&OP implementation scenario in the organization. In the first 7 months after the project go-live, a monthly average of 18.42% inventory cost reduction was obtained. Stock turns went from 2.63 to 5.25 and service level had a 3% growth from the company’s target of 95%. These quantitative results highlight the effectiveness of the S&OP process, obtaining the firm`s best operational performance in the historical record analyzed.

A monthly forecast accuracy metric was also implemented to track the planning efficiency. The MAD of each product family was compiled to assess the evolution of the S&OP team in forecasting activities. Since the company did not have a forecast process established, the new KPI comparison was based on the month-to-month evolution. The forecast accuracy of the period is presented in Figure 28.

Figure 28 – Forecast Accuracy



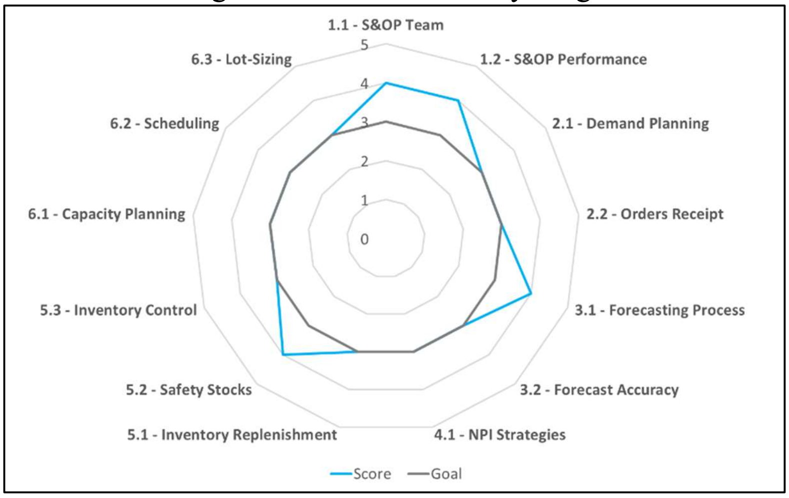
Source: Created by the author (2020)

An evolution of forecast accuracy is perceived in the period after the proper S&OP implementation in the organization. The aggregated forecast accuracy depicted a 40% increase from the initial month. These results are correlated with the inventory levels and service level improvements of the system.

4.2.2 Final Maturity Assessment

After the first 7 months, a new maturity evaluation was performed to identify the efficacy of the implemented actions within the organization. The stakeholders responsible for each department were engaged in the audit process for the reevaluation of the firm's maturity level. The process was performed in February of 2020 and the results are presented in Figure 29.

Figure 29 – Final Maturity Stage



Source: Created by the author (2020)

The final maturity evaluation brought a view of the overall improvement in the S&OP pillars. In comparison with the initial assessment, the new maturity stage is representatively higher in the organization due to the several implementation steps aforesaid taken. For the continuous improvement, a new action plan, presented in Table 12, was created to address the future actions to keep the evolutionary S&OP growth.

Table 12 – New Action Plan

Topic	Current Stage	Actions	Future Stage
1.1 – S&OP Team	**Score 4** • Formal Superordinate Identity S&OP team structure defined • Executive management engagement in the process	• Promote engagement of external supply chain stakeholders within the process	**Score 5** • All of 4+ • External supply chain stakeholder engagement
1.2 – S&OP Performance	**Score 4** • Specific KPIs defined and shared with S&OP stakeholders • Maturity Models are used to track the process • Identification of maturity gaps and definition of stage transitions actions	• Link external supply chain indicator with the S&OP performance	**Score 5** • All of 4+ • External supply chain indicators are linked to S&OP performance
2.1 - Demand Planning	**Score 3** • Centralized formal demand planning process • Routinely scheduled meetings • Defined variables and business assumptions	• Introduce sophisticated IT optimization tools for demand planning	**Score 4** • All of 3+ • Sophisticated tools are used in the demand planning process
2.2 – Orders Receipt	**Score 3** • Orders receipt is integrated to ERP system	• Automate the order receipt into the production and capacity planning system	**Score 4** • All of 3 + • Automated integration with production and capacity planning system
3.1 - Forecasting Process	**Score 4** • Formal forecasting process • Integration with marketing and sales qualitative variables • Sophisticated statistical techniques are used	• Implement Collaborative Planning, Forecasting and Replenishment (CPFR)	**Score 5** • All of 4 + • Collaborative Planning, Forecasting and Replenishment (CPFR)
3.2 – Forecast Accuracy	**Score 3** • Forecast accuracy is tracked and shared in the organization	• Link forecast accuracy to other metrics	**Score 4** • All of 3 + • Forecasting accuracy is linked to other performance metrics (inventory costs, service level, capacity utilization, production costs, profit...)
4.1 - NPI Strategies	**Score 3** • Formal NPI plan is shared • Demand is forecasted for the new launches • Production constrains are evaluated at the development phases	• Introduce sophisticated IT optimization tools for ramp-up planning	**Score 4** • All of 3 + • Sophisticated tools are used for the ramp-up planning process
5.1 - Inventory Replenishment	**Score 3** • Centralized integrated supply chain planning • Inventory is adjusted based on demand projections	• Introduce programming techniques for inventory planning	**Score 4** • All of 3 + • Combination of programming techniques
5.2 - Safety Stocks	**Score 4** • Service level and lead times are defined and updated regularly • Forecasts accuracy and statistical deviations are used when determining safety stock levels	• Introduce sophisticated IT optimization tools for establishing safety-stock levels	**Score 5** • All of 4 + • Sophisticated models are used

5.3 – Inventory Control	**Score 3** • ERP integration • First in first out (FIFO) plan • Documented process for managing expiration dates	• Implement real time inventory control • Track inventory accuracy of the system	**Score 4** • All of 3 + • Real-time inventory data is available • Inventory accuracy is tracked regularly
6.1 - Capacity Planning	**Score 3** • Rough Cut Capacity Planning (RCCP) is used • Capacity Utilization is monitored	• Implement IT system for generating feasible capacity plans	**Score 4** • All of 3 + • IT Systems are used for generating capacity plans
6.2 - Scheduling	**Score 3** • Master Production Schedule (MPS) is defined • Scheduling rules are applied and documented	• Implement programming techniques	**Score 4** • All of 3 + • Combination of programming techniques
6.3 - Lot-Sizing	**Score 3** • Lot-sizing approaches are documented • Constrains are defined and updated regularly	• Implement programming techniques	**Score 4** • All of 3 + • Combination of programming techniques

Source: Danese, Molinaro and Romano (2017)

In the first stage, the S&OP implementation was a breakthrough in the organization culture, laying the foundation of the planning process with core tools and process formalization. From this point, a new phase of optimization is suggested with the introduction of sophisticated tools and process automation. The new action plan provides the next steps to be taken by the organization to leverage the results and to keep the improvement motion.

5 CONCLUSIONS

The aim of this research was to develop a systematic for the S&OP implementation in an automotive company. Due to the firm's market positioning, the goal was to improve the organization results throughout optimal resource allocation. The S&OP has been proven an elementary process in the supply and operational planning of the organization, with the ability of generating reliable future scenarios for making decisions at the operational, tactical, and strategic levels.

To meet the main research goal, four specific objectives were set. The first one, to identify the best set of tools for the S&OP implementation, had the purpose of providing a comprehensive analysis of specific tools in the literature. This objective was achieved with the insights obtained from the systematic review performed. Three hundred and sixty-eight papers were analyzed, where 42 articles were selected to synthesize a set of tools for the S&OP implementation. A S&OP tools framework was presented, categorized in six pillars: Demand Management, Forecasting, Human Resources, New Product Introduction, Supply Chain Management and Tactical Planning, providing a foundation for developing the S&OP implementation systematic in the researched environment.

The second objective was to create a systematic for the S&OP implementation. For achieving this goal, a six-step method was proposed: maturity evaluation, team development, demand planning, supply planning, operational planning and KPIs evaluation. Those steps were established based on the pillars of the S&OP tools framework aforesaid, with the support of the specific tools in each step, allowing the deployment of the S&OP implementation in the real studied context.

Afterwards, the next objective was to implement the S&OP process in the organization. Initially, a maturity evaluation model was created for identifying the company's current state of the planning process. An action plan was defined for addressing the gaps and stage transitions actions of improvement. Subsequently, a multidisciplinary team was established with 17 stakeholders to sustain the organizational core change. A formal S&OP process with several specific tools was established, enhancing the effectiveness of the demand and supply balancing process in the organization, fulfilling completely the third objective proposed.

Finally, the evaluation of the S&OP results in the researched environment was the last objective achieved. Specific metrics were defined to measure the real impact of the proposed method in the organization. Seven months after implementation, an 18.42% of inventory cost reduction, followed by an increase of 3% in the service level was portrayed. Forecast accuracy also depicted a 40% growth in the period. A revaluation of the maturity level was later performed, illustrating the overall company's growth in every S&OP pillar. Furthermore, a new action plan was established for following the continuous improvement steps in the organization.

In the practical aspect, the S&OP process depicted expressive results in the company, fulfilling the general objective established. The projected scenarios granted useful data for planning ahead, streamlining inventory costs of the system while still maintaining the desired service level by the organization, guaranteeing monetary gains, and improving the cash flow of the company. In the theorical side, two significative contributions are identified, first, the S&OP tools framework, which presents a categorization of the tools and their correlation to specific metrics and pillars, to solve problems in real contexts. The other contribution is the maturity evaluation model, which provides a structured model based on the tools and pillars defined in the literature review, to identify organization`s maturity levels and to highlight benchmarks among industries and sectors.

Despite the results obtained, limitations are identified in this research. The implementation systematic as well as the maturity evaluation model proposed are new literature contributions, created throughout the development of this work. Therefore, they are not validated in any different industry environment. Another limitation is in the researched context, in which the proposed actions were unfolded in regards of the variables and constrains of the system. As the company depicted a low initial maturity level, the actions proposed, tools introduced, team learning strategies and leadership style of the action researcher were adapted to the environment to face the barriers identified throughout the S&OP implementation.

With the success obtained from the objectives proposed and the limitations identified, future field for new research is evident. A cross-industry survey for the validation of the S&OP implementation systematic and the maturity evaluation model is a suggestion to provide benchmarks of the S&OP maturity in different sectors. The evolution of the tools dedicated to the human resources pillar within the S&OP process is also a suggestion for future research. Furthermore, the exploration of a new pillar with advanced technologies applications in SCM as big data, artificial intelligence, machine learning, IoT and other digital solutions is a suggestion for a new line of research. Besides, the practical evolution of the S&OP in the researched context with the introduction of sophisticated tools in an optimization phase is also a suggestion to further evaluate the full potential of S&OP in the organization.

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ANNEX A – S&OP MATURITY MODEL

#	Topic	Questions	Scoring Criteria				
			1	2	3	4	5
1	**Human Resources**						
1.1	**S&OP Team**	*Does your company have a specific team to ensure the capacity to meet future customer demands?*	There is no team to plan demand and supply operations No collaboration between departments	Only an informal team for the decision-making process exists Occasionally meetings to plan demand and supply matches	A formal S&OP team is defined Clear roles and stakeholders defined Routinely scheduled meetings	All of 3 + S&OP Superordinate Identity team Executive management engagement in the process	All of 4 + External supply chain stakeholders engagement
1.2	**S&OP Performance**	*How do you evaluate the S&OP performance in your organization?*	No methods are used to evaluate the S&OP process	Functional metrics are tracked isolated but S&OP performance is not measured	Specific KPIs are defined and shared with S&OP stakeholders	All of 3 + Maturity models are used to assess the process maturity Action plans are established for continuous improving S&OP dimensions	All of 4 + S&OP performance is linked with external supply chain partners S&OP globally shared KPIs are defined and tracked
2	**Demand Management**						
2.1	**Demand Planning**	*How is your future market demand behavior planning process?* *How is the overall demand and supply chain balancing process in your organization?*	No formalized planning process No collaboration between departments	Informal decentralized process Low collaboration between departments Occasionally meetings to plan future demand	Centralized demand planning process Routinely scheduled meetings Variables and business assumptions defined Tools: Business Assumption Packages (BAP) Demand Management Organization (DMO)	All of 3 + Sophisticated tools are used Tools: Kriging Metamodels Linear Programming Model (LP) Nested booking limits (NBL) Simulation-optimization Stochastic programming	All of 4 + Process is performed together with supply chain players Global plan is shared with whole supply chain
2.2	**Orders Receipt**	*How do you receive purchasing orders from your clients?* *How do you manage the orders into your production planning system?*	Manual process to receive customers orders	Orders receipt is electronically but a manual process is performed to input into the ERP system	Orders receipt is automatically integrated to the ERP system Tools: Electronic Data Interchange (EDI)	All of 3 + Order receipt is automatically integrated with MRP/ production schedules (MPS) Tools: IT Systems	All of 4 + External real time updated information Tools: Point of Sales (PoS)

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 only on human judgment	Formal forcasting process Integration with marketing and sales qualitative variables Tools: Forecasting Management Competence (FMC) Forecasting support system (FSS)	All of 3 + Statistical forecasting techniques are combined with human judgment Tools: ARIMA Single Exponential Smoothing (SES) Backpropagation Neural Network (BPNN)	All of 4 + External supply chain collaboration in joint forecasting activities Collaborative Planning, Forecasting and Replenishment (CPFR)
3.2	**Forecast Accuracy**	*How do you monitor your forecast accuracy?*	Forecasting accuracy is not tracked	Forecasting accuracy is monitored Metrics are only shared with employees upon request	Forecast accuracy is tracked and shared at the organization	All of 3 + Forecasting accuracy is linked to other performance metrics (inventory costs, service level, capacity utilization, production costs, profit...)	All of 4 + Forecasting accuracy is linked to external supply-chain metrics
4	**New Product Introduction**						
4.1	**NPI Strategies**	*How do you plan new products introduction into your production?* *How is the demand ramp-up process managed in your organization?*	No new product introduction plan or process exists	Informal NPI plans exist but strategy is not documented	Formal NPI plan is defined Demand is forecasted for new launches Production constrains are evaluated at the development phases	All of 3 + Sophisticated programming tools are used for planning the ramp-up process Tools: Simulation-optimization Mixed-integer Linear Programming (MILP)	All of 4 + Real time customers information integration Tools: IT Systems Point-of-sales (PoS)
5	**Supply Chain Management**						
5.1	**Inventory Replenishment**	*How do you plan your inventory replenishment process?*	Manual process to plan the inventory replenishment process (spreadsheets)	Automated planning system Reorder point (ROP) defined for each SKU Historical data available Tools: IT Systems	All of 2 + Centralized integrated supply chain planning Inventory is adjusted based on demand projections Service level and logistical costs are monitored	All of 3 + Programming techniques are used to plan inventory replenishment Tools: Mixed-integer Linear Programming (MILP) Mixed-integer Programming (MIP) Hybrid heuristics Stochastic Programming	All of 4 + Sophisticated models are used Tools: Simulation-optimization

5.2	**Safety Stocks**	*How do you determine inventory safety stocks levels?*	No metrics or rules are documented for establishing safety stocks Safety stocks levels are determined based only on human judgment	Safety stocks are determined based on historical data Linear parameters are established for product families	Service level and lead times are defined and updated regularly Documented strategies at SKU level Automated planning system Tools: IT Systems	All of 3 + Programming techniques are used Forecasts accuracy and deviations are contemplated when determining safety stock levels Tools: Mixed-integer Linear Programming (MILP) Linear Programming (LP)	All of 4 + Sophisticated simulation models are used Tools supporting evidence: Simulation-optimization Stochastic Programming
5.3	**Inventory Control**	*How do you control your inventory?*	General storage area Inventory control is disaggregated Inventory accuracy is not tracked	Centralized stock areas Storage locations defined for each SKU ERP integration	All of 2 + First in first out (FIFO) plan Documented process for managing expiration dates Inventory accuracy is monitored	All of 3 + Automated planning system Storage space constrains are established Tools: Warehouse Management Systems (WMS)	All of 4 + Real-time data is available
6	**Tactical Planning**						
6.1	**Capacity Planning**	*How do you plan and quantify your production capacity?* *How do you evaluate forecasted demand scenarios into your production constrains?* *How do you identify when projected demand exceeds production capacity?*	No capacity planning is performed Production orders are released to production site without any capacity evaluation	Capacity is measured for critical process by parts units (for instance: parts/hours, hours/month, etc) Manual process to plan the capacity (spreadsheet)	Capacity is measured and planned for all resources Manufacturing cycle times and routings are updated regularly Capacity Utilization is monitored Tools: Rough Cut Capacity Planning (RCCP) IT Systems	All of 3 + Programming techniques are used for generating feasible capacity plans Tools: Mixed-integer Linear Programming (MILP) Linear Programming (LP)	All of 4 + Sophisticated simulation models are used. Computation time is monitored regularly Tools: Simulation-optimization Stochastic Programming
6.2	**Scheduling**	*How do you schedule your production orders?*	No production schedule is defined	Production schedule is defined based only on human judgment Manual process to develop schedule (spread sheet) No scheduling rules documented	Master production scheduled is integrated with ERP/MRP system Scheduling rules are applied and documented Tools : Master Production Schedule (MPS) IT Systems	All of 3 + Programming techniques are used for generating feasible schedules Planning Efficiency is monitored Tools: MILP Stochastic Programming Heuristics	All of 4 + Advanced Planning Systems are used Production execution is monitored in real time Changes to schedules deviations are managed fast Tools: Advanced Planning and Scheduling (APS)
6.3	**Lot-Sizing**	*How do you define your production lot-sizes?* *How do you deal with 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 Constrains are defined and updated regularly ERP/IT integration	All of 3 + Programming techniques are used for stablishing lot-sizes Tools: Mixed-integer linear programming (MILP)	All of 4 + Sophisticated simulation models are used. Computation time is monitored regularly Tools: Simulation-optimization Stochastic Programming