Systemic Practice and Action Research (2023) 36:755–782
https://doi.org/10.1007/s11213-022-09627-7

ORIGINAL RESEARCH

Challenges of Implementing S&OP in a Mid-sized Automotive Components Company: An Action Research Approach

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Accepted: 5 December 2022 / Published online: 20 December 2022

Abstract
The purpose of this paper is to present an action research (AR) study of the Sales and Operations Planning (S&OP) implementation in a mid-sized automotive components company located in Brazil. This study provides a detailed empirical exploration of the S&OP implementation steps, challenges and results obtained in the researched context. An AR method was adopted in this work, seeking: (1) to find effective solutions to the dynamics of the specific context faced during the S&OP implementation, and (2) to promote large-scale changes through the engagement of the company and the researcher in the problem. The S&OP implementation presented significant results in the organization, streamlining inventory, and maintaining the service level desired by the company. The reactivity of the S&OP process also led to a quick adaptation to the COVID-19 challenges, which stands out in the operational key performance indicators (KPIs) analyzed in the period. This work contributes to theory and practice by reporting in-depth empirical research on S&OP implementation and its benefits. Practitioners and researchers can benefit from this research by understanding the best practices, challenges, and potential outcomes of implementing S&OP.

Keywords Sales and Operations Planning · S&OP · S&OP implementation · Action research

Introduction

S&OP is a coordinated business process that aims to achieve financial and marketing goals by balancing demand with supply capabilities. Through a series of meetings and activities, the S&OP process brings together all plans from sales, marketing, development, procurement, manufacturing, and finance departments into an integrated plan that links strategic with tactical levels (Thomé et al. 2012; Tuomikangas and Kaipia 2014). This cross-functional alignment is critical to providing organizations with a competitive advantage based

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on market-oriented supply chain management and a resource-based approach. This article presents an AR approach for implementing S&OP where significant operational and financial results were obtained in the researched context, further corroborating the value of its potential benefits for organizations.

The S&OP theme emerged from early aggregate production planning (APP) practices in the pioneering work of Holt, Modigliani, Muth and Simon in the 1950s, to manufacturing resource planning (MRP) in the mid-1980s, making the transition to an integrated business planning process that aligns different pillars of the organization's supply chains (Thomé et al. 2012). Based on the company's intrinsic need to adapt to rapidly changing conditions, the emergence of S&OP resulted in major improvements in traditional production planning and control paradigms (Olhager 2013).

In recent years, there has been an upward trend in publications and the development of the S&OP literature. This growing trend is reflected in the academic and professional fields, with the highest rate of publications occurring after 2010 (Tuomikangas and Kaipia 2014; Kristensen and Jonsson 2018). At the same time, there is also a solid body of knowledge provided by several relevant works in the literature, indicating a high level of maturity on the subject.

The S&OP implementation benefits on organizational performance have been evaluated by several surveys, highlighting the S&OP positive impacts across different ranges of operational performance. From a large sample of organizations around the world, Thomé et al. (2014) developed a research-based study, evaluating the impact of S&OP practices in different markets and company sizes, showing the S&OP key influence in manufacturing performance in terms of quality, flexibility, and delivery. Likewise, relevant empirical case studies such as Ivert and Jonsson (2010), Oliva and Watson (2011), Nemati et al. (2017), and others derived from mathematical modeling approaches (Feng et al. 2008; Chen-Ritzo et al. 2010; Hahn and Kuhn 2012; Lim et al. 2017) endorse the positive effects on the performance of organizations. However, there is still a need for further research on S&OP implementation and its benefits in different contexts (Rexhausen et al. 2012; Thomé et al. 2014; Tuomikangas and Kaipia 2014; Kristensen and Jonsson 2018).

To address this research opportunity, the purpose of this study is to report a detailed action research study of the S&OP implementation process in a mid-sized automotive company located in Brazil. This article is structured in five sections. After the introduction, "Context Description" section presents the specific context of the company under study. Next, "Research Method" section presents the research method adopted, followed by the results and main empirical findings discussed in "Results (Evaluating Action)" section. Finally, the conclusions are presented in "Summary and Conclusions" section.

Context Description

The mid-sized company under study is a components supplier for the automotive industry, specifically for heavy vehicles (buses, coaches, trailers, and agricultural tractors), located in Brazil. Its market share is balanced between the aftermarket and Original Equipment Manufacturer (OEM) markets, currently with a product portfolio divided at approximately 60 and 40 percent, respectively. Positioned in two niches with different demands, the organization requires a high degree of technology and quality control in its production system in order to meet the demands of its customers. Also, from a different perspective, it requires

flexibility, productivity and, above all, efficiency to assure the order-winning criteria in the aftermarket. Hence, the company needs a hybrid strategic position in this market context.

To compete in the aftermarket, the company has a broad product portfolio with short delivery times. Due to this manufacturing strategy, the organization has high levels of inventory in its manufacturing process. Conversely, the company also depends on intrinsic renewal and the launch of new products to capture new demands and business opportunities from OEM customers and potential markets. The Research and Development (R&D) department is extremely valuable in the current context, with New Product Development (NPD) being one of the organization's main business drivers.

The company`s strategic context is portrayed in Fig. 1. A trade-off regarding the company's positioning can be identified in the presented context. In one market, the organization needs investments in tools and new technologies, demanding cash flow in the development, validation and launch of new products. On the other hand, it requires financial resources for manufacturing and supply chain effectiveness, thus raising challenges in allocating resources to meet both markets drivers. In this context, the S&OP process has the potential to provide greater cash flow availability, maintaining the desired service level with the least possible use of resources, leveraging the operational and financial performance of the company under study, as already observed by Thomé et al. (2014) and Wagner et al. (2014).

Research Method

This study is classified as an action research (AR), which can be described as a systematic approach that allows people to find effective solutions to the problems they face in their everyday lives. It is based on the proposition that generalized solutions may not fit in all contexts, therefore, its real objective is to find a suitable solution for contexts of 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).

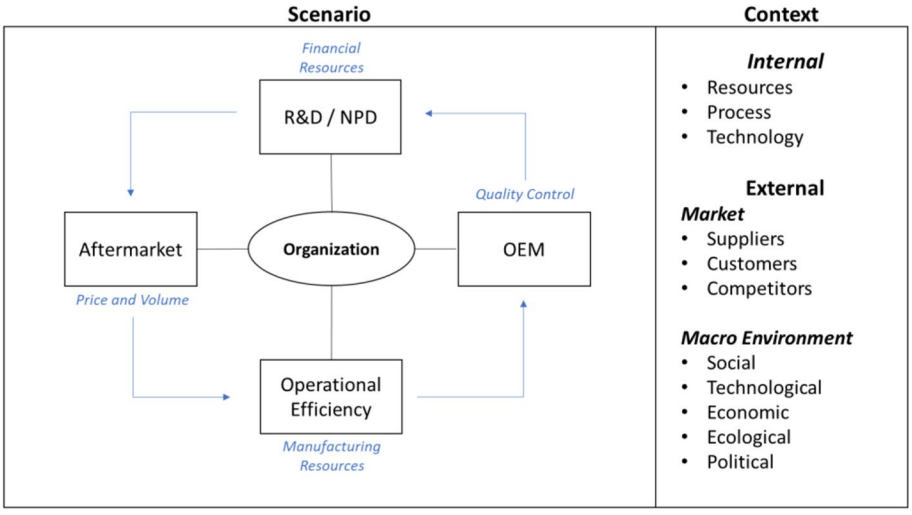

Fig. 1 Strategic context framework

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

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

For AR implementation, Coghlan and Brannick (2005) propose a three steps cycle: (i) pre-step – to understand the context and purpose; (ii) main steps – diagnosing, planning action, taking action, and evaluating action; and (iii) a meta-step to monitor each cycle.

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), researchers should always aim at practical knowledge, as the critical feature of AR is how you can learn about yourself and how you can shape the quality of your actions at any given moment. The authors present a four activities cycle for learning during an action research: Experiencing, Reflecting, Interpreting and Taking Action, incorporated into each main step of implementation to ensure hands-on learning at each step, as illustrated in Fig. 2.

AR 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 research can take, depending on the system and the researcher's commitment to learning in action. As a central topic of their book, this framework illustrates how members may undertake action research in their organizations.

Figure 3 presents the four quadrants framework proposed by Coghlan and Brannick (2005) to classify any action research. Each quadrant reflects the outcome depending on the focus reflected by the system and the researcher's commitment. In this classification, this research is located in the fourth quadrant, meaning that both, the company (system)

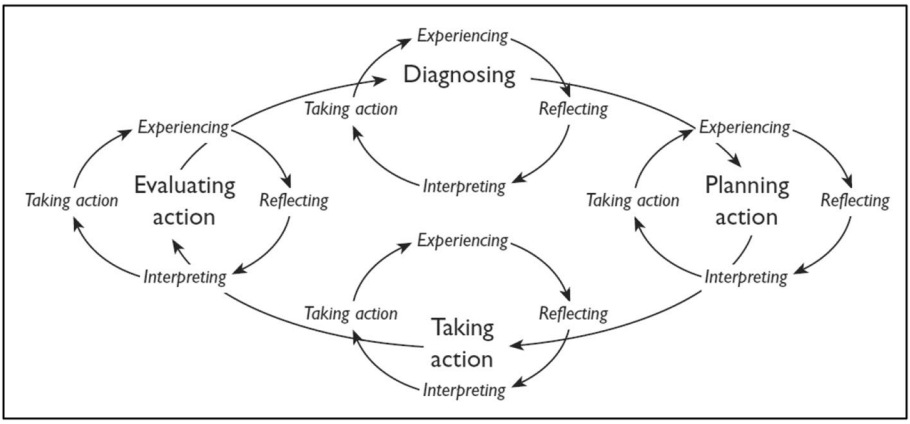

Fig. 2 Learning cycle. Source: Coghlan and Brannick (2005)

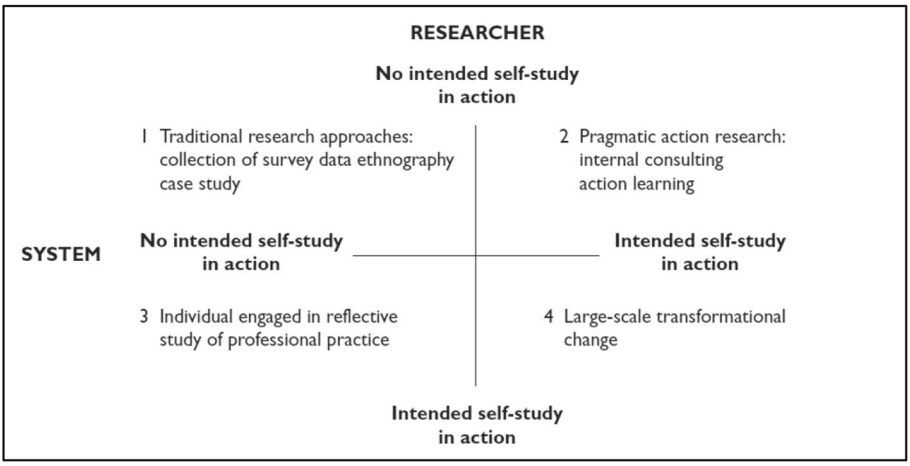

Fig. 3 Focus of researcher and system. Source: Coghlan and Brannick (2005)

and the researcher are engaged in an intended self-study in action seeking to promote large-scale transformational change.

Research Design

The adoption of AR in this research was due to two main factors. First, as the goal was to promote large-scale organizational change through the S&OP implementation, AR was considered the most suitable approach to conduct the empirical investigation and to direct the actions to promote the desired changes in the system. Second, as the first author of this paper was previously involved in the organization, the AR approach was also perceived as a method that could be extremely valuable for promoting the desired changes in the system due to the researcher's prior understanding of the organization's culture and values. Within this context, this research was designed based on the previously mentioned AR steps. A structured approach was defined to achieve the goal of this work, while addressing the expected challenges and cultural resistance of the system under study. The final research process is presented in Fig. 4.

After defining the purpose and having a deeper understating about the context under study, AR was defined as the research method and the data type, collection and analysis used in this work were described. Then, in the following sections, the main AR steps (diagnosing, planning action, taking action, and evaluating action) performed on the system are explored in depth. The following sections highlight in detail the actions taken, results and challenges faced by the researchers during the S&OP implementation process in the system. Subsequently, conclusions based on observations and findings are presented and discussed.

Data Type, Collection & Analysis

A qualitative approach was used to conduct this research. This approach was selected to support the empirical investigation of the S&OP implementation process in the automotive components company as the unit of analysis of this research. The data type can be

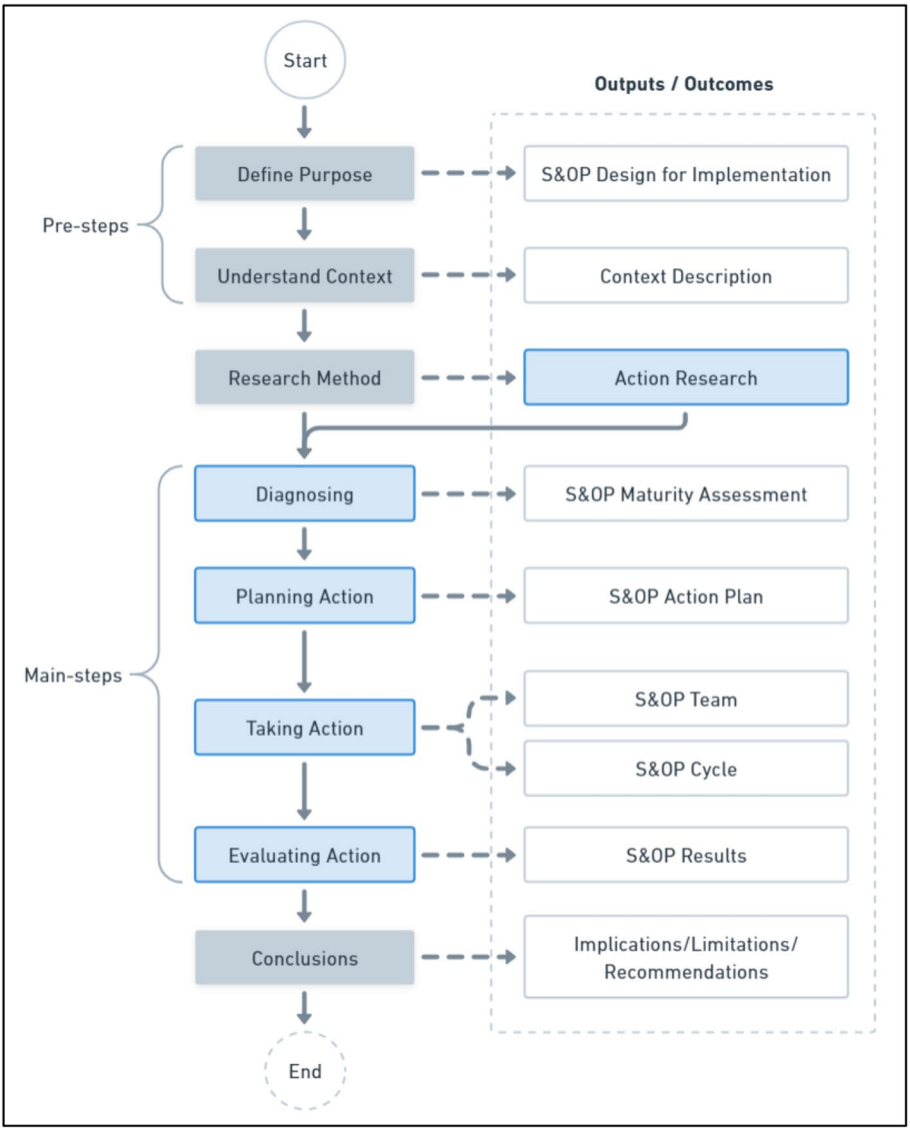

Fig. 4 Research design

classified as primary as it was generated by the researchers through multiple interviews and participant observations to understand the system and achieve the research purpose (Myers 2013).

Data collection began in May of 2019 and lasted 27 months, until the end of the AR cycle. During this period, several interviews, meetings, and brainstorming sessions were held across the organization throughout the various stages of the S&OP implementation and post-implementation evaluation. The project began with a kick-off meeting where the S&OP concept was presented. The head of each department involved in the organization's

supply and demand process attended this event. In total, 13 stakeholders participated, including the board of directors. The same stakeholders were later interviewed in the diagnosing step of the AR approach. Later, during the project development, the data was collected through observations of the action researcher, who was actively on site throughout the AR process.

Data analysis was performed through a constant comparison and revision of the multiple sources of data collected during the extensive period analyzed. This approach allowed the researchers to triangulate data based on the evidence collected, while addressing contextual issues identified at each AR step. This data analysis procedure, based on active observations and constant comparison from within the system, provided a valid and reliable approach to capture and understand the reality of the researched context (Voss et al. 2002; Barratt et al. 2011; Moghadam et al. 2021).

Diagnosing

In the first action research step, a system diagnosis was performed to identify the organization's initial S&OP maturity level. To this end, the S&OP maturity model presented in Appendix 1 was used. The model was created by the authors in 2020, during the research process, and is the result of AR's intended self-study engagement and learning in action components, as noted by Coghlan and Brannick (2005). The model covers six S&OP pillars (Human Resources, Demand Management, Forecasting, New Product Introduction, Tactical Planning and Supply Chain Management), in which 13 specific S&OP dimensions are unfolded. Using a five-stage maturity scale that represents evolutionary boundaries based on the presence of tools, processes and metrics of each S&OP dimension stage, the model serves as a structured assessment guide to assess the maturity of an S&OP process in a system. The model development and its complete explanation can be found in detail in Rampon Neto et al. (2022).

The assessment audit carried out in the organization was conducted by the action researcher in May of 2019 and took 2 days to complete. Several participants from different departments were involved in a set of semi-structured interviews to capture in detail the initial state of the system. The results are depicted in Fig. 5. The graph illustrates the score for each S&OP dimension in the model, based on observations and data collected by the researcher.

The initial maturity assessment process provided insight into the company's strengths and weaknesses in each S&OP pillar. As illustrated in Fig. 5, overall, the organization showed 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 and the involvement of executives in the planning process were the main shortcomings of the initial 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 no formal S&OP planning process in place. Some collaboration between departments is demonstrated, but only informal meetings take place without a defined schedule to plan demand and supply operations. In the same pillar, the company presented an online order receiving system integrated with the Enterprise Resource Planning (ERP) system to manage the receipt of orders. In Forecasting, the lack of a structured process is the main gap identified. Sales projections are generated only based on historical moving averages of demand, automatically calculated by the ERP system. Forecast accuracy is also not tracked. In the New Product Introduction (NPI) pillar, as it is positioned in the automotive

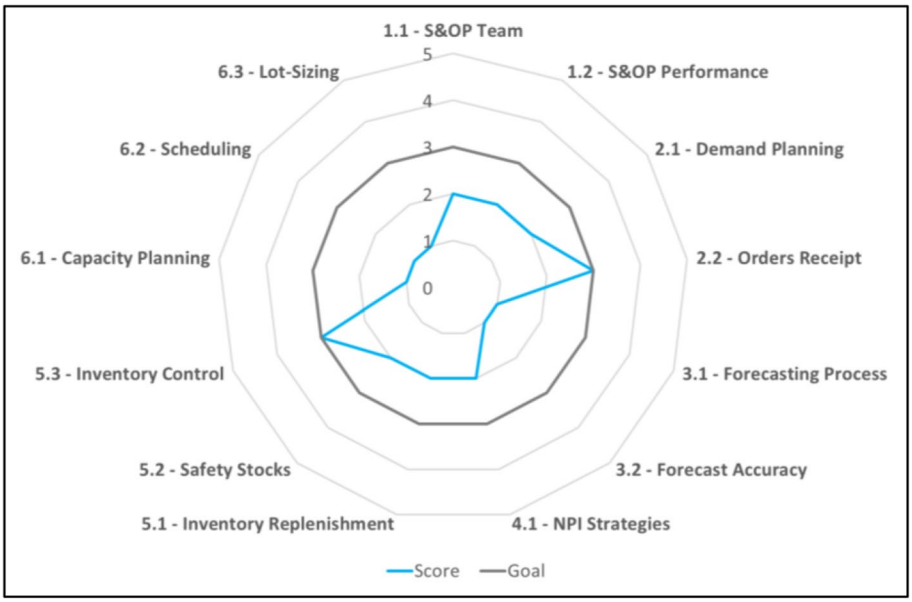

Fig. 5 Initial maturity stage

market, the company presented a solid methodology for the development of new products. An annual NPI plan is defined with projected demand, however no operational constraints assessment is performed for a holistic view of capacity. With regard to Supply Chain Management, the company has an automated inventory replenishment process controlled by the ERP system, but there are no projections of future demands integrated into the planning. Safety stocks are calculated based on linear historical demand patterns, with no defined service levels and lead times. The company scored 3 points in inventory control as it has a centralized warehouse system with ERP integration and a documented *First In, First Out* (FIFO) plan. The Tactical Planning pillar had the lowest score, with several gaps identified, as the lack of capacity planning and scheduling techniques. Infinite-capacity MRP logic is used to generate production orders, which are released to the production site without a defined production schedule. Production batch-sizes are parameterized into the ERP system; however, they are based on human judgment only, therefore batch-sizing approaches are not documented.

Planning Action

In the second action research step, the findings of the system diagnosis through the use of the S&OP maturity model made it possible to define a set of actions necessary to bridge several S&OP gaps in the organization. The result was the creation of the action plan, presented in Table 1, to guide the S&OP implementation steps in the organization. The first information presented in the current stage column is a summary of the researcher's perceptions of the initial maturity level of the system based on the use of the S&OP maturity model. The actions column then describes the specific actions defined for each S&OP dimension as a roadmap of tools, processes, and metrics deemed necessary for the proper

Table 1 S&OP action plan

S&OP dimension	Current stage	Actions	Future stage
1.1 – S&OP Team	**Score 2** • The company does not have a formal S&OP team • There is only an informal team to make decisions • Lack of executive management engagement in the process	• Create a multidisciplinary S&OP team • Define roles and responsibilities • Promote the involvement of executive management in the process	**Score 3** • Formal S&OP team • Clear roles and defined stakeholders • Executive management engagement in the process
1.2 – S&OP Performance	**Score 2** • The company does not have any method to evaluate the performance of the planning process • Isolated metrics are tracked but not integrated into the planning process • S&OP performance and maturity level are not known	• Define specific metrics to track the planning process performance • Establish stakeholders feedback meetings to share 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** • There is only an informal decentralized demand planning process • No routine scheduled meetings • 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
2.2 – Orders Receipt	**Score 3** • Order receiving is integrated into the ERP system, but no capacity assessment is performed	• No action has been defined at this stage	**Score 4** • -

Table 1 (continued)

S&OP dimension	Current stage	Actions	Future stage
3.1 – Forecasting Process	**Score 1** • Sales projections are generated only based on ERP historical values (moving average)	• Create a forecasting process • Integrate quantitative projections with qualitative marketing information • Introduce statistical forecasting techniques	**Score 3** • Formal forecasting process • Integration with qualitative marketing variables
3.2 – Forecast Accuracy	**Score 1** • Forecast accuracy is not tracked across the organization	• Create a forecast accuracy indicator	**Score 3** • Forecast accuracy is tracked and shared across the organization
4.1 – NPI Strategies	**Score 2** • The organization has a formal defined annual NPI plan • Demand is projected at early stages of development, but operational constraints are not assessed	• Integrate the NPI plan into the S&OP cycle to evaluate NPI forecasts against operational constraints	**Score 3** • The formal NPI plan is shared • Demand is forecast for the new launches • Production constraints are evaluated in the development phases
5.1 – Inventory Replenishment	**Score 2** • The company has an automated inventory replenishment reorder point (ROP) in the ERP system • Inventory levels are calculated based on historical values only (moving average) • Sales projections are not assessed in the planning process	• Establish an integrated supply chain planning • Integrate sales forecasts into the planning system	**Score 3** • Integrated supply chain planning • 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 stock keeping unit (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

Table 1 (continued)

S&OP dimension	Current stage	Actions	Future stage
5.3 – Inventory Control	**Score 3** • ERP integration • FIFO plan • Documented process for managing expiration dates	• No action has been defined at this stage	**Score 4** • -
6.1 – Capacity Planning	**Score 1** • No capacity planning is performed • Infinite MRP capacity logic is used to generate orders	• Implement Rough Cut Capacity Planning (RCCP) • Track capacity utilization	**Score 3** • RCCP is used • Capacity Utilization is monitored
6.2 – Scheduling	**Score 1** • No production schedule is defined • Lack of scheduling rules	• Implement Master Production Schedule (MPS) • Define scheduling rules	**Score 3** • MPS is defined • Scheduling rules are applied and documented
6.3 – Lot-Sizing	**Score 2** • Lot sizes are parameterized in the ERP system • Production batches are defined by human judgment	• Establish lot-sizing approaches • Define and update production constraints for calculation	**Score 3** • Lot sizing approaches are documented • Constraints are defined and updated regularly

Source: Adapted from Danese et al. (2017)

S&OP implementation in the organization. Finally, the future stage column presents the desired vision for the system as a result of the actions defined for the proper maturity level.

Due to several gaps identified, only S&OP dimensions with a score of less than 3 were addressed in the implementation stage, leaving two dimensions: order receipt and inventory control for a second improvement transition stage when the organization's overall maturity level increases.

Taking Action

In the third step, the defined actions were performed in the system. The execution strategy was tailored based on the maturity level of the researched context. The action researcher acted as project manager in the organization. To conduct the process, the implementation guidelines also presented in Rampon Neto et al. (2022) were followed as the general approach. The following subsections detail the actions performed and the results in the system under study.

Team Development

The first action was to develop an S&OP team in the organization. The purpose was to create a multidisciplinary team to promote a mindset shift and sustain the changing process in the company, since several gaps were identified within the S&OP process in the maturity assessment. To define this team structure, the superordinate team identity proposed by Ambrose et al. (2018) was followed. The authors define four key variables in the S&OP performance:

- Centralization – having a negative impact associate with performance, inhibiting the exchange of ideas, autonomy, and, hence decreasing the levels of collaboration levels among stakeholders;
- Reward/Incentives – S&OP contributors will gain superordinate identity when they are rewarded on collective goals extended beyond functional metrics;
- Information quality –adequate information, both in content and form, shared among the S&OP team leads to higher levels of team identification;
- Resources/Time – Lack of resources and time will negatively impact achieving team identity. Adequate training, education, and mandatory attendance at meetings are key success factors for the performance of S&OP teams.

Following this special team structure by Ambrose et al. (2018), the S&OP team was established in the organization. The team's complete organizational chart is presented in Fig. 6.

To create a team with high levels of identification, 17 stakeholders from different departments were selected. The team structure, as illustrated in Fig. 6, was established in conjunction with the company's board of directors to promote engagement in the project. To avoid centralization, the action researcher acted as a mediator in conducting the process throughout the early stages of implementation and, mainly, to enhance the exchange of ideas between departments, building a decentralized decision-making process.

After defining the team structure, a strong emphasis was developed on change management and cross-integration, especially to create "buy-in" from stakeholders and kick-start the change momentum in the organization. To this end, several workshops were

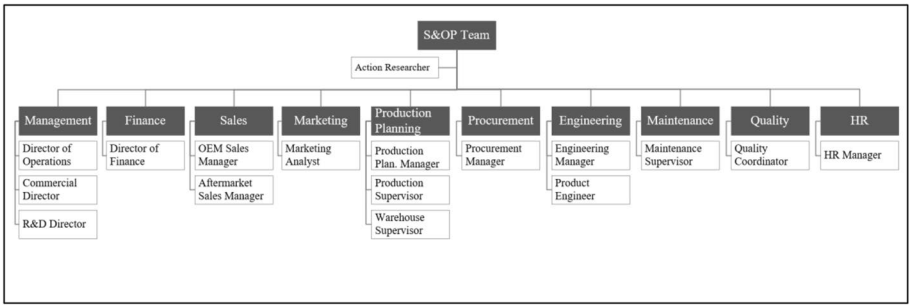

Fig. 6 S&OP Team

held to raise the stakeholder's awareness. The training introduced the main concepts, integration variables, and the role of each department into the planning system. The emphasis was on information quality and time management as key factors in the performance of the S&OP team. Finally, collective goals were defined to track the entire process and reward the team's performance.

Establishing the S&OP Process

After creating the S&OP team, the next action was to establish the S&OP process in the organization. At this step, the tools, processes, and metrics defined in the action plan presented in Table 1 were implemented to support the desired S&OP process for the company. Through the engagement of the action researcher and S&OP team members, this step was successively implemented in the organization after substantial context-oriented training efforts. The established S&OP workflow is presented in Fig. 7, describing the information flow and the department's responsibilities at each stage of the process.

This step started in May 2019 and took two months to finish. After the project go-live, the workflow shown in Fig. 7 started being performed monthly in the organization. The results obtained are discussed in the next section.

Results (Evaluating Action)

As the last action research step, this section presents the results obtained with the S&OP implementation in the organization. The evaluation of the collected data was carried out in line with the core concepts, variables, and system relationships to lead to conclusions based on the implications of theory and practice. First, an assessment of the S&OP effects on the organization's operational KPIs is presented. Afterwards, a second S&OP maturity assessment of the system was performed to assess the effectiveness of actions taken during the implementation steps and identify new S&OP maturity gaps to be addressed in future improvement stages. Then, the COVID-19 impacts on the organization and the role of the S&OP process during crisis management are presented and discussed.

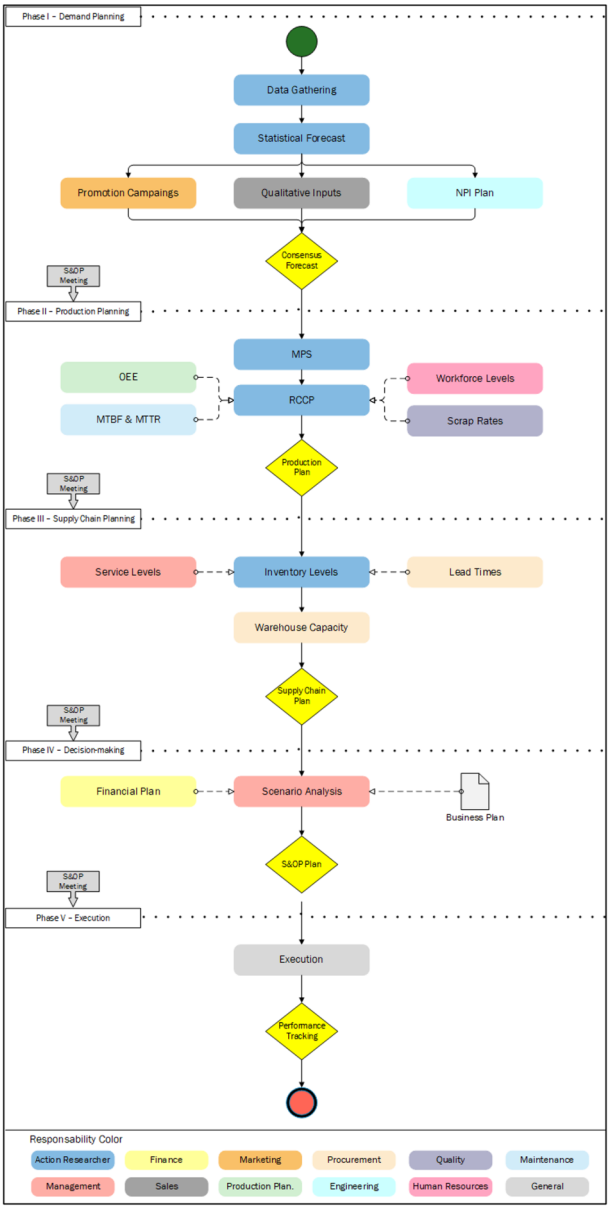

Fig. 7 S&OP process

Operational KPIs

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

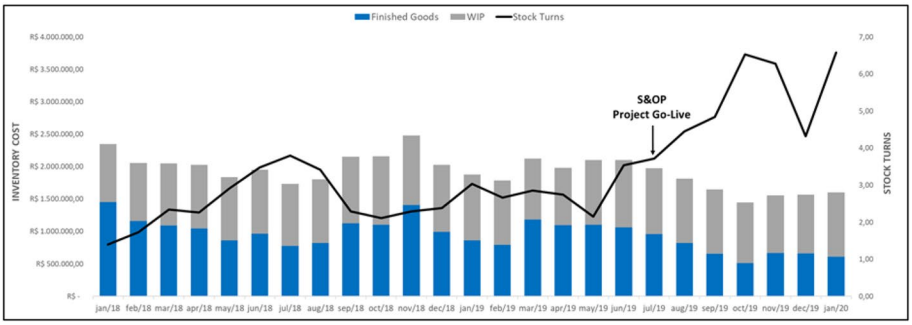

Fig. 8 Inventory Levels

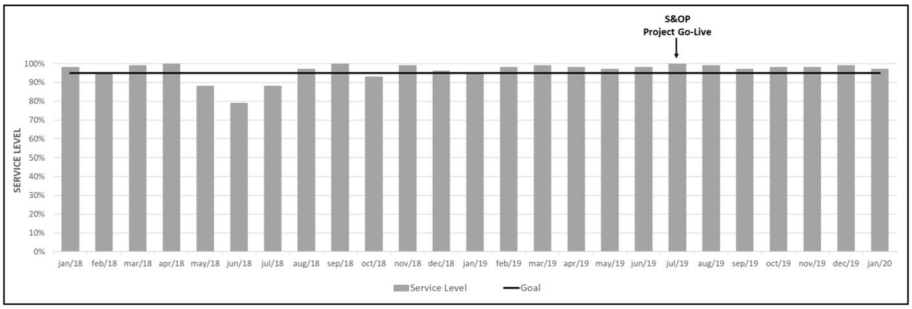

Fig. 9 Service levels

The main KPIs defined to measure the efficiency of the S&OP process in the organization were two: inventory levels, presented in Fig. 8, and service levels, as depicted in Fig. 9.

These two metrics combined provide an assessment of the impact of the primary objective of the S&OP process: balancing supply and demand with the least possible use of resources. As perceived from the go-live of the S&OP project, after July 2019, a significant drop in inventory levels and increase in inventory turnover, while maintaining the service level target by the organization is portrayed in the period. The visual reduction in stock turns in December 2019, as illustrated in Fig. 8, was due to an organizational decision to partially stop activities during the year-end holidays to manage employee vacations and perform special operations such as inventory counts and machinery maintenance, impacting revenue compared to previous months. However, as illustrated in Fig. 8, inventory costs remained at desired levels, and in January 2020, under normal operating conditions, the results brought stock turns to expected levels. This particularity was later used as input for the following planning periods that could be influenced by the similar variables.

The results are summarized in Table 2, portraying the scenario before and after S&OP implementation in the organization. In the first 7 months after the project go-live, there was an average monthly reduction of 18.42% in the cost of inventory. Inventory turns went from 2.63 to 5.25 and the service level grew by 3% in relation to the company's target of 95%. These quantitative results evidence the effectiveness of the S&OP process, obtaining the best operational performance of the company in the analyzed historical record.

Table 2 S&OP initial results

Metrics	Before S&OP (monthly avg.)	After S&OP (monthly avg.)
Inventory Costs	R$ 2.033.843,88	R$ 1.659.301,72
Stock Turns	2,63	5,25
Service Level	95%	98%

Final Maturity Assessment

After the first 7 months, a new maturity assessment was carried out to identify the effectiveness of the implemented actions within the organization. The stakeholders responsible for each department were re-engaged in the audit process to reassess the firm's maturity level, according to the S&OP Maturity Model presented in Appendix 1. The process was carried out in February 2020 and the results are presented in Fig. 10.

The final maturity assessment provided an overview of the improvement in the S&OP pillars. Compared to the initial assessment, the new maturity stage is significantly higher in the organization due to the various implementation steps already mentioned. For continuous improvement, a new action plan, presented in Table 3, was created to address the future actions to maintain the evolutionary S&OP growth.

In the first stage, the S&OP implementation was a breakthrough in the organization's culture, laying the foundations of the planning process with core tools and formalizing the process. From this point, a new optimization phase was suggested with the introduction of sophisticated tools and process automation. The new action plan provides for the next steps to be taken by the organization to leverage results and maintain the improvement movement.

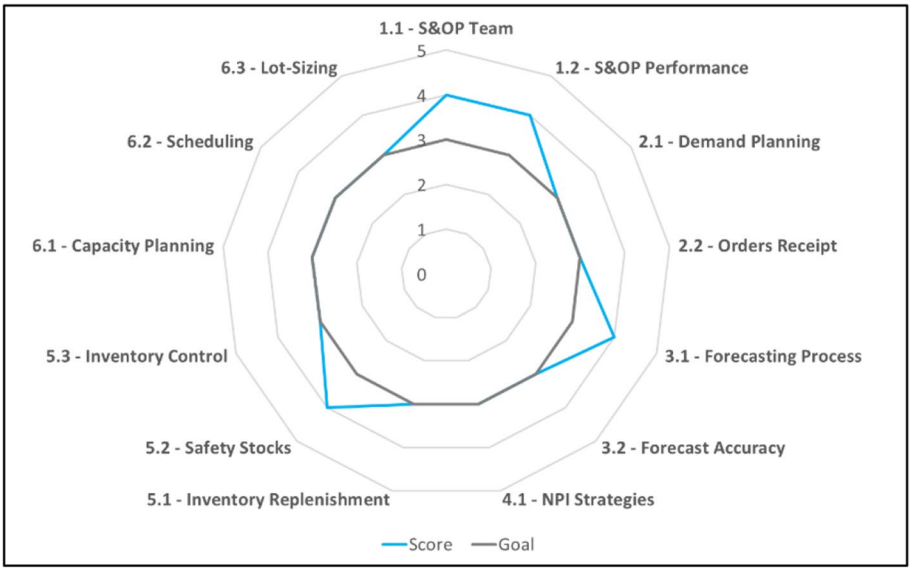

Fig. 10 Final maturity stage

Table 3 New S&OP action plan

S&OP dimension	Current stage	Actions	Future stage
1.1 – S&OP Team	**Score 4** • Formal structure of the defined superordinate identity S&OP team • Executive management engagement in the process	• Promote the engagement of external supply chain stakeholders within the process	**Score 5** • All 4 + • External supply chain stakeholder's 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 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 3 + • Sophisticated tools are used in the demand planning process
2.2 – Orders Receipt	**Score 3** • Order receiving is integrated into the ERP system, but no capacity assessment is performed	• Integrate order entry with production scheduling and capacity planning	**Score 4** • All 3 + • Automated integration with production scheduling and capacity planning
3.1 – Forecasting Process	**Score 4** • Formal forecasting process • Integration with qualitative marketing and sales variables • Sophisticated statistical techniques are used	• Implement Collaborative Planning, Forecasting and Replenishment (CPFR)	**Score 5** • All 4 + • Collaborative Planning, Forecasting and Replenishment (CPFR)

Table 3 (continued)

S&OP dimension	Current stage	Actions	Future stage
3.2 – Forecast Accuracy	**Score 3** • Forecast accuracy is tracked and shared across the organization	• Link forecast accuracy to other metrics	**Score 4** • All 3 + • Forecast accuracy is linked to other performance metrics (inventory costs, service level, capacity utilization, production costs, profit…)
4.1 – NPI Strategies	**Score 3** • The formal NPI plan is shared • Demand is forecast for new launches • Production constraints are evaluated in the development phases	• Introduce sophisticated IT optimization tools for ramp-up planning	**Score 4** • All 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 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 to establish safety-stock levels	**Score 5** • All 4 + • Sophisticated models are used
5.3 – Inventory Control	**Score 3** • ERP integration • FIFO plan • Documented process for managing expiration dates	• Implement real-time inventory control • Track system inventory accuracy	**Score 4** • All 3 + • Real-time inventory data is available • Inventory accuracy is tracked regularly

Table 3 (continued)

S&OP dimension	Current stage	Actions	Future stage
6.1 – Capacity Planning	**Score 3** • RCCP is used • Capacity utilization is monitored	• Implement IT system to generate feasible capacity plans	**Score 4** • All 3 + • IT Systems are used to generate capacity plans
6.2 – Scheduling	**Score 3** • MPS is defined • Scheduling rules are applied and documented	• Implement programming techniques	**Score 4** • All 3 + • Combination of programming techniques
6.3 – Lot-Sizing	**Score 3** • Lot sizing approaches are documented • Constraints are defined and updated regularly	• Implement programming techniques	**Score 4** • All 3 + • Combination of programming techniques

Source: Adapted from Danese et al. (2017)

COVID-19 Impacts

In a matter of a month after the final assessment of the system's S&OP maturity, the global COVID-19 pandemic hit the world. This unprecedented event has caused major impacts on many industries and even economies, as explored by several authors (Rapaccini et al. 2020; Singh et al. 2020; Kumar et al. 2020; Hu and Zhang 2021). Since there is this temporal coincidence of the S&OP implementation in this study and the COVID-19 outbreak, we took the opportunity to assess and report the impacts on the organization, as well as the way in which the S&OP process responded to the challenges brought by the pandemic in the specific context. First, the initial impacts of COVID-19 on the organization will be described. Second, empirical findings on the S&OP role during crisis management will be addressed and, finally, how this was reflected in the organization's operational KPIs.

Unfolding of Events

After approximately just two months of what appeared to be a 'distant' monitoring of COVID-19 numbers, the first case was reported in Brazil on 26 February 2020. Not far from that date, the World Health Organization (WHO) declared the new coronavirus a global pandemic on March 11, 2020. In a matter of a week, the situation quickly escalated and a lockdown was imminent and needed to be planned. The organization's Board of Directors defined the first set of actions, and, by March 18, 2020, all activities were stopped for the first lockdown period. Because of these measures, the company suffered an immediate impact on its sales, finances, and operations. By the end of March 2020, a 37% decrease in total revenue was observed, followed by a 43% drop in sales compared to the projected scenario before the outbreak.

This initial impact on the organization, coupled with the uncertainty of the spread of the disease, led to some critical decisions taken by the company in the early stages. The board decided to reduce the number of employees, anticipating even more impacts on demand and financial aspects. The organization ended up reducing about 35% of its operational staff and reducing from 3 to 1 production shifts. Two weeks after the first lockdown, the return of activities was gradually allowed on April 6, 2020. During this period, all manufacturing organizations were authorized to operate with 25% of total capacity, respecting the defined guidelines. To cope with the challenges brought about by the scarcity of resources, the internal consensus in the organization was to channel all efforts towards planning activities, and as one of the main pillars, the use of the S&OP process to try to overcome the challenges and mitigate the impacts of the outbreak of COVID-19. In this context, the next section will discuss how S&OP behaved during the crisis and the main developments of the process and decisions taken during the period.

Role of S&OP amid COVID-19

The unpredictability of the COVID-19 outbreak situation, combined with the decisions taken by the organization in the early stages, revealed a complex scenario to be managed by the organization. To explain how S&OP behaved in this crisis, this section

describes how each pillar of the process was affected and the measures taken by the organization.

Forecasting As assessed in the first pillar, forecasting practices have been discontinued since the beginning of the COVID-19 outbreak. In an unprecedented scenario, no matter how advanced the organization's methods and qualitative inputs are, forecasting techniques are unable to generate projections to direct decisions at this time. Therefore, in the months following the outbreak, the company momentarily stopped using forecast inputs in operational planning activities. As the outbreak progressed, some markets did not take the anticipated impact and showed a highly volatile demand pattern in the following months as a result of suppressed orders in the early stages. Nonetheless, forecasting activities continued as an effort to maintain the process previously established in the organization, as well as to try to adapt to the turbulent market situation triggered by the outbreak. We can conclude that despite the quality of the process outputs during the crisis, the forecast pillar was still of great importance, promoting strategic thinking within the organization on how to find ways to overcome the challenges caused by COVID-19.

Demand Management The demand management pillar was strongly focused by the organization to deal with the uncertainty of the market situation and because of the impacts on the forecasting process. We can say that the unpredictability of new orders and the reduction of manufacturing capacity were the main operational challenges faced by the organization. The company's strategic hybrid market positioning also added a complexity to the demand management process during the crisis. As mentioned earlier, all markets had a high impact at the beginning of the outbreak, however, different recovery patterns and particularities were observed for each market after the outbreak. In response to this situation, it was found that the key factors in defining demand management strategies relied on the organization's internal knowledge of the different market requirements and on the clear definition of its business assumptions. By adopting a flexible stance in defining and negotiating delivery times and managing the receipt of sales orders receipt, the organization was able to deal with the impacts on market demand amid the COVID-19 crisis.

New Product Introduction Likewise, the global supply chain crisis has had major impacts on the new production introductory pillar. As explained earlier, one of the company's main business drivers is the research and development of new products. Therefore, a substantial part of the forecasted revenue depends on the organization's product development efforts. Since the early stages of the outbreak, a slowdown was seen in both ongoing projects and projects in the evaluation phase. On the one hand, the organization's own developed and proprietary projects have substantially increased its risks due to the unpredictability of the situation and the financial impacts of the COVID-19 outbreak. Additionally, projects dedicated to specific OEM clients were also impacted and some even discontinued for the same reasons. From a managerial perspective, it could be said that the new product introduction pillar was important during crisis management as a way of predicting and preparing for the impacts on the organization's operational and financial metrics due to the reduction of new developments and, hence, new sources of revenue.

Supply Chain Management The impacts on supply chain management were obviously expected and can be observed to this date. Issues involving all levels of the supply chain have brought various challenges to organizations around the world. The disruption created by component shortages, order delays, and higher logistical costs required a granular management approach throughout the different periods of the crisis. The S&OP role in supply chain management activities was based on the essence of the process, where the alignment of the organization decisions is fundamental to sustain the company's goals. It was possible to perceive that from this cross-integration, the organization was able to find ways to overcome the previously mentioned challenges. First by working closely with the sales department to understand future purchasing demands and prioritize key business drivers when decisions about compromised material availability needed to be made. As well as increasing agility in decision making with the help of the engineering department to evaluate alternatives in a reactive and synergetic way.

Tactical Planning With the challenges in forecasting, demand management, new product introduction and supply chain management, the tactical planning pillar was essential in dealing with the impacts of COVID-19 in the organization. Through a constant assessment of the operational and logistical constraints raised during the crisis, combined with an approach focused on optimizing capacity planning, scheduling and lot sizing activities, the organization was able to effectively manage and deal with the challenges brought about by the outbreak. This flexible approach, from the earliest stages, allowed the company to meet market requirements despite the complexity observed in shop-floor decisions due to impacts on resource availability. As one of the main conclusions of this research, it can be said that the operational planning and especially the flexibility promoted by the S&OP process can sustain results even in unprecedented events where sales planning outputs are compromised.

Human Resources The human resources pillar importance cannot be emphasized enough during the pandemic management process. In a global health crisis, all decisions must be intrinsically related to the organization's role in the local community. Efforts to provide a safe environment where people can carry out their activities, facilitating the information flow and channeling the decisions that really matter were the most important factors to act during the crisis. The HR pillar was more than ever approached with higher levels of caution, with a focus on monitoring the health and engagement of all employees during the pandemic situation. Through a close relationship and constant feedback assessments, the organization was able to follow and understand people's feelings and struggles during the COVID-19 pandemic, adapting quickly and providing the environment to overcome the challenges raised and seeking to maintain the maturity gains previously consolidated to the system. As a further conclusion to this research, it can be said that human interactions within the S&OP process are the core component to sustain the objectives and results of the process, regardless of the context or situation that may be faced.

The Aftermath

To discuss the impacts of COVID-19 and how S&OP decisions were reflected in the organization's metrics, this section presents updates to the KPIs discussed earlier in "Results (Evaluating Action)" section.

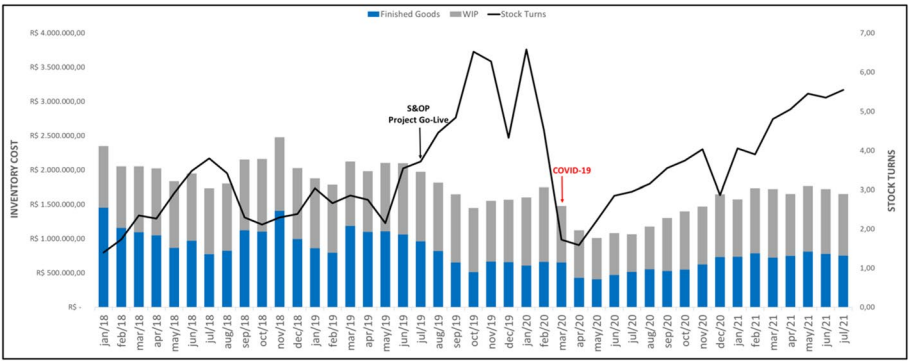

Fig. 11 Post COVID-19 inventory levels

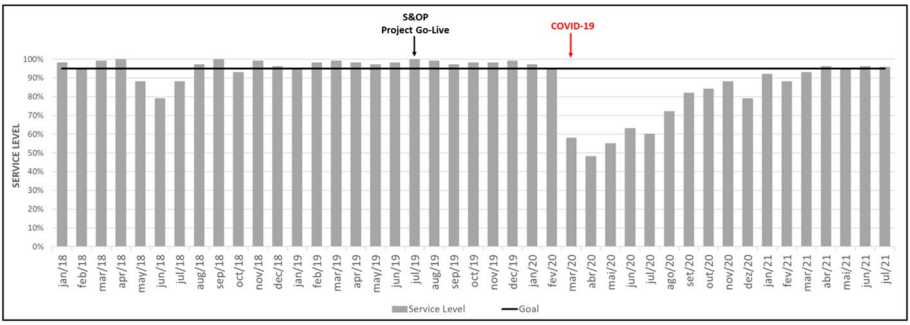

Fig. 12 Post COVID-19 Service Levels

Table 4 Post COVID-19 results

Metrics	Before S&OP (monthly avg.)	After S&OP (monthly avg.)	Post COVID-19 (monthly avg.)
Inventory Costs	R$ 2.033.843,88	R$ 1.659.301,72	R$ 1.446.216,30
Stock Turns	2,63	5,25	3,89
Service Level	95%	98%	78%

As illustrated in Figs. 11 and 12, from initial operational decisions, logistical constraints, and revenue impacts, the company faced a critical drop in its operating results in the first few months following the COVID-19 outbreak. It was only around September 2020 that signs of a positive market response started to be seen by the organization. This positive outlook led to the decision to increase production capacity levels that were reduced in the beginning of the pandemic. In the following months, even with the partially increased capacity, the

company still faced logistical challenges in dealing with the volume of sales orders received and, therefore, still had negative impacts on revenue and service levels. Starting in January 2021, it was possible to start to see a reverse trend in revenue and demand patterns and, by the end of the second quarter, a full recovery and even growth in some markets compared to pre-COVID-19 levels.

The summary of the COVID-19 impacts compared to the situation before the S&OP implementation is presented in Table 4. Despite the turbulent initial impacts reflected in the KPIs, the S&OP process was instrumental in guiding the company's decisions effectively through the series of events, increasing awareness and reactivity to the fluctuations in the scenario at the time.

This overview of the role of S&OP during the COVID-19 outbreak provides substantial managerial insights into the flexibility and scope of the S&OP process. It highlights that even in unprecedented times, where sales forecasting techniques are unreliable, the operational pillars are capable of sustaining the process. Therefore, organizations that recognize the inevitability of these unpredictable situations and are willing to be prepared are more likely to overcome the potential challenges.

Summary and Conclusions

Summary of Findings

In this work we report the S&OP implementation process in an automotive components company located in Brazil. A research method following the AR steps proposed by Coghlan and Brannick (2005) was adopted. In the first step, a maturity assessment was carried out to diagnose the current state of the company's planning process. Subsequently, in the action planning step, an action plan was defined to address the S&OP gaps and promote the S&OP implementation in the organization. Afterwards, in the action taking step, a multidisciplinary team was defined to support the organizational core change and a formal S&OP process was established with several specific tools to enhance the effectiveness of the demand and supply balancing process in the organization.

Then, the evaluation of the S&OP results in the researched environment was carried out as the last step of the AR method. Specific metrics were defined to measure the real impact of the proposed method on the organization. Seven months after implementation, there was an 18.42% reduction in inventory cost was observed, followed by a 3% increase in service level. Subsequently, a reassessment of the maturity level was carried out, illustrating the company's global growth in all S&OP pillars. In addition, a new action plan was established to follow the stages of continuous improvement in the organization. Then, the role of the S&OP process in the midst of the COVID-19 crisis was explored, demonstrating how the process reactivity and coverage of different operational pillars were fundamental to mitigate the negative impacts on the organization.

Managerial Implications

Due to the firm's market positioning, the goal of the S&OP implementation was to improve the organization's operational and financial results. S&OP has been proven to be an elementary process in the organization's supply and operational planning, with the ability to generate reliable future scenarios for decision-making at operational, tactical, and strategic levels. Significant results were obtained in the company. The S&OP process provided useful data for planning ahead, streamlining inventory costs, maintaining the organization's desired service level, ensuring monetary gains, and improving the company's cash flow to support its strategic business drivers. Intangible gains were also realized as the overall level of organizational S&OP maturity increased following substantial efforts devoted to training and improving stakeholder knowledge regarding the S&OP process. Moreover, following the results obtained in this study, the organization made the decision to invest in an Advanced Planning and Scheduling (APS) solution as a new effort to further develop its S&OP maturity level, as suggested in the final system maturity assessment.

Theoretical and Practical Implications

On the theoretical side, this study contributes to theory by reporting an S&OP implementation process using an AR approach. The use of AR in S&OP implementations is a subject that, to this date, is not commonly explored in the literature. Hence, this work sheds light on a new line of research within the S&OP literature that may provide greater understanding of the complexity and potential benefits of context-oriented S&OP deployments. In the practical aspect, this work provides a better understanding of the challenges, practices and results obtained with the S&OP implementation. Practitioners can benefit from these findings by adapting the steps and tools used in this work to address different systems in large scale transformations efforts.

Limitations and Future Research Recommendations

Limitations are identified in this work. First, in the researched context, in which the proposed actions were unfolded in relation to the variables and constraints of the system. As the company had a low level of initial maturity, the proposed actions, the tools introduced, the team's learning strategies and the action researcher leadership style were adapted to the environment to face the barriers identified during the S&OP implementation. In addition, the metrics and results obtained are also context-specific and must be adapted to cover other S&OP business contexts.

Future research is evident, as this work only aims at a specific context for the S&OP implementation process. Therefore, other S&OP implementation contexts based on the AR method adopted in this work could broaden the research scope and provide additional contributions to practice and theory. Furthermore, the evolution of the S&OP in the researched context with the introduction of sophisticated tools in a new optimization phase is also a suggestion to further assess the full potential of S&OP in the organization.

Appendix 1: S&OP maturity model

#	Pillar	Assessment Question(s)	Scoring Criteria				
			1 - Undefined	2 - Reactive	3 - Integrated	4 - Optimized	5 - World Class
1	**Human Resources**						
1.1	**S&OP Team**	*Does your company have a specific team to ensure the capacity to meet future demand?*	• There is no team to plan demand and supply operations • No collaboration between departments	• There is an informal team for the decision-making process • Occasionally meetings to plan demand and supply matches	• A formal S&OP team is defined • Clear roles and defined stakeholders • Scheduled routine meetings	• All of Stage 3 + • Superordinate Identity teams • Involvement of executive management in the process	• All of Stage 4 + • Involvement of external stakeholders in the planning process • The global plan is shared with the entire supply chain
1.2	**S&OP Performance**	*How do you evaluate the S&OP performance in your organization?*	• No method is used to evaluate the S&OP process	• Functional metrics are monitored in isolation, but the overall performance of S&OP is not known	• Specific key performance indicators (KPIs) and key business indicators (KBIs) are defined and shared with stakeholders to measure the process effectiveness	• All of Stage 3 + • Maturity models are used to assess the maturity of the process • Action plans are established for the continuous improvement of S&OP dimensions	• All of Stage 4 + • S&OP performance is linked to external supply chain partners
2	**Demand Management**						
2.1	**Demand Planning**	*How do you deal with demand uncertainties?* *How do you manage orders in your production planning system?* *How do you define order due dates?*	• Reactive planning process • There are no defined constraints for establishing order due dates	• Informal demand planning process • Order due dates are defined based on human judgment and rough constraints	• Centralized planning process • Definition of capacity limitations and bottlenecks • Frozen windows and decoupling points established Applicable tools: • Business Assumptions Package (BAP) • Demand Management Organization (DMO) • Customer order decoupling point (CODP) • Nested Booking Limits (NBL)	• All of Stage 3+ • Programming tools are used to manage demand • Feasible delivery plans are generated Applicable tools: • Linear Programming (LP) • Mixed-integer Linear Programming (MILP) • Kriging metamodels • Heuristics	• All of Stage 4 + • Sophisticated simulation models are used • Computation time is monitored Applicable tools: • Simulation-optimization • Stochastic Programming
2.2	**Orders Receipt**	*How do you receive purchasing orders from your clients?*	• Manual process for receiving orders	• Order receipt is electronically but a manual process is performed to input into the ERP system	• Order receipt is fully integrated with the ERP system Applicable tools: • Electronic Data Interchange (EDI)	• All of Stage 3 + • Order receipt is integrated with MRP / production schedules (MPS)	• All of Stage 4 + • Integration of customer information in real time Applicable tools: • Vendor Managed Inventory (VMI) • Point-of-sales (PoS) • Efficient Customer Response (ECR)
3	**Forecasting**						
3.1	**Forecasting Process**	*How is the forecasting process in your organization?*	• No forecasting process exists	• Informal forecasting process • Forecasts are generated based on human judgment only	• Formal forecasting process established • Scheduled routinely meetings • Integration with marketing (promotions), qualitative variables and new products introduction plans	• • All of Stage 3 – • Statistical forecasting techniques are combined with human judgment Applicable tools: • Autoregressive Integrated Moving Average (ARIMA) • Big data • Exponential Smoothing • Neural Network • Stochastic Programming • IT systems	• All of Stage 4 + • External supply chain collaboration in joint forecasting activities Applicable tools: • Collaborative Planning, Forecasting and Replenishment (CPFR)
3.2	**Forecast Accuracy**	*How do you monitor your forecast accuracy?*	• Forecast accuracy is not tracked	• Forecast accuracy is monitored but only shared upon request	• Forecast accuracy is tracked and shared across the organization	• All of Stage 3 + • Forecast accuracy is linked to other metrics (inventory costs, service level, capacity utilization, profit, …)	• All of Stage 4 + • Forecasting accuracy is linked to external supply-chain metrics
4	**New Product Introduction**						
4.1	**NPI Strategies**	*How do you plan to introduce new products in your production?* *How is the demand ramp-up process managed in your organization?*	• There is no new product introduction plan or process	• There are informal NPI plans, but the strategy is not documented	• Formal NPI plan is defined • Demand is forecasted for new launches • Production constraints are assessed at the development phases	• All of Stage 3 + • Programming tools are used to plan the demand ramp-up process Applicable tools: • Mixed-integer Linear Programming (MILP) • Monte Carlo Simulation • Simulation-optimization	• All of Stage 4 + • Integration of customer information in real time Applicable tools: • Vendor Managed Inventory (VMI) • Point-of-sales (PoS) • Efficient Customer Response (ECR)
5	**Supply Chain Management**						
5.1	**Inventory Replenishment**	*How do you plan your inventory replenishment process?*	• Manual process to plan the inventory replenishment cycle (spreadsheets)	• Automated planning system • Reorder point (ROP) defined for each SKU • Historical data available Applicable tools: • IT Systems	• All of Stage 2 + • Centralized integrated supply chain planning • Inventory is adjusted based on demand projections • Service level and logistical costs are monitored	• All of Stage 3 + • Programming techniques are used to plan inventory replenishment Applicable tools: • Mixed-integer Linear Programming (MILP) • Mixed-integer nonlinear programming (MINLP) • Mixed-integer Programming (MIP) • Heuristics	• All of Stage 4 + • Sophisticated simulation models are used • Computation time is monitored Applicable tools: • Simulation-optimization • System Dynamics (SD) • Stochastic Programming
5.2	**Safety Stocks**	*How do you determine safety stock levels?*	• No metrics or rules are documented to establish safety stocks	• Safety stocks are determined based on historical data • Parameters are established for product families	• Service level and lead times are defined and updated regularly • Documented strategies at the SKU level • Automated planning system Applicable tools: • IT Systems	• All of Stage 3 + • Programming techniques are used • Forecasts accuracy and deviations are taken into account when determining safety stock levels Applicable tools: • Linear Programming (LP) • Mixed-integer Linear Programming (MILP)	• All of Stage 4 + • Sophisticated simulation models are used • Computation time is monitored Applicable tools: • Simulation-optimization • Stochastic Programming
5.3	**Inventory Control**	*How do you control your inventory?* *Do you track the accuracy of your inventory?*	• Open access storage areas • Inventory control is disaggregated • Inventory accuracy is not tracked	• Centralized stock areas • Storage locations defined for each SKU • ERP integration	• All of Stage 2 + • First in first out (FIFO) plan • Documented process for managing expiration dates • Inventory accuracy is monitored	• All of Stage 3 + • Automated planning system • Storage constraints are set Applicable tools: • Warehouse Management Systems (WMS)	• All of Stage 4 + • Real-time data is available Applicable tools: • Radio Frequency Identification (RFID)

6	Tactical Planning						
6.1	Capacity Planning	*How do you plan and quantify your production capacity?* *How do you assess the forecasted demand scenarios in your production constraints?* *How do you identify when the projected demand exceeds the production capacity?*	• No capacity planning is carried out • Production orders are released to the production site without any capacity assessment	• Capacity is measured only for critical processes by units • Manual process for planning production capacity (spreadsheet)	• Capacity is measured and planned for all resources • Manufacturing cycle times and routings are updated regularly • Capacity utilization is monitored Applicable tools: • Rough Cut Capacity Planning (RCCP) • IT Systems	• All of Stage 3 + • Programming techniques are used to generate feasible capacity plans Applicable tools: • Linear Programming (LP) • Mixed-integer Linear Programming (MILP) • Mixed-integer Programming (MIP) • Heuristics	• All of Stage 4 + • Sophisticated simulation models are used • Computation time is monitored Applicable tools: • Simulation-optimization • Stochastic programming
6.2	Scheduling	*How do you schedule your production orders?* *How do you minimize your production timespan?*	• No production schedule is defined	• Production schedule is defined based on human judgment only • Manual process to develop schedule (spread sheet) • No documented scheduling rules	• Master production schedule is integrated with ERP system • Scheduling rules are applied and documented Applicable tools: • Master Production Schedule (MPS) • IT Systems	• All of Stage 3 + • Programming techniques are used to generate feasible schedules • Planning efficiency is monitored Applicable tools: • Mixed-integer Linear Programming (MILP) • Mixed-integer Programming (MIP) • Stochastic Programming • Heuristics	• All of Stage 4 + • Advanced Planning Systems are used • Production execution is monitored in real time • Computation time is monitored Applicable tools: • Advanced Planning and Scheduling (APS) systems • Manufacturing Execution Systems (MES)
6.3	Lot-Sizing	*How do you define your production lot-sizes?* *How do you handle low volume orders?*	• No metrics or rules are documented for lot-sizing	• Lot-sizes are defined based only on human judgment • Manual process and data review (spreadsheet)	• Lot-sizing approaches are documented • Constraints are defined and updated regularly • ERP integration	• All of Stage 3 + • Programming techniques are used to stablish lot sizes Applicable tools: • Decision Support System (DSS) • Mixed-integer Linear Programming (MILP) • Heuristics	• All of Stage 4 + • Sophisticated simulation models are used. • Computation time is monitored Applicable tools: • Simulation-optimization • Stochastic Programming

Source: Rampon Neto et al. (2022)

Data Availability Statement The datasets generated during and/or analysed during the current study are not publicly available due to the confidentiality agreement with the researched organization but are available from the corresponding author on reasonable request.

Declarations

Conflict of Interest All authors declare that they have no conflict of interest that are relevant to the content of this article.

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