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Analysis of production planning and control (PPC) through the approach of systems thinking

Análise do planejamento e controle da produção (PPC) através da abordagem do pensamento sistêmico

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ABSTRACT

This study aims to examine the positioning of the activities of Production Planning and Control (PPC) under the paradigm of systems thinking. The research is carried out in a metalworking midsize company, where it was sought to apply the systems thinking to assist in understanding the interactions and activities developed in the PPC system of the company object of study. For this reason, the aspects of influence on the local PPC decisions were detailed in a systemic way, analyzed the strategic positioning and responsibilities of the system of PPC researched and reviewed its structure of decisions and activities performed. From a future designed state, contemplating a framework of suggested actions, the results with this approach point to a better understanding of the company regarding its processes involved in the PPC activities, fundamental to organizational learning and improvement in decision-making.

Keywords: production planning and control (PPC), systems thinking, decision-making

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RESUMO

Este estudo tem como objetivo examinar o posicionamento das atividades de Planejamento e Controle da Produção (PPC) sob o paradigma do pensamento sistêmico. A pesquisa é realizada em uma empresa de médio porte metalúrgica, onde se buscou aplicar o pensamento sistêmico para auxiliar no entendimento das interações e atividades desenvolvidas no sistema PPC do objeto de estudo da empresa. Por esse motivo, os aspectos de influência nas decisões locais do CPP foram detalhados de forma sistêmica, analisaram o posicionamento estratégico e as responsabilidades do sistema de PPC pesquisado e revisaram sua estrutura de decisões e atividades realizadas. De um estado projetado no futuro, contemplando uma estrutura de ações sugeridas, os resultados com essa abordagem apontam para um melhor entendimento da empresa em relação aos processos envolvidos nas atividades de PPC, fundamentais para o aprendizado organizacional e a melhoria na tomada de decisão. Palavras-chave: planejamento e controle da produção (PPC), pensamento sistêmico, tomada de decisão

1 INTRODUCTION

Manage a productive system, seeking to maintain a balance between demand and capacity of resources (OLHAGER; JOHANSSON, 2012), this is a critical and highly complex task (SIMÕES et al., 2015), because they contain numerous influences of context, relations between the operations and developments activities. It is up the area and the PPC system (Production Planning and Control) the function to organize and track all the productive flow of the organization (CRUZ; MESQUITA, 2018). Understanding the strategies and establishing a line of thought can contribute to the good overall performance of this system.

Due to being a process with a high degree of interactions with a strong impact on the performance of the production system of companies, PPC ends up becoming complex, due to the difficulty identifying and predicting all the variables that may interfere in the process of planning, scheduling and control of production (STADNICK; COELHO, 2006; MÖLLER et al., 2013). The use of a systemic approach inserted in differentiated business environment makes the decision-making process of the organization unequal (ANDRADE et al., 2006; BOPP; DA SILVA, 2017). In this sense, the processes inherent to PPC have preponderant role in support to management for decision-making concerning the production (SILVA et al., 2015). Thus, it was sought to study the positioning of a PPC under the paradigm of systems thinking.

The rationale of this study is related to the need to collaborate with the understanding of the complexity of the structure and decision-making process in the PPC. The PPC systems, involving human resources, hardware and software, organizations responsible for coordination and implementation of productive resources, in order to meet the strategic plans (TUBINO, 2017), end up interacting with several critical points of business, forming a complex network

of decisions, seen globally. Understanding the operation of all this flow of information and their relations, provides the management body of a systemic view of the context in which the PPC is inserted.

The study is carried out in a midsize metalworking company (CRUZ; MESQUITA, 2018), which has a small team of PPC composed by a manager, an analyst and an assistant. Aiming to comply with the exposure of the object of study, the same is called as AlfaCompany. Among the resources available for the production management (CORRÊA et al., 2007; OLIVEIRA; HATAKEYAMA, 2012; SILVA JR.; DA SILVA, 2014; NEUHAUS et al., 2014), it is possible to highlight the use of ERP system (Enterprise Resource Planning), without formal application of MRP (Material Requirement Planning*)* and Master Production Plan. The productive system of Alfa company is constituted by the processes of Molding, Casting, Heat Treatment and Finishing, arranged in functional layout, with repetitive production system in batches. The portfolio of products offered is composed of a high mix distributed into four lines: penetration of soil, crushing, rail and special. As productive strategy (OLHAGER; JOHANSSON, 2012), in a general way, the company adopts both the system MTS - Make to Stock (for the lines of penetration of soil and crushing) and MTO - Make to Order (for rail lines and special), except for some occasional decision by definition of strategic management.

The central motivating issue of this research is: how can the systems thinking contribute to the analysis of the PPC processes in an enterprise organization? In this sense, the general objective is to apply the systems thinking to assist in understanding the interactions and activities developed in the PPC system of Alfa Company, seeking to accomplish a process of organizational learning and improvement in decision-making. This overall goal is broken down into three specific objectives, namely: (I) to detail systemically the aspects of influence on the PPC decisions and their interactions; (ii) to reflect on the strategic positioning and responsibilities of the system of PPC researched; (iii) to revise the structure of decisions and activities performed in PPC investigated seeking help with future better decisions in the company Alfa.

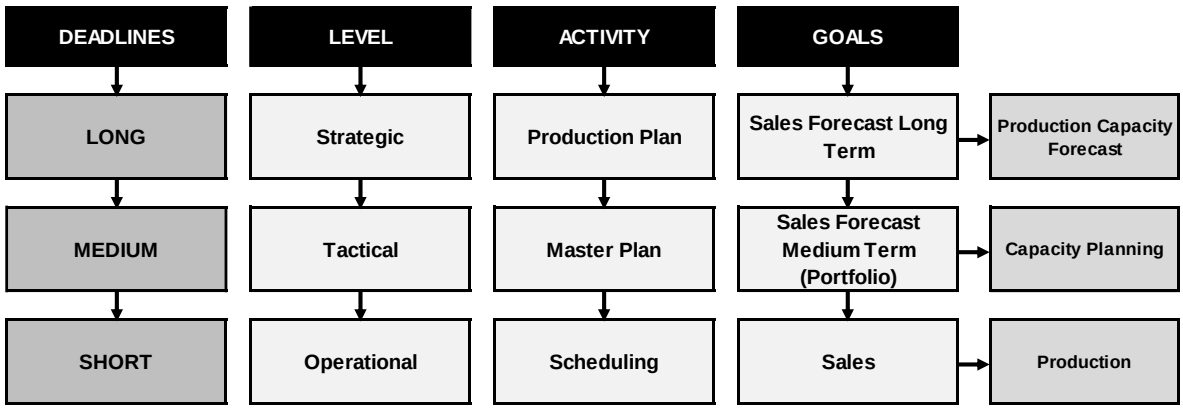
2 THEORETICAL REFERENCE

2.1. PPC

The performance of organizations depends on the alignment between the demand (Li et al., 2013) and its level of production planning and control (SLACK et al., 2013), which

serves as the basis for the operation of all the productive system. In this sense, there are arguments that point to PPC as direct influencer of the company's competitiveness (MÖLLER et al., 2013). A PPC system seeks to meet the objectives of the internal and external demands - of customers, generating satisfaction for both through appropriate compliance of their needs (CORRÊA et al., 2007). To ensure that the productive system to function properly, it is necessary to think in the form of deadlines, where actions are planned and implemented in order to make the plan a reality (TUBINO, 2017). In the organizations, it is incumbent upon the PPC system this task of planning, scheduling and control the flow of information and materials of the productive system, in different planning horizons: long, medium and short-term (CORRÊA; CORRÊA, 2017).

Figure 1 - Deadlines, activities and goals for decision making



Source: Adapted from Tubino (2017)

- Long term (usually months or quarters): consists of structuring a Production Plan, designing a sales forecast, seeking to show the capacity needed to meet this demand (CORRÊA; CORRÊA, 2017; TUBINO, 2017);
- Medium term (usually in weeks or months): it consists of planning the use of capacity, so as to make the operation more efficient. Through the Master Production Plan, ways to maneuver the productive system are analyzed (advance production, set hours per shift, decide to outsource part of the processes...) (CORRÊA; CORRÊA, 2017; TUBINO, 2017);
- Short term (usually days or weeks): it is during the short period that the planning of production is defined, after assembling the system and the definition of the tactical operation (CORRÊA; CORRÊA, 2017; TUBINO, 2017).

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A productive system will be much more efficient as its ability to synchronize the deployment strategies for the tactics and tactics for the operations of production and sales. In order to organize the assembly of data and decision-making regarding these activities over time, the organizations structure an area of strategic support to production, commonly called PPC. The respective unfolded activities indicate in a general way to (EVANGELISTA et al., 2011; TUBINO, 2017):

- Strategic Planning of Production;
- Master Planning of Production;
- Production Scheduling;
- Monitoring and Control of Production.

According to Silva et al. (2015) and Evangelista et al. (2011), the PPC aims to supply the need for optimization of productive processes, through the alignment among the strategic, tactical and operational levels.

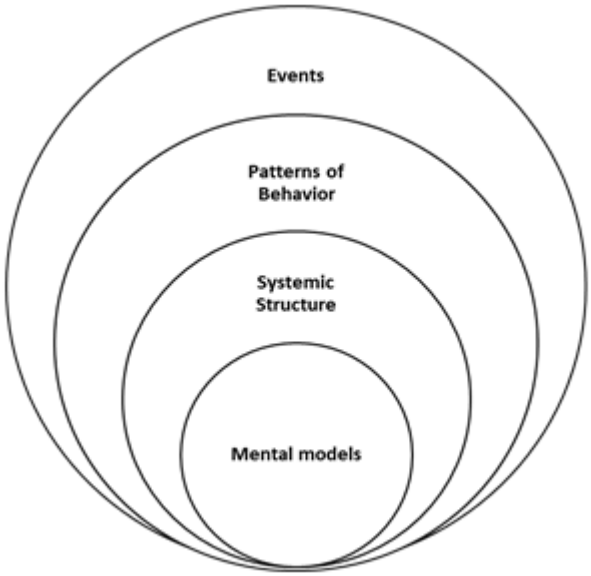
2.2 SYSTEMS THINKING

Systems thinking is one of the five disciplines of knowledge proposed by Peter Senge (2010). Andrade et al. (2006) defines systems thinking as the method to analyze the understanding of forces and inter-relationships that shape the systems behavior.

Much more than a mere organizational culture, the systems thinking is highly recommended for organizations that seek to think differently, always aiming the continuous learning and cultural changes (ANDRADE et al., 2006; SENGE, 2010). Within the systemic paradigm, four levels of perception are classified, according to Andrade et al. (2006) and Bopp and Da Silva (2017):

- Events: visible and perceived by those involved;
- Patterns of behavior: analysis of the long-term trend;
- Systemic structure: causes of behavior patterns of seeking to understand the mutual relationships of cause and effect;
- Mental models: ideas deeply rooted, generalizations or images that influence attitudes.

Figure 2 - Relationship among the levels of perception of reality



Source: Bopp and Da Silva (2017)

Morandi et al. (2010) highlights the importance of establishing a language for mapping the systemic structures, thus enabling the assessment of actions. According to Bopp and Silva (2017), the systemic language seeks to highlight the relationships in form of systemic map, making clear the sense of influence among the independent variables (or cause; dependent or effect) and their nature (direct or reverse). The dependent variable suffers modifications from the behavior of the independent variable.

3 WORKING METHOD AND APPLICATION OF CASE

The present study uses the method action research (DE FREITAS; DA SILVA, 2017), with the involvement of researchers in conducting the research. Additionally, the research is classified as qualitative and exploratory nature (Miguel et al., 2012), because it seeks to identify the variables that may affect the conduct of the process of PCP, through the approach of systems thinking.

The working method employed is organized into four major stages (Figure 3): (i) an analysis of the current routine of PPC; (ii) development of the current systemic map; (iii) a critical analysis and learning about the aspects of influence; and (iv) propositions for the future state of the PPC.

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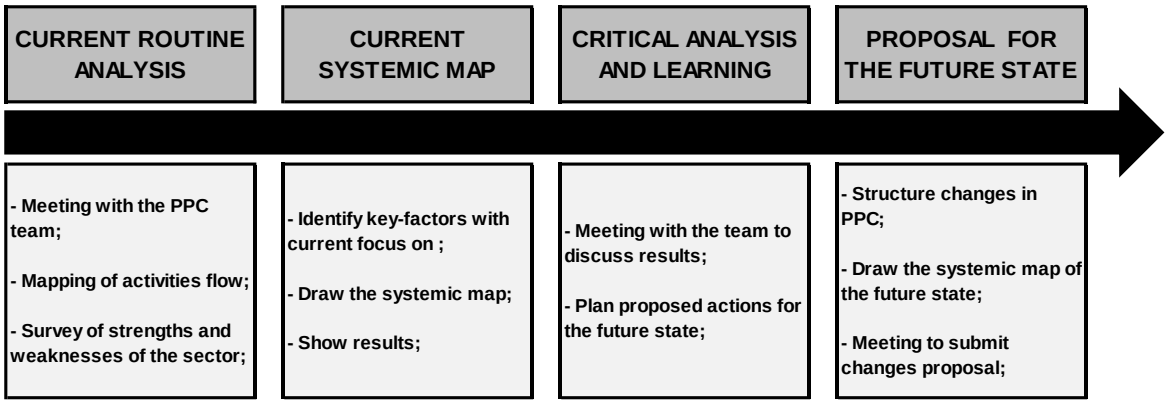
Figure 3 - Detailing the steps of the method of work



Source: Authors

3.1 ANALYSIS OF THE CURRENT ROUTINE OF PCP

To better understand the PPC process in the company Alfa, it is necessary to understand the strategic context that involves the productive system of the organization. The company object of study operates in several market segments (Soil penetration, rail, Crushing, Grinding, Special), possessing a level of development of new products and automation technology considered by managers relatively low.

The productive flow is characterized by a system of repetitive production in batch with programming pushed, allied to a productive model merged between MTS (make to stock*)* and MTO (make to order*)*, having an extremely dynamic environment coupled with a very short period of planning.

Accompanying the productive flow of the company, the mapping follows the corresponding sequence of processes: (i) modeling, (ii) shaping, (iii) leak, (iv) thermal treatment of pieces, (v) surface finishing and (vi) quality inspections. During the analysis of the interactions among the processes, it was noticed that the activities of PPC worked with their controls directly in just 3 steps of production: molding, casting and entry of stock.

The company Alfa has a formalized area for PPC. Checked this sector, the team is composed by a manager (who is also responsible for coordinating the factory floor), an analyst (launch of data; issuing reports; sequencing of production) and an auxiliary (support). However, it was possible to identify that the company Alfa does not have in the whole the structure of its products and application of Master Production Plan (PMP). In addition, the planning of production is not entirely the responsibility of the designated PPC, because the administration of stock, issuance of production orders and setting of deadlines is performed by the commercial sector.

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Table 1 - Criteria and the characteristics of the local PPC system

ASPECT	CRITERIA	CHARACTERISTICS
Planning	Two main strands: - Production Orders by request - Production Orders for stock	- Short Term - Does not consider the raw material - Definition of priorities for production
Scheduling	More detailed scheduling in the fusion process (programming of batches by material per day and per order)	- Does not consider the availability of resources
Control	Collection and release of information daily	- Control focused on the leak and treatment - There is no control of efficiency of processes

Source: Authors

After meeting with the PPC team and through the observation carried out, it was possible to establish the main strengths and weaknesses related to the PPC activities in the company, as shown in Table 2.

Table 2 - The positive and negative local aspects

POSITIVE ASPECTS	NEGATIVE ASPECTS
+ Use of identifications for sequencing of priority products + Aggregated Production Plan (general schedule) + Daily production meetings with supervisors	- PPC sector has little performance in sales planning and definition of delivery periods - Capacity and efficiency of the resources are not periodically monitored - ERP system is not enough to manage a such a complex productive system - Control over the inputs is not performed in a synchronized way directly with the productive demand

Source: Authors

3.2 CURRENT SYSTEMIC MAP

After the survey on the PPC routine information, the criteria of language used for systemic mapping were defined as shown in Figure 4.

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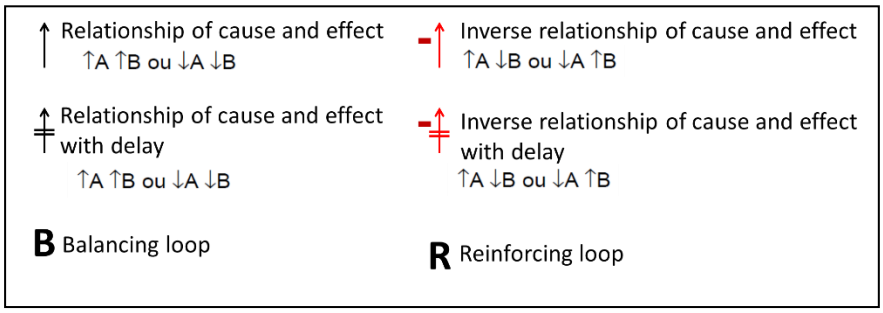
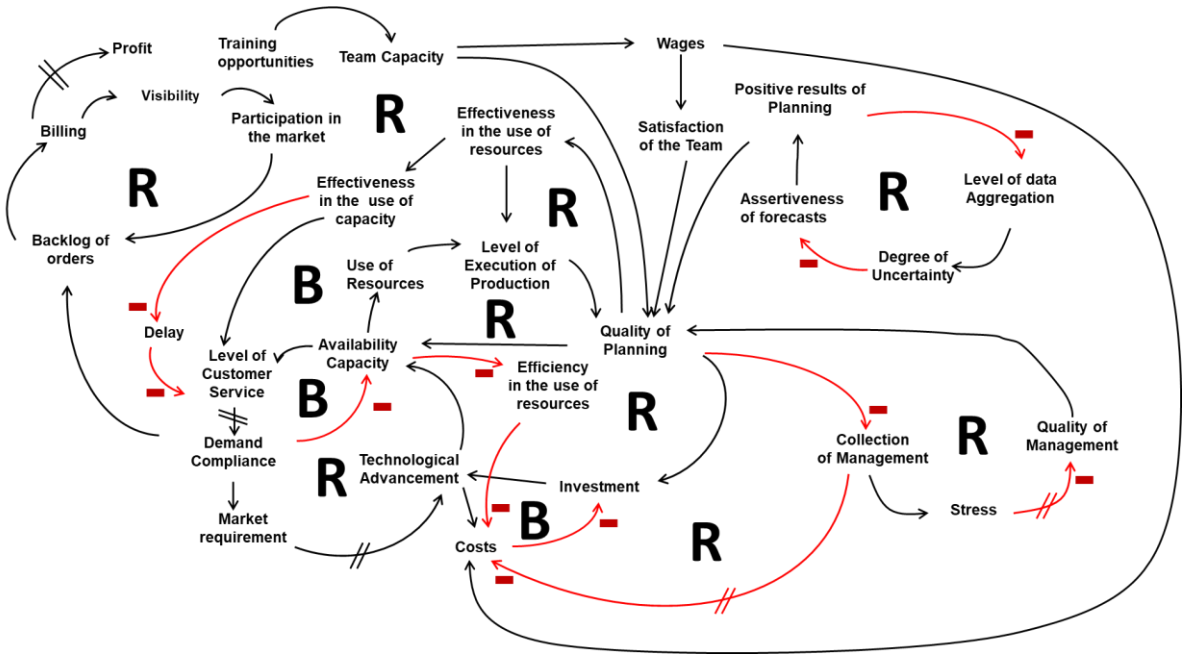
Figure 4 - Legend of the language used in systemic map



Source: Authors

Aligned with the PPC team, the map was constructed from several factors involved in issues such as planning, capacity and demand of production, considering more direct aspects (closer and with greater influence on PPC) even more indirect ones to the local PPC system. Therefore, the map was drawn resulting in 10 feedback loops - 7 reinforcing loops and 3 balancing loops (Figure 5).

Figure 5 - Current systemic map of PPC with focus on aspects of planning, capacity and demand



Source: Authors

The reinforcing feedback loop originated after the variation in the quality of planning directly impacts on the efficiency of use of resources, which influences the level of implementation of production, closing the loop. In addition, the effective use of resources, directly affects the efficiency of utilization of capacity, which in turn ends up impacting

inversely the production delays, which influence the level of care planning, where as time goes by, alter the levels of customer demand. The variation in the level of service demand infringes on the availability of capacity, which returns to influence the level of planning attendance, characterizing a link balancer. This case exemplifies the concept of finite capacity, where the change in the demand ends up affecting the availability of capacity, i.e., the balance between capacity and demand.

But according to the evaluation of the group for analysis, the variation in the demand compliance also changes directly the demands of the market, which in turn, as time goes by implies in the fronts of development and technological advancement of the productive system. This technological advancement, in addition to changing the level of availability of productive capacity, reflects the costs of the operation, which conversely reaches the investments affecting again the technological advancement in a balanced way.

Because this is a medium-sized company, there is great proximity of direction with the implementation, where the recoveries of goals are made personally and with frequency. Thus, when the quality response from planning tends to affect the productive flow, this impacts inversely on the level of collection of direction for results. Thus, it was noticed that from the moment in which there is a change in the level of collection of direction, this entails direct changes in the work environment as the stress aspect, which as time goes by, indirectly affects the outcome of quality management, leading to the impact on the quality of planning. Finally, this situation returns with an inverse intensity to the level of collection of direction by closing a reinforcing loop. Now, this recovery, as time goes by, also changes the costs in the company, but in reverse. Following other relationships, it is noticed a great balancing loop in this line of thought, passing by the investment, technological advancement, availability of capacity, level of service from planning, customer demand, backlog of orders, billing, profit, training and qualification of the team, returning to the quality of planning and closing the variable collection of direction.

Regarding the commercial interactions, it is possible to highlight the line of reasoning originated after the demand compliance, which impacts on the response to the backlog of orders, which in turn changes the billing, the visibility of the organization, the participation in the market, returning its influence directly to the backlog of orders, i.e., another reinforcing feedback loop in the system. In addition, mapping suggests that the billing, as time goes by, affects the organization profits. With such profits, there are opportunities for training of employees, fact which modifies the level of the team training, which ends up reflecting on the

quality of the planning, creating in this way another reinforcing loop through the continuity of interactions, passing by the variables effectiveness in the use of resources, efficiency in the use of capacity, delays, level of planning attendance and customer demand.

During the elaboration of the systemic map it was identified a balancing loop regarding the positioning of investment in the company. Depending on the level of investment, this directly influences the technological progress achieved, which in continuity affects the availability of capacity. However, the availability of capacity operates in reverse on the efficient use of resources, which also inversely modifies the costs, which consequently responds inversely on investment decisions. It is worth noting that the costs suffer direct influences of wages, which reflect the level of internal training. However, according to the teamwork, the result of the quality of the planning is directly related with the wage level applied by the investigated company. These feedback loops explain the complexity of the analyzed situation.

Regarding the level of integration of data processed by PPC, a reinforcing loop arose where the level of aggregation of data in analysis directly influences the degree of uncertainty resulting from the information, which in turn affects inversely the assertiveness of forecasts that directly impact on the results of planning, that come back and alter in inverse order the level of aggregation of data required and affects directly the quality of planning. Having said that, when the planning is based on momentary data, there is a decrease in the uncertainty of these data, thus allowing an increase in the assertiveness of planning, which strengthens the potential results of a qualified planning. Even remembering that the previous inverse logic is also true, the mental model used in this reinforcing feedback loop is unique fruit of the reality of the organization, which does not have an information system that supports a set of more complex data and in large numbers. Thus, for the company, the simpler and more recent the set of data is, the greater the ease of control will be, increasing the reliability of information and planning.

3.3 CRITICAL ANALYSIS AND LEARNING

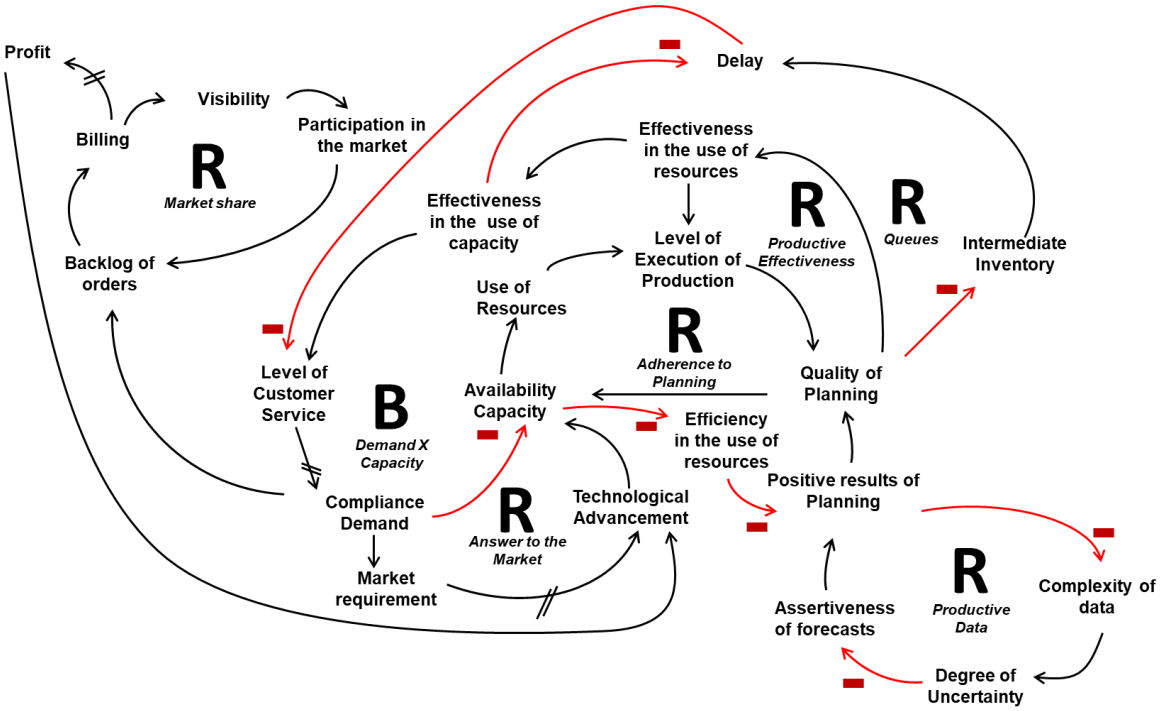
After structuring the current systemic map, the teamwork and research studied all the interactions presented in the systemic map of the current state. By owning a varied mix, with distinct characteristics, there may be different consequences depending on the sales policy established. For example, for items worked as MTS, the intermediate inventories are functioning as a lung, which allow a greater flexibility of priorities, where thus the increase in

inventory will not necessarily have an impact on the increase of delays. Unlike the MTO products, where the intermediate stock affects directly the lead time. From the critical analysis of these local characteristics it was defined that the future state map will be prioritized for care of the production flow of the MTO parts (CRUZ; MESQUITA, 2018), because they have greater "value-added" to the company Alfa.

3.4 PROPOSAL FOR A FUTURE STATE

After the analysis together with the work team - local professionals and researchers, the new relationships stand out among the factors fundamental to the development of the PPC activities. Figure 6 illustrates the changes in an evolved and focused map on the repercussions on MTO productions of Alfa company.

Figure 6 - Evolved systemic PPC map with a focus on the repercussions on MTO productions of Alfa Company



Source: Authors

The reading of this map (Figure 6) allows the identification of 6 main feedback loops that have an impact on the functioning of the PPC system of Alfa company: (i) capacity versus demand, (ii) response to the market, (iii) market share, (iv) data analysis, (v) queues and (vi) adhesion. The proposal is supported by the following propositions:

- The adherence to the production planning is dependent on the reliability of the analyzed data;
- Intermediate inventories cause queues that unbalance the relationship capacity versus demand;
- The balance of the relationship between the productive capacity and the demand compliance enhances the quality of the responses to the market and the generation of future demands;
- The variation of the backlog of orders reflect in market share and in technology investment for the development of productive resources.

Table 3 - Proposed actions to sustain the changes in the future state of the PPC system of Alfa Company

LINK FOCUS	ACTIONS	JUSTIFICATION
DATA ANALYSIS	- Training to review data recorded before the launch in the ERP system - Automate analysis reports in Excel, migrating them to the ERP system	Increase the reliability of the data obtained for analysis in planning
ADHERENC TO PLANNING	- Daily analysis of producing capacity - Training and alignment of the PPC team and production supervisors on the importance of the planned items compliance	Improve the level of the production execution
QUEUES	- Revision of minimum stocks for the MTS items - Prepare the production plan respecting the daily, weekly, and monthly capacity	Reduction of the intermediate inventories and reduction of production lead time
CAPACITY X DEMAND	- Structure a systematic for periodic readjustment of the projected demand - Evaluate the anticipated demand and plan daily, weekly, and monthly goals - Monitor results periodically through meetings with PPC, Commercial and Production teams	Level the relationship capacity versus demand

Source: Authors

4 CONCLUSION

The present work studied the positioning of the PPC activities of Alfa Company through the perspective of the Systems Thinking. The study was developed in the form of aid in the understanding of key decision factors and their respective characteristic interactions of the local PPC site system. For detailing of the aspects of influence on the PPC decisions it was made use of systemic map, allowing a wide view of the strategic positioning and responsibilities of the adopted PPC system. This step allowed the revision of the structure of

decisions and activities performed in production planning and control, leading to the development of a framework of suggested actions.

In addition to the proposition of a future state, the research provided a series of reflections and critical analyzes to the participants, in particular the professionals of the company. The PPC team involved in field work expressed satisfaction with the results obtained, justifying the approach that led them to a better level of understanding of the company and its processes related to the PPC activities. Such evidences reinforce the systems thinking as an agent of organizational learning and improvement in decision-making (ANDRADE et al., 2006; SENGE, 2010; BOPP; DA SILVA, 2017).

It is concluded that the experience along the work led to new and potential initiatives in the company, in addition to the expansion of participants' knowledge on the internal processes. However, dealing with complex situations such as in a PPC system requires continuous effort. The immaturity of local professionals with the systemic approach is understood as a limitation on the results found. Even though the findings have significance limited to the investigated environment, there are opportunities for advancement. Thus, new studies are suggested for continuity in the learning process, in company Alfa and/or in another PPC system.

Note: The work integrates the Annals of SIGEPRO 2019.

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