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PROPOSAL OF AN INSTRUMENT TO VERIFY THE ADHERENCE BETWEEN THE FOCUS AND THE PRACTICE OF PRODUCTION PLANNING AND CONTROL: A STUDY IN THE METAL-MECHANICAL SEGMENT IN SERRA GAÚCHA, RIO GRANDE DO SUL

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ABSTRACT

Choosing a Production Planning and Control (*Planejamento e Controle da Produção* – PCP) technique that is aligned with and is appropriate to a company's production environment scenario is considered a crucial factor in its strategy. Such a choice may reflect on how the company manages its timing, inventory, and, consequently, its costs. This study proposes an instrument to evaluate the adherence between the focus and practices of PCP in companies. Six PCP techniques were considered within the scope of work in four production environments: Assemble to Order, Make to Stock, Engineer to Order, and Make to Order. The selected techniques were based on the work of Stevenson, Hendry and Kingsman (2005), and they three classic techniques – Material Requirements Planning, Drum Buffer Rope and Kanban and three emerging – Constant Work in Process, Workload Control and Paired cell Overlapping Loops of Cards with Authorization. Two different perspectives within a company were considered: the one of management and the one of operation, for the analysis, with questions addressing the relations between the techniques and the production environments. The research instrument was developed based on sensitive parameters, to a greater or lesser degree, to the use of each of the techniques in each company. A multiple case study with eight companies from the metalworking segment aligned with the four production environments located in the Serra Gaúcha was carried out. We interviewed managers, who established the focus of the PCP in each company, and PCP and operation specialists, who informed the practices of the production environment. The use of the research instrument was adequate, making it possible to capture the essence of the company's PCP activities. The results show that some techniques have greater compatibility with certain production environments, while others still deserve a finer adjustment.

Keywords: Production Planning and Control Techniques; Production environment; Adherence, Focus and Practice of Production Planning and Control.

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1. INTRODUCTION

As suggested by Vollmann et al. (2006) and Zeithaml et al. (2014), customer expectations and requirements have become more complex. With a wide range of products on the market, companies feel pressured to issue faster responses on aspects related to delivery times, maintenance of lower inventories and operating costs. Demand stability is a distant reality, and product lifecycles have become increasingly smaller, while the variety of them has been increasing significantly (Junqueira, 2003; Kerzner, 2016). In this way, this requires that the choices as to the ways to plan and control the production of a company be made according to this conjunction of scenarios.

For Stevenson et al. (2005) and Guerra et al. (2014), the choice of a Production Planning and Control (PCP) approach that is more appropriate to their realities is a difficult task due to the number of possibilities available. Allied to this, the emergence of integration software, which seeks to offer answers considered as "universal", can be a problem, since decisions on aspects of the shop floor can be based only on superficial characteristics, not taking into account the real points that are contained in the essence of the company and that are constituted, in fact, as the productive environment verified in them (Stevenson et al., 2005; Guerra et al., 2014).

For Tenhiälä (2010), despite the apparent maturity that permeates PCP, research involving the success in the implementation of approaches more appropriate to each reality should be performed. It also argues that the lack of a contingent view at the time of defining these approaches can translate into failures or misunderstandings in the introduction of the production system.

Thus, this article proposes a study about PCP approaches, emphasizing their functions as well as their impacts on the objectives of the organization. The proposal of this study has as its motivation the following question: is the focus of PCP, which is being adopted by the current companies, really being reflected in the practices of the productive area of these companies?

Finally, a conceptual model of analysis, containing the relationship between production characteristics in relation to the PCP focus will be presented, with the aim of facilitating the categorization of the companies regarding the productive systems used.

The general objective is: to validate an instrument developed to assess adherence between the approaches of PCP assumed as the focus of the companies and the practice of their productive systems.

From this general objective, the following specific objectives were defined:

a) Identify and characterize the approaches of PCP presented in the current literature;

b) Identify categorization parameters for the PCP approaches and selected production environments, as well as their relationships;

c) Evaluate the focus of PCP in relation to the characteristics of productive systems;

d) Develop an instrument to verify the adherence between focus and reality of PCP;

e) Validate the instrument created within different production environments.

Thus, due to the above, verification is also necessary with the idea of identifying whether the positioning by one of these models still occurs or whether the boundaries between them no longer exist.

2. THEORETICAL REFERENCE

2.1 Importance of PCP

According to Olhager et Selldin (2007) and Pereira et al. (2015), the way to plan and control production is part of the company's manufacturing strategy, in addition to influencing the company's long-term objectives. According to Stevenson et al. (2005) and Pereira et al. (2015), the activity of PCP is fundamental for meeting the demands of consumers, in a highly competitive context, being a fundamental strategy for the economic success of the industries. According to these authors, the method or technique of the PCP must be in line with the manufacturing environment, since the essential elements must correspond to the characteristics of the production system, in which one can consider, as an example, the high level of customization currently verified.

In this sense, choosing the PCP approach that is most appropriate for increasingly dynamic and customized production environments is a challenge (Pereira et al., 2015).

Among the types of classification, the models categorized by type of operation, by process flow and by production environment stand out (Lustosa et al., 2008). The knowledge and the distinction between the different planning environments are fundamental at the moment of the elaboration of the planning strategies (Martinez et

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Toso, 2015).

Regarding classification by type of operation, Lustosa et al. (2008) list the following characteristics: (a) system by project; (b) cellular manufacturing system; (c) continuous process system; (d) flow-shop repetitive system; (e) intermittent job-shop system.

With respect to systems by process flow, Biotto et al. (2015) enumerate the existence of three environments, classified as follows: (a) mass production; (b) intermittent production; and (c) unit production.

According to Vollmann et al. (2006), Lustosa et al. (2008) and Souza et Pires (2014), with respect to the production environment to meet demand, production systems can be classified as: (a) - make to order (MTO) or production to order; (b) make to stock (MTS) or production for stock; (c) assembly to order (ATO) or custom assembly; (d) engineer to order (ETO) or custom design.

For Rodrigues (2014), a basic difference between production systems is that the pulled systems control the material in process and verify the quantity produced, whereas the pushed systems control the quantity produced and check the material in process. Moreover, in a pushed system, the production depends on the analysis of the program, whereas in a pulled system the next production step is analyzed for the determination of what will be necessary, that is, nothing is sent anywhere until the moment that the request occurs.

2.2 PCP Techniques and Approaches

As an initial clarification, it is necessary to point out that, because this work does not aim to broaden the discussion about the different nomenclatures that permeate the PCP approaches found in the literature, the denomination that will be used in the course of this work will consider Kanban, Material Requirements Planning (MRP) and others that will be presented as PCP techniques, supported by the work of Stevenson et al. (2005) and Vollmann et al. (1997).

Castro (2016) conceptualizes Kanban, MRP and Drum-Buffer-Rope (DBR) as PCP techniques within a classical approach, while Workload Control (WLC), Paired-cell Overlapping Loops of Cards with Authorization (POLCA), and Constant Work in Process (CONWIP) are considered techniques of a more emergent approach. This classification is also presented by Vollmann et al. (1997), who state that MRP, for example, is perceived as a basic manufacturing planning technique.

Thus, it is important to consider that the scope of this study will be restricted to the MRP, Kanban, DBR, CONWIP, WLC and POLCA techniques, supported by the work of Stevenson et al. (2005), Fernandes (2007) and Van Berkel (2010).

The characteristics of the market, which can be identified by the wide variety of products, and the adaptability of the productive environment, which implies the ability to control a non-repetitive production with a high degree of customization, reinforce the emerging character about these three techniques (Melchert et Francischini, 2005).

It is important to emphasize that this work approaches classic techniques based mainly on the study developed by Stevenson et al. (2005). For a better comparison and distinction of these techniques, they were analyzed according to the following perspectives:

a) Concept: addresses historical aspects of each technique, in addition to important features;

b) Prerequisites: encompasses the resources and factors that, according to the researched literature, are fundamental for the successful implementation of the technique;

c) *Modus operandi*: it is the form of operation of each technique;

d) Benefits: are the main advantages obtained by the introduction;

e) Considerations: observations are addressed as well as results of experiences commented on by the bibliographic review.

2.2.1 Material Requirements Planning (MRP)

The concept of MRP can be translated as the material requirements planning. Its emergence occurred from the need to plan the supply of dependent demand, which comes from independent demand, basically due to the needs of finished products delivered to consumers (Martins et Laugeni, 2016). Slack et al. (2013) define MRP as a way to help companies plan and control their resource needs by using computerized information systems to control materials. According to Vollmann et al. (1997), it is a basic PCP technique that aims to provide the right piece at the right time.

According to Stevenson et al. (2005), MRP can be considered as a legacy system, but still very important for the PCP approach. For Rodrigues (2017), it is one of the pro-

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duction control systems used by companies, giving rise to Manufacturing Resource Planning (MRP II) and Enterprise Resource Planning (ERP), among others.

As it is a pushed system, production is sequenced online, regardless of whether the next sector will be able to handle it (Slack et al., 2013). For Corrêa et Corrêa (2017), MRP disregards capacity constraints, which requires constant adjustments to avoid idleness as well as saturation of resources. In addition, the requirements generated by MRP can lead to longer lead times and considerably increase Work in Process (WIP) (Suri, 2018).

However, according to Vollmann et al., (2006) MRP deployment is essential for companies that need to coordinate deliveries with a wide range of other activities and, therefore, it still remains widely employed despite handling so much data to prevent the ability to respond quickly.

2.2.2 Drum-Buffer-Rope (DBR)

According to Goldratt (1990), the DBR technique, also known as Drum-Lung-Rope, is derived from Theory of Constraints (TOC) or Restriction Theory, being oriented to the concept of bottleneck management. It is also a systematic approach to resource management, which is focused on managing in the best possible way the bottlenecks that prevent the company from achieving its stated goals and objectives (Krajewski et al., 2007, Castro, 2016). In addition, it is a technique that is derived from the software Optimized Production Technology (OPT) (Goldratt, 1990).

The DBR technique presents good results when applied in companies that produce products with moderate customization, in which it was verified better performance in delivery, besides the reduction of lead times (Wahlers et Cox, 1994; Castro, 2016). However, a stationary bottleneck position in an MTS environment, for example, tends to be more suitable for the use of the technique, whereas in ETO environments the DBR deployment tends to present greater difficulty (Stevenson et al., 2005).

In addition, a good performance of DBR depends on factors such as the availability of resources and work centers, the complexity of the product structure, the quantity of resources with capacity restriction and the detailing of the production scripts (Vollmann et al., 1997; Castro, 2016).

2.2.3 Kanban

Kanban is a card-based pull system designed to reduce inventory and flow times. (Stevenson et al., 2005; Rodrigues, 2014).

For an effective implementation of a traditional Kanban system, it is necessary that there is a virtually constant demand, where the variability is low, as well as the variation of products, according to Monden (1981). This essentially constant and repetitive production system is the most suitable environment for the use of Kanban (Hall, 1981).

In addition, Kanban needs to maintain a certain amount of stock between each operation, which can become large amounts of inventory if a large variety of products are produced in the manufacturing environment, thus making it difficult to deploy them because, when a box or container is empty, it should, as a rule, be replaced immediately. (Suri et Krishnamurthy, 2003; Castro, 2016).

Kanban can be considered as a replanning tool that needs to keep a minimum inventory of each product, which can be a problem for companies with a high degree of customization that cannot keep stocks of components as they do not know when they will use them. The companies that work with a wide variety of products allied to a variable demand constitute environments not suitable for the implementation of this system, since this combination will increase the WIP (Suri et Krishnamurthy, 2003).

2.2.4 Workload Control (WLC)

According to Stevenson et al. (2005) and Melchiors (2018), the WLC is a PCP technique suitable for companies that produce to order (MTO and ETO). It can also be considered as an effective method to reduce the work in process and to control the productive capacity (Land et Gaalman, 1996). Haskose et al. (2002) complement that this concept was, originally, designed for job-shop environments. The goal was to control queues in the factory, seeking to meet delivery dates based on the available manufacturing resources.

According to Fernandes (2007), the full functioning of WLC is based on the relation between load and time.

The main logical premise of the WLC is that, by keeping the waiting queues small and constantly under control, waiting time and lead time will also be controlled, thus providing support for delivery dates and the consequent attendance of these queues (Fernandes, 2007; Melchiors, 2018).

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The conditions of diversity and flexibility, which can be verified in the production environments to order, make difficult the use of planning strategies linked to the philosophy of Just in Time (JIT), justifying the importance of WLC (Kingsman et Hendry, 2002).

2.2.5 POLCA

In environments with constant changes, where there is a wide variety of possibilities for customized products, the concepts of a pulled kanban are no longer meeting the needs of the companies. Based on this, Suri (2018) developed the POLCA technique, presented in his book Quick Response Manufacturing (QRM). According to Suri et Krishnamurthy (2003), the POLCA technique is a hybrid materials control mechanism, that is, pulled and pushed, which combines the drawn carton system of Kanban with the pushed system of MRP. Collaborating with this view, Stevenson et al. (2005) complement that the use of the said technique provides the reduction of production lead time.

Despite presenting characteristics similar to Kanban, there are some differences, such as the movement of the cards, which in this technique occurs inside the workstations, while in the POLCA system this movement happens between the stations (Suri et Krishnamurthy, 2003).

According to Suri (2018), it is a production control system suitable for environments that use the ETO system. In addition, the POLCA technique also finds applicability in companies that tend to offer customized products with smaller batches and to companies that little personalize their products, but present a varied *portfolio* of goods that should not or cannot be stocked. This system is still considered incipient, mainly in relation to its applicability, requiring further studies (Stevenson et al., 2005).

2.2.6 Constant Work in Process (CONWIP)

For Fernandes (2007) and Yann et al. (2017), the concept of CONWIP is related to the control of inputs and outputs proposed by Wight (1970), but with the main objective of controlling WIP, not the productivity. It is also a method to limit the amount of work, since the release of new orders to the factory is only authorized after the completion of previous activities and the consumption of finished products (Fernandes, 2007; Yann et al., 2017).

According to Spearman et al. (1990) and Yann et al. (2017), CONWIP is an alternative to extend the scope of JIT concepts, especially a repetitive production system, to environments where these concepts are not considered adequate. However, according to Stevenson et al. (2005), CONWIP would not be the best technique for job-shop environments, but tend to be more successful when deployed in flow-shop environments. In addition, there is a question as to the effectiveness of the hierarchical control system of the technique at the moment of the entry of the tasks in production (Hopp et Spearman, 2000).

2.3 Final considerations of the theoretical framework

At the end of the literature review, one can see the emphasis of each technique in relation to its focus in the scope of production planning and control. As delimitation, this work used such foci as the main form of differentiation between the techniques (Figure 1). The establishment of this focus at the managerial level is important because it tends to guide the actions related to the company's PCP.

Technique	Focus
Kanban	Inventory reduction
MRP	Control of materials
DRB	Production limiting management
WLC	Control of productive capacity
POLCA	Lean production reduction
CONWIP	WIP Reduction

Figure 1. Main focus of each PCP technique
Source: Adapted by Van Berkel (2006)

In addition, it was possible to identify and characterize the four production environments (ATO, MTS, ETO and MTO) and the influence they exert in choosing a PCP technique.

Thus, based on the review carried out, parameters related to the productive activities developed were established, such as productive capacity, inventory control level, product variety, product structure complexity (Bill of material - BOM) and routs and customization made available (Figure 2), which are related to PCP techniques and that, according to each production environment, can influence, in a positive or negative way, the choice of a specific technique (Jonsson et Mattsson, 2003). Corrêa et Corrêa (2016) commented that for a correct choice of the PCP's form of operation, such parameters need to be taken into account.

These parameters formed the basis for the identification of the main dimensions of this study, thus serving as a reference for the research instrument. They were

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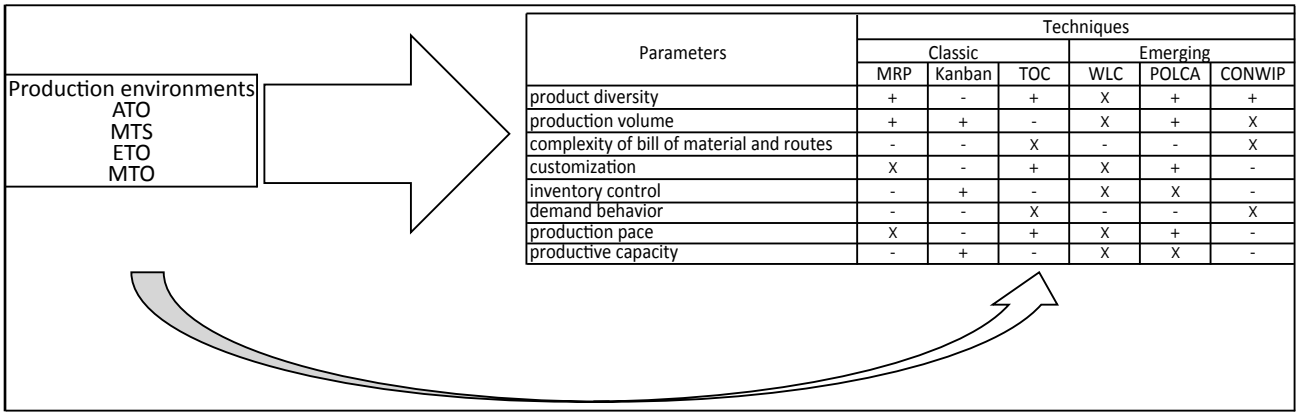

Parameters	Techniques					
	Classic			Emerging		
	MRP	Kanban	TOC	WLC	POLCA	CONWIP
product diversity	+	-	+	X	+	+
production volume	+	+	-	X	+	X
complexity of bill of material and routes	-	-	X	-	-	X
customization	X	-	+	X	+	-
inventory control	-	+	-	X	X	-
demand behavior	-	-	X	-	-	X
production pace	X	-	+	X	+	-
productive capacity	-	+	-	X	X	-

Figure 2. Relations between PCP techniques, parameters and production environments
Source: Own elaboration.

associated with the six PCP techniques discussed in this paper. Based on the work of Stevenson et al. (2005) this provided the formation of a reference matrix for the proposed study.

It is important to note that, for each technique alone, the implications and influences that the presence or not of these parameters exerted on it were verified. In this way, for each association a symbol was assigned, representing the type of influence verified, being (+) a positive or a favorable influence, (-) a negative or unfavorable influence and (X) little or no influence. This can be seen in Figure 2, by means of a generic example.

3. RESEARCH METHOD

3.1 Search feature

It is a research of an exploratory nature (Cooper et Schindler, 2016), qualitative (Gil, 2010), of the multiple case study type (Yin, 2015). In most cases, exploratory research involves a bibliographical survey, interviews with people who have had practical experiences with the problem researched and analysis of examples that stimulate understanding (Gil, 2010). In this study, we sought to understand, identify and categorize the concepts of the PCP approach, which enabled an analysis of the PCP activities under historical aspects, basic requirements and mode of operation.

The multiple case study, which presents a complete investigation of each case individually, and which, through the search of how and why, performs a deep investigation of the facts and conclusions, was adequate to the characteristics of this research involving the analysis of the environment of the companies together with the knowledge of the researcher, through an *in loco* observation, with the theoretical basis (Yin, 2015).

As a delimitation of the work, it should be pointed out that the proposal consisted of the analysis of eight organizations that formally employ the PCP activity and that belong to the metalworking sector of the Serra Gaúcha. The choice was made by the industrial vocation of the northeast region of Rio Grande do Sul, which has been consolidated as an important industrial axis. The work was carried out in 2013.

For each environment, two companies were selected. For reasons of confidentiality, the name of the companies will be preserved, and they will be named according to Figure 3.

Company	Production environment
Companies 1 and 2	custom assembly (ATO)
Companies 3 and 4	production to stock (MTS)
Companies 5 and 6	Custom Design (ETO)
Companies 7 and 8	Custom Production (MTO)

Figure 3. Production environments of sample companies
Source: Own elaboration.

The companies were chosen because their production environments meet demand, as suggested by Vollmann et al. (2006) and Lustosa et al. (2008).

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3.2 Research Model

After choosing the sample, the research proposal consisted of delimiting, within the industrial environment of each company, two visions and perceptions about the PCP:

a) Vision from the point of view of the management area of PCP;

b) Vision from the perspective of the PCP operational area.

This division reflects the need to capture the data in the most reliable and unbiased way possible, without the strong influence of the parties involved, or by the author of the paper. For this, different research instruments were used in each of the three interviews conducted with each company, as follows:

a) 1st interview - initial contact with the managers: an opportunity to explain the research and to know some characteristics of the companies;

b) 2nd interview: establishing the focus of the PCP, through a semi-structured interview with the managers;

c) 3rd interview: observation of the practice, through the application of a questionnaire with closed questions to the PCP operating area, in addition to participant observation.

Each of the interviews with the professionals was carried out individually on different days. In this way, it was possible to identify the different perceptions between the focus of the company's PCP and the established practice in its productive environment.

As delimitation, this research defined the professionals who act in the strategic part and in the command of the PCP area as a management area of PCP, since these professionals are responsible for the managerial actions and the long-term planning of the area. Regarding the operational area, the professionals who were exclusively involved in the activities and functional tasks of PCP were considered.

4. RESULTS

Eight companies located in Serra Gaúcha with different characteristics, mainly because they were framed in different production environments, were analyzed.

Figure 4 presents the main characteristics of the companies studied based on the questions that were part of the research instrument.

4.1 PCP focus adherence with the reality of the company

4.1.1 Company PCP Focus

A semi-structured interview was conducted with the PCP managers of each of the companies. The objective of this interview was to know the focus of the PCP determined by the management of the company, which chose one of the six available focus possibilities, as shown in Figure 3. Each of these six possibilities of focus has an association with a specific PCP technique, also presented in Figure 3. Thus, Figure 5 presents the focus established by the managers of each company and the associated PCP technique.

Company	Size	Capital	Environment	Variety of products	Production volume	Customization	Production
Company 1	average	foreign	ATO	small	small	low	pushed
Company 2	small	national	ATO	average	small	low	hybrid
Company 3	average	national	MTS	large	large	low	pushed
Company 4	average	foreign	MTS	large	large	low	pushed
Company 5	average	national	ETO	large	small	high	hybrid
Company 6	average	national	ETO	large	small	high	hybrid
Company 7	large	national	MTO	average	average	average	pushed
Company 8	average	national	MTO	average	average	low	pushed

Figure 4. Differences in business identification

Source: Own elaboration.

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Company	Company PCP Focus	Associated PCP Technique
Company 1	material control	MRP
Company 2	lead time	POLCA
Company 3	material control	MRP
Company 4	capacity	WLC
Company 5	lead time	POLCA
Company 6	lead time	POLCA
Company 7	bottlenecks	DBR
Company 8	material control	MRP

Figure 5. Company PCP Focus
Source: Research Data.

Knowledge of the company's PCP focus is important for later comparison with the practice verified by the values obtained through the application of the questionnaire. It is important to emphasize that the establishment of the focus was not determined by the attribution of values.

4.1.2 Discussion on adherence focus and practices of PCP

According to the criteria established for this work, only adherence between the focus and the practices of the PCP in the company 5 (ETO) was observed. The technique that stood out in both scenarios was the POLCA, related to the control of the production lead time. This search for better control of the lead time is considered by the company 5 as the main differential due to the characteristics of the company, especially the great possibility of customization, and can be perceived both at the operational level and in the management level. This adherence tends to provide competitive advantages to the company.

In the other seven companies, no adherence was found between the focus and the practices of the PCP, according to the criteria established by this work. This result may be due to the difficulty of aligning guidelines and information between the management and the operational level. It may also be due to some incomplete perceptions of PCP found in these companies that, for example, were considering some techniques, such as MRP, just as software. Figure 6 presents a summary of the adherence between the focus and the PCP practices observed in the sample companies.

Production environment	Company	Focus adherence and practices of PCP
ATO	Company 1	lower adherence
	Company 2	lower adherence
MTS	Company 3	lower adherence
	Company 4	lower adherence
ETO	Company 5	greater adhesion
	Company 6	lower adherence
MTO	Company 7	lower adherence
	Company 8	lower adherence

Figure 6. Summary of the adherence between the focus and the practices of PCP
Source: Research Data.

This lack of adherence can be aggravated by the use of software that suggest universal PCP control methods, without taking into account the reality and characteristics of each company, in addition to having greater availability of supply in the market. However, the values of some techniques were close to the technique that obtained the highest score, which suggests that they cannot be disregarded.

5. DISCUSSION

Based on the results obtained through the application of the research instrument for professionals in the PCP area of the companies of the sample, it was found that the values obtained for the POLCA and CONWIP techniques differ little and, in two of the companies, such values were identical. In addition, the values for the POLCA and CONWIP techniques were positive for companies in all production environments, except the MTS, which suggests a compatibility with these environments. However, the limited amount of studies on such techniques, as commented by Stevenson et al. (2005), may have influenced the research instrument in a way that it has failed to capture the essence of these techniques. As a result, further analysis is needed.

In the companies of the ETO production environment, the values obtained showed a large amplitude: for the classical techniques MRP and Kanban presented a strong negative trend, whereas the emerging techniques - WLC, POLCA and CONWIP - presented a strong positive trend.

Moreover, in all companies, although a technique presented the highest positive score, the values obtained from the research instrument also showed positive results for other techniques, which suggest a combination between them.

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Another point to be emphasized is that the results verified in some techniques, for some companies individually or for production environments, presented great amplitude, which suggested a high or low compatibility. Thus, they were categorized as being many positively accented (scores greater than or equal to 20) or negative (scores lower than or equal to -20), or as being attenuated, with values between 20 and -20 and that were considered as moderate (Figure 7). As an example, the values found for Kanban and MRP were negatively accentuated for the ETO companies, suggesting an incompatibility of the systems adopted by these companies with such techniques, whereas for the MTS companies the values established for the Kanban and the MRP presented a positive accentuation, which tends to favor the use of these techniques.

As these results are within the expected by the scores determined for this work, based on the literature, it is suggested that the research instrument was able to correctly capture the essence for these techniques.

6. CONCLUSION

The main objective of this study was to validate an instrument developed to assess adherence between PCP approaches assumed as the focus of companies and practices verified in their productive systems.

The identification and characterization of the different classification types of the PCP approaches discussed in the current literature were presented, highlighting the MTO, MTS, ETO and ATO production environments. The six PCP techniques studied in this study were also identified and delimited, three of them (MRP, DBR and Kanban) belonging to the classical PCP approach and three others (WLC, POLCA and CONWIP) to the emerging PCP approach. The selected techniques presented characteristics that could differentiate them from each other.

These six PCP techniques were discussed according to the theoretical framework. PCP categorization parameters were identified, including the variety of products, the capacity of the production resources, the inventory control and the customization available, which are important for choosing the PCP technique. These parameters were used for the elaboration of an evaluation instrument to verify the adherence of the PCP approaches, associated with the six techniques and the four production environments. This association consisted in the use of scores, which allowed trend identification for each technique, and which showed compatibility with the analysis of the results.

A semi-structured interview was conducted with the managers to verify the focus of the company's PCP and applied a questionnaire with closed questions to PCP specialists from eight companies in the metalworking segment of Serra Gaúcha, in order to identify the company's PCP practice. These interviews were conducted separately, and it is possible to minimize interference between the parties, in order to favor the understanding of each one of them.

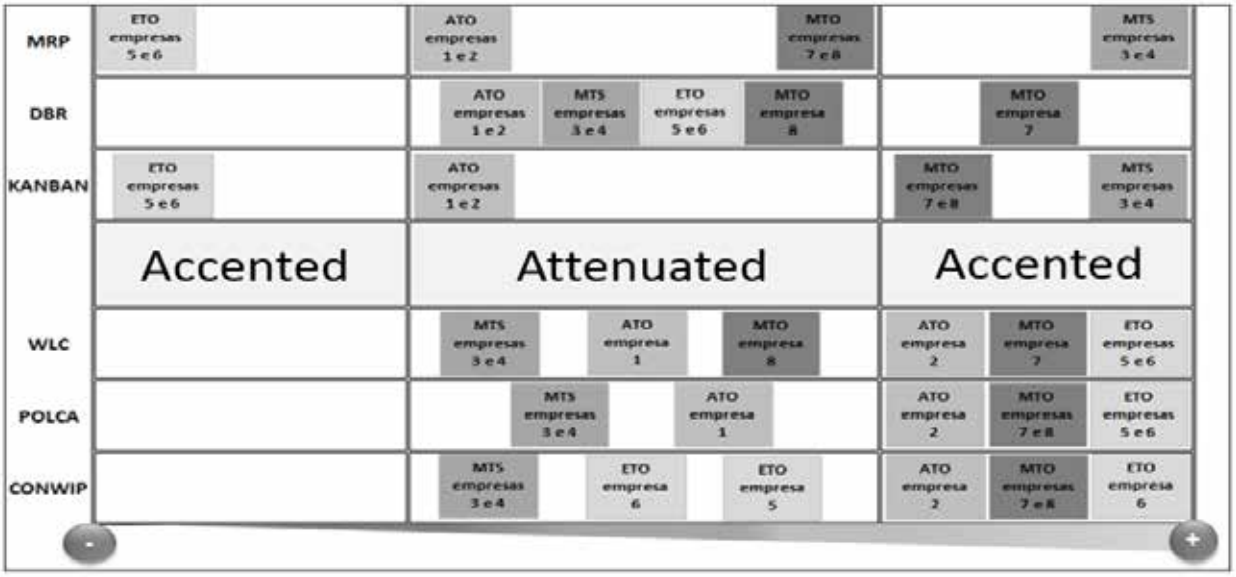

Figure 7. Amplitude of results by company
Source: Research Data.
Legend - empresa: Company

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The eight companies chosen – two from each production environment – were appropriate for the study, since their production environments are well defined. The research carried out with the managers was adequate for the knowledge of the focus of the company's PCP and the research instrument was able to capture the reality of the PCP in production environments.

The results obtained through the application of the research instrument referring to the individual analysis of each PCP technique were presented and then the consolidated results observed by company were demonstrated, verifying the adherence between the focus of the PCP determined by the managers with the practices observed in the production environment. However, since the adherence between focus and practice was observed only in a company, there is a possibility that the instrument could not capture this adherence, which indicates the need for greater compliance through a review of its parameters and of the questions asked.

For future studies, it is suggested refinement of the research instrument using resources of computer programs, with the intention of carrying out simulations with real data of companies; and the analysis of the specific questions directed to each technique.

In addition, although this study prioritized the search for relationships between production environments, it is recommended to perform one test per segment and, also, the replication of the proposal to other companies.

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