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Scientific Literature on Production Planning and Control: A Bibliometric Analysis

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***Abstract*—** *Learning about the subjects of PPC (Production Planning and Control) for students of production and administration engineering in an emerging economy like Brazil is extremely important. This paper emphasizes the foundations of the phases that encompass the hierarchical stages of the PPC, from the strategic level to the operational level: Sales and Operations Management (S & OP), Aggregate Planning, Master Planning, MRP I (Material Requirement Planning) . Through a qualitative and quantitative approach, this paper makes use of bibliometrics intrinsic to its methodological aspects. The Web of Science database and the Nails software are used to obtain the research resources, which is used to foster and select the theoretical framework of the most pertinent themes of the specific literature of PPC, exposing the main scientific works of international relevance and the state of the art and innovations about the theme. At the end of the article the conclusion about the theme is engendered in the rational aspect of the scientific literature of PPC and its methods of teaching learning in the Brazilian universities.*
***Keywords*— Production Planning and Control; PPC; Teaching-learning.**

I. INTRODUCTION

Taking as context the university teaching-learning model, practical programmatic content, such as the PPC (Production Planning and Control), can have its improved approach by increasing the efficiency of teaching learning. One of the most unspoken ways of achieving good performance in classrooms is by defining a quality scientific literature.

The themes inherent in the content of PPC addressed in university halls and laboratories should follow not only the basic theory founded by traditional authors, but also the progress and trends that occur in the practical field.

Entering this practical field, we have most of the organizations inserted in a market scenario of high competitiveness. This requires managers to continually update on new technologies to master large amounts of information and gain assertive decision-making amid increasing amounts of variables.

In this way, it becomes necessary to develop efficient strategies of acquisition and use of information to achieve organizational effectiveness and adapt to the speed with which the market environment progresses.
Senior management's primary focus for anticipating future actions and making the right decisions should be to understand the greater number of aspects of the organization and the environment in which it operates.

That is, to plan the chain of aspects intrinsic to the capacity of production (supply) and also aspects related to demand. PPC, which is encompassed by ERP (Enterprise Resource Planning), responds to the decisions of top management by promoting improvements in their production processes.

The development of a theoretical framework about PPC ando realization of PPC bibliometrics considering the impact factor of the articles in order to classify their relevance are the major objectives of this paper.

The paper's structure is divided into: Introduction; Background; Method; Webibliomining Analysis; Conclusion and finally, in the last section of the dissertation the Bibliographical References in alphabetical order are displayed.

II. LITERATURE REVIEW

Following its line of research on Workload Control, Stevenson (2006) focuses on this article in significant conceptual refinements to improve the applicability of the approach methodology to the factory floor characteristics found in practice. The first step is centered on the development of a decision support system based on the concepts of WLC designed for make-to-order companies.

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The proposed refinements include changes in the scheduling procedure (of jobs) and the way the jobs are thrown on the factory floor; The problems addressed include grouping machines and determining productive capacities. Using a case study of a real company, the article describes the strategy taken for the successful implementation of the concept of Workload Control, thereby optimizing aspects relevant to the operational sphere of Production Planning and Control of the organization.

Following a similar research line to Stevenson (2006), Hendry et al. (2008) also discusses the Workload Control, addressing its importance to the operational levels of PPC in manufacturing environments subject to demand uncertainty (such as in the make-to-order industry, for example). This paper explores two parallel longitudinal WLC empirical empirical projects in which both have chosen to incorporate the same decision support methodology, providing an ideal platform for cross-comparison.

Another similarity with Stevenson (2006) is that the article focuses on theoretical refinements that need to be made for both cases. The article justifies the need for refinement of Workload Control processes, reporting the time elapsed since the development of the original methodology and the rapid changes in the scenario that occurred; and due to specific characteristics of the companies. Finally, the article also reflects a number of common and routine implementation difficulties for both case studies, providing information on how this could be avoided in the future.

According to Silva, Almeida and Roque (2006) the presentation of MAPP, "Mold: Assistant Production Planner", a decision support system for the mold industry. Therefore, we see that although relevant, the article deals with very specific organizations (mold industry) within the defined macro-field of Production Planning and Control. MAPP approaches the PPC methodology based on the concept of Workload Control, adapted to the context of the mold industry, under a case study of Rapid Prototyping. The objectives of the paper are to present a discussion of the functions of the system at the service of the planning methodology and explain the development decisions in the socio-technical context of the case study company.

On the other hand, the authors Land & Gaalman (2009) aim to provide a deep picture of how existing concepts of PPC fail in small and medium-sized companies through in-depth empirical evidence of research or observations. The case study covers seven companies. In order to distinguish between common problems and specific elements of the company, a comparative analysis was carried out in all cases.

The analysis shows that a significant proportion of PPC problems are tied to a limited set of decision points in the order flow. In addition, most performance losses can be perceived before an order is thrown on the shop floor. Such PPC problems identified as common to the companies studied (which occur prior to the release of orders) were: inadequate capacity planning surveys to support sales decisions; and uncontrolled delays in engineering. The observed problems that appear after the launch tend to be more diverse and specific to the company.

Zäpfel and Missbauer (1993) explain that a considerable number of computer-aided PPC systems were already offered, most based on known MRP logic. As such systems often led to unsatisfactory results, several new concepts for PPC systems were developed. It is noticed that, at the time of the article, there was poor condition of control of information compared to the present day. Therefore, the authors basically describe the concept of traditional PPC and review the concepts available for practical application.

Hendry Huang and Stevenson (2013) presented an implementation of the comprehensive Workload Control concept was presented through longitudinal research using a contingency-based approach to ensure alignment between the company (case study) and the characteristics of the WLC approach; and the expected improvements in performance.

Such improvements include: reduced leadtime; significant improvement in the delays of materials, machinery and labor; reduced costs; improvement of internal and external coordination; and higher quality products. The article also shows that the choice of improvement priorities is related to very particular aspects of the company and cites that trust was a more important competitive priority in this company than speed; and therefore WLC's ability to reduce deadlines has not been fully evaluated. Comprehensive WLC approaches are aligned with the context of wide range / low volume custom manufacturing companies.

As we could realize, the PPC's theme is very wide and represents a large variety of applications services in industries. Next section, it will be presented the methodological structure of this paper.

III. METHODOLOGICAL ASPECTS

According to Ciribelli (2003) the definition of research focuses on the act of investigation from a problem situation; Its purpose is to broaden the understanding of a particular research topic, maximizing scientific knowledge, improving or developing new theories, and characterizing new principles.

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In the view of Rampazzo (2005), research is an activity focused on the solution of problems through the processes of the scientific method; It is characterized as a reflexive, systematic, controlled and critical procedure that allows discovering new facts or data, solutions or laws, in any area of knowledge.

For the present dissertation we used the methodology of bibliographic research that, according to Gil (2002), is developed from an already elaborated material, consisting mainly of books and scientific articles.

In this paper, a qualitative research was carried out. The principle of representativeness presented by Bardin (2011) (quoted by Santos, 2012) was obeyed, where a representative sample of relevant content from a consulted bibliographic universe was extracted rigorously. The quantitative approach also characterizes this work in the webibliomining review where the Web of Science database, an important source of scientific studies of international relevance, was used.

For the background formulation, it has been prioritized the most relevant publications in the literature, elementary quotations that offered a concise basis of understanding for the themes also had greater freedom outside the chronological limit because they represent information of high relevance and therefore enriching the body of the present article.

3.1. Webibliomining development

The advent of the Internet and the electronic databases have indicated the variation of the term bibliometry for the terms: webmetrics or webmetrics; and, informetria or informetrics, both with own metrics associated to the research through Internet, such as: number of citations in the internet; number of accesses to articles; and, number of downloads, among others (COSTA, 2016).

In the spectrum of bibliometric analysis as a tool, Wormell (1998) classifies the five main types of methodology used as: citation analysis; co-citation analysis; bibliographic grouping; co-word analysis; and "webmetry". In this work the focus is on the methodology of citation analysis and, for this reason, it will specifically focus on this type of study, in its origins, potentialities, applications and limitations.

Regarding the approach of this dissertation project, this can be defined as qualitative and quantitative. This fact implies in qualifying and quantifying the data obtained through information collected through observations, organizational documents and data analysis.

An example of this is the natural subjective behavior of the researcher in relation to the relevant content generated by the bibliometry of the subjects carried out through the Web of Science database and classified by the Nails software. That is, relevance data are generated quantitatively by this software, which analyzes the number of citations and the impact factor of the articles to rank them in order of importance for the research.

However, the subjectivity of the researcher engenders the qualitative character of the research approach when the articles that have greater affinity with the project theme are analyzed, among those considered relevant in the first quantitative analysis.

IV. WEBIBLIOMINING ANALYSIS

From the use of the bibliometric research feature of relevant scientific articles in the renowned Web of Science database, it is possible to determine the state of the art in the literature on Production Planning and Control as well as its authors and most important study fronts .

One of the most notable aspects of PPC processes is the decision-making model, which according to Erol & Nakiboglu (2017) is relevant in the process that seeks to solve the problem through the generation and evaluation of alternatives and finally, the choice of the best taking into consideration an organization that is oriented towards profitable and efficient results.

The importance of decision-making can also expand to its implementation and control the decision-making process to determine when additional decisions are required. In this case, decision making becomes practically synonymous with management.

In a reference model, with the objective of promoting the learning of the concepts of Production Planning and Control, the decision making enters as one of the main philosophies, since it is an inherent attribute at all levels of PPC and its relevance is easily understood in the concept holistic approach of the planning in question.

Another attribute of such a reference model would be mathematical models adjacent to the (complex) levels of planning, such as mathematical and computational models of inventory.

Nahmias (1997) explains that inventory theory naturally comprises inventory models because of their high complexity of variables. Such models have as their main objective to minimize the total cost of this and to balance the economy of large orders or large production launches against the cost of maintaining the stock and the cost of scarcity.

Still speaking about inventory, but to a greater extent, we have the Supply Chain Management that is an essential part of the PPC methods. Based on data from an international survey of 322 companies in the metal-

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mechanic sector, Frohlich and Westbrook (2001) show a positive correlation between the degree of integration of the PPC processes and the performance of the supply chain. This fact corroborates for the establishment of the Supply Chain as one of the foundations of the PPC.

In the specific case of scientific literature about Production Planning and Control, we have the first result for the analysis, the production of articles of this theme over the years, as can be seen in figure 01.

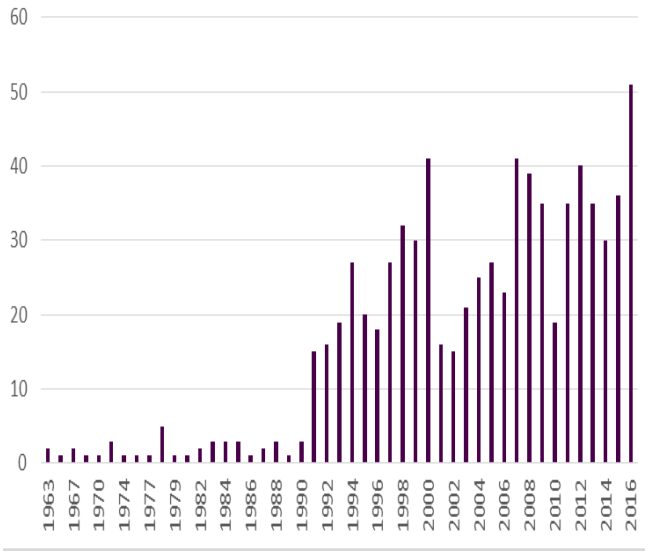

Fig. 1 : PPC articles published per year

There are conditions to notice a huge increase in the production of articles on the themes of PPC from the 1990s. This can be explained, in a cause and effect model, by the intensification of market competition between organizations. With the advent of new technologies it has become plausible and tangible to control more and more variables that affect a company's value chain.

In this context, Girotti and Mesquita (2016) explain that value generation in an organization is dependent on its competitive priorities such as: cost, quality, flexibility, and delivery service; which are like the final variables of business strategy.

Based on this understanding, it is possible to formulate the hypothesis that in the 1990s, there was greater availability of equipment to improve Production Planning and Control, and also, there was a greater need on the part of the organizations to develop in this subject on account of the evolution of competition in the market.

Thus, managers began to explore more and more the data and variables of their organizations..

Another characteristic about the themes of PPC and its correlates that is also observed in the production of scientific articles per year is the lack of regularity in the quantity of articles during the years, after the 1990s.

One of the possible explanatory bases for this result in the graph is to highlight the dynamism of the PPC processes in the industry. The market is rapidly advancing as companies incessantly pursue new methods and procedures in the constant attempt to outdo competitors; or stay at the top, dominating the largest share of sales in the market.

Such market competition can provide a kind of acceptance by managers to try to approach PPC-related philosophies, such as APS, which provides differentiated guidelines for PPC, but which aim to achieve the same ultimate goal of managing production with maximum possible efficiency in its factors.

These factors are described by Mesquita (2008) as reducing production lead times, reducing inventory costs (raw materials, consumables and final products), reducing production costs (idleness, overtime, subcontracting), compliance and agility to respond to changes in demand.

It is beyond the scope of this dissertation project to delve into issues related to the PPC, so we will use the fact that these themes exist only as a plausible justification for explaining the variation in the quantity of scientific articles produced since 1990.

Regarding the most relevant authors for the PPC themes, the list of the most cited authors generated by the Nails software was obtained from the bibliometric research data in the Web of Science database. The result is given in figure 02.

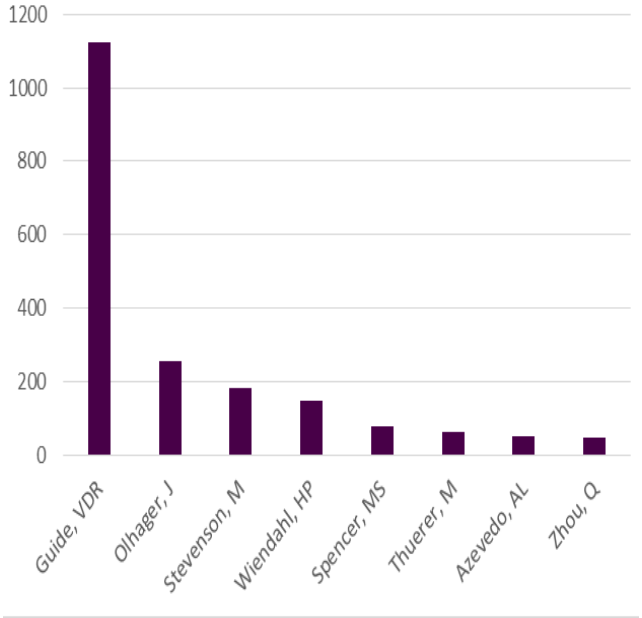

Fig. 2 : Most cited authors on PPC themes

The most cited author, and consequently the most relevant to the fronts of study of PPC themes, VDR Guide addresses the issue of the concept of remanufacturing (remanufacturing), where processes of

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the philosophy of PPC have to be remodeled to fit a line with some particularities.

Expanding the explanation of remanufacturing and exploring its theoretical concept, we have that this is consistent in production models where the organization has as input the product used and occurs the transformation of it with activities of disassembly, maintenance, repair of damaged parts and cleaning. The output, in a simplistic approach would be the same input product, however, refurbished, restored, remanufactured.

According to Gray and Charter (2006), a product can only be considered remanufactured when it is conditioned to the same specification of the original manufacturer from the perspective of the consumer.

Thus, a remanufactured product or component can be defined as one that can be brought to the condition of new after being used (or discarded) by the consumer. An example of a remanufacturing process model is given in figure 10.

In the view of Guide (2000), the most cited author, remanufacturing represents a greater form of value-added recovery than material recovery, that is, recycling.

Remanufacturing systems are common and profitable in the United States. However, the author discusses that the management of PPC activities in the remanufacturing processes may differ greatly from management activities in traditional manufacturing and, through his scientific research, proposes a PPC model adapted to this.

Another author considered relevant in the bibliometric research carried out is J. Olhaguer, professor of Supply Chain Management at Lund University. His research is naturally based on topics related to efficiency in supply chain management.

In his main work, Olhaguer (2003) discusses the Order Penetration Point (OPP). According to the author, the OPP defines the moment in the value chain where a given product becomes linked to a specific customer order.

Different manufacturing environments (make-to-stock, assembly-to-order, make-to-order, engineer-to-order) relate to different OPP positions. In these different ways, PPC displays varied strategies in delivering products, having different implications for manufacturing objectives such as customer service, manufacturing efficiency and inventory investment.

Finally, as the third most cited author, we have Stevenson (2006) that explains different approaches to PPC based on methodologies such as Kanban, MRP II, Theory of Constraints, among others.

This author considers factors such as the importance of the step of analyzing customer demand, company size, degree of customization and factory floor configuration and shows that they play an important role in the applicability of PPC concepts.

In this way, the aspect of raising awareness of researchers and professionals for the flexible options offered by the PPC philosophy to aid in decision-making in the selection of the management model is addressed. The same author stresses the importance of a clear implementation strategy for such a model.

There is, therefore, a dynamism inherent in PPC practices. For the creation of a reference model that serves as a teaching and learning tool on the subject, one should address its basic conceptual principles and foundations.

However, the various processes and their variables (depending on the type of industry, market, production) that impact the final PPC model for a particular organization should also be mentioned in terms of dynamism, flexibility and mutability.

As for the most relevant articles (classified according to the impact factor of the Nails software), we have, besides the authors already cited above, works such as that of Kingsman (2000), who lectures on Work Load Control or WLC), a PPC concept available for practical operations.

According to the author his principle is to control queues in front of the workstations on the factory floor by means of rules and pre-established rules. With better control of waiting times in the overall manufacturing, queues are kept short, increasing the operational efficiency of the organization.

In addition to the objective of controlling the workload and queue length in front of workstations on the shop floor, it is desired at the same time to process the products in order to meet the promised delivery dates with machine and machine capabilities and capabilities. available.

Macro specific aspects inherent to the theme are also frequently cited as: Workload Control and Supply Chain Management. These aspects guide the concept of PPC to be used. Be it a more operational approach such as the WLC, or a more strategic one such as Supply Chain Management.

Basic actions of PPC processes also appear as the most cited words: Optimization and Simulation. And finally, we have Remanufacturing and Make-to-Order as specific production styles often cited in scientific articles on bibliometrics.

Having knowledge about the themes of PPC through the resources obtained from the bibliometric research carried out, one has the necessary knowledge base to foment the structuring of the content that will be

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present in the reference model for the learning in said subject.

V. CONCLUSION

In this paper, it was reflected on the reference of the relevant scientific literature on PPC available for Brazilian students.

In the context of universities, especially those located in countries such as Brazil, where production activities are more operational and focused on Production Planning and Control (PPC). The PPC is responsible for the good planning of activities and resources that will directly influence the availability of the final product to the clients, as well as the economic aspects for the company.

This process is responsible for surveying demand, production planning, capacity planning, materials management, production scheduling, etc. Improvements achieved in terms of PPC can turn in competitive advantage for manufacturing companies in particular.

Most companies, especially small and medium-sized ones, are aware that they must improve their management of PPC activities in order to obtain reductions in time and work in process, thereby achieving greater operational and economic efficiency. However, for the authors, organizations simply do not know how to do this, since the vast majority of research and solutions for PPC are focused on large and complex companies.

In order to become competitive in the industrialized world Brazilian should first become in how efficient the scientific literature use has to be.

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