Model Proposal to Evaluate the Quality of a Production Planning and Control Software in an Industrial Context

Ricardo M. P. Gonçalves[1(✉)], Maria L. R. Varela[1(✉)], Ana M. Madureira[3], Goran D. Putnik[1], and Jose Machado[2]

[1] Department of Production and Systems, University of Minho, Braga, Guimarães, Portugal
pg32968@alunos.uminho.pt, leonilde@dps.uminho.pt
[2] Department of Mechanical Engineering, University of Minho, Guimarães, Portugal
[3] School of Engineering, Polytechnic of Porto (ISEP/IPP), Porto, Portugal

Abstract. The domain of Production Planning and Control, or in a broader sence Production Management has been deserving a special and increasing attention by the companies, which intend to continuously achieve better results through continuous improvement, which also fits in the context of Industry 4.0. Companies tend to implement management systems with the purpose of achieving greater competitiveness and, consequently, greater sustainability in their sector. The selection of the appropriate production management system is a serious problem for the companies. The main objective of this study is to support companies in the correct choice of a Decision Support System. The method used to achieve the proposed objective consists on formulating a model for comparing functionalities and specifications, where selection of criteria were also defined and analyzed. Based on a large Company scenario, the model is applied to three production execution systems: SAP PP (Systems Applications and Products - Production Planning), Prodsmart and GenSYS.

Keywords: Production management · Production management systems · Production planning and control · Decision support systems · Comparative analysis

1 Introduction

Society is currently very strict and complex, which makes it difficult for companies to meet customer expectations, thus increasing the competitiveness and complexity of markets by giving companies greater flexibility and speed of response, as well as a rapid take-up [1].

The increase in the number of pieces produced does not necessarily translate into increased profit, if this increase does not result from the use of more efficient production processes that are able to handle the needs of the most diverse products, in different amounts and moments of time. Therefore, in order to achieve these objectives, companies must design their production systems so that they can plan, program and

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control the entire production process. Thus, it becomes possible to have a detailed knowledge of the productive processes and their variables, allowing the detection of opportunities to improve the productive activity and increase the companys' performance.

Currently, the different hierarchical levels of an industry are well supported by the tools of Information Technology (IT), which allows the effective supervision and control of specific subsystems [2–4]. However, an obstacle to the adoption of an integrated information system stems from the lack of standards and the existence of various market solutions offered by various suppliers. These solutions, using IT, allow access to the right information, in the right place, at the right time, and in the right format [4].

The Production Planning and Control (PCP) is fundamental for improving the performance of a production system, however, it is evident that even a good PCP system may not be 100% efficient and not overcome the deficiencies of the design and organization of the same system, but in many cases dictates its survival or not in the market. It is common for the PCP not to be able to follow the evolution of production systems whose complexity is increasing, thus reducing its performance to below sustainable levels, and may often jeopardize the company's viability [5].

2 Production Planning and Control Systems

A Production Planning and Control System (PPCS) provides information to efficiently manage material flows, efficiently use people and equipment, coordinate internal activities with suppliers, and communicate with customers about market needs, along with interactions among other stakeholders and business partners. The key in this definition is management need to use information to make smart decisions. A PPCS does not make decisions or manage operations by itself - managers carry out these activities. The system provides the support for them to do it sensibly [5].

In production planning and control decision making processes Decision Support Systems (DSS) hold special importance in situations where the amount of information available is too much for the intuition of a decision maker who has no support or knowledge at all through other kind of means or persons and in situations where process accuracy and optimization are essential [2, 5]. Thus, DSS integrate various sources of information, and may prove intelligent access to relevant knowledge, while assisting in the process of structuring decisions, and thus, enable to properly support the decision making process of managers [6].

A production manager is overwhelmed with data from various sources during a decision-making process. In this way, it becomes usually a very complicated taks to extract the relevant information from the vast amount of data to make quick and assertive decisions. Therefore, the monitoring of the state of the production system, in conjunction with a well suited DSS, may provide an efficient production management process [7].

3 System Requirements Specification Model

In a system requirements specification model (SRSM) requirements are goals or constraints set by clients and system users that define the various properties of the system. The software requirements are obviously those among the system requirements that pertain to software properties. A set of requirements can be defined as a necessary condition or capacity that the software must possess so that the user can solve a problem or achieve a goal [8, 9].

In accordance to the general requisites of a SRSM, the proposed model in this work is conceived to contemplate the following issues: configuration of product structures (materials); operative ranges; costing; planning; Manufacturing Execution Systems (MES) [9].

After defining this issues, for being addressed and included in the proposed model, these were explored to analyze the required and fundamental functionalities for each issue, as shown in Table 3 set forth in Sect. 4.

In order for the model to be comprehensive for the sector in which it focuses, several exchanges of impressions and knowledge were made among several consultants of management software companies, in order to minimize the limitations of the developed model.

3.1 Selection Criteria and Parameters

Production Management (PM) software is an asset to any company, however, choosing it is a crucial and compromising decision for your future.

Therefore, due to the complexity of such decision, it is necessary to have an early study of the functionalities inherent to the company, as well as the definition of selection criteria and parameters. Such criteria may vary from company to company, however, most will be similar among them, but with different levels of importance. There are many different kind of approaches and methods that can be used for supporting a decision making process for selected a best suited software, such as is the case in this work, about the selection of a PPCS, for instance based on analytic hierarchy process (AHP) [10] The designed selection criteria and parameters used in our proposed model are shown in Table 1.

These criteria and parameters were defined considering the current scenario of the industrial sector, namely “Industry 4.0”. This concept gains an increasing weight for companies since it is an evolutionary trend, where production processes become increasingly efficient, autonomous and customizable. In this sense, the quality of the system to be adopted is also an important factor, highlighting, among the main benefits: cost reduction; greater productivity in development; deliveries more aligned with business strategies; agility of the production system to respond dynamically and flexibly to customer requests.

The agility of a production system, according to the creators of this concept, is a system with resources (technological, human and information) to respond to the changing needs of the market (flexibility, customers, competitors, suppliers, infrastructure, capacity of response, among others) [11–15].

Table 1. Selection criteria and parameters defined.

Criteria	Parameters
Cost	Determination of cost affection to the adoption of the system (CS)
Friendly features/interface	Appreciation of the software user interface (UI)
Versatility in the planning module	Contemplation of the number of functionalities of the planning module (FMP)
Ease of use	Inquiry about their intuitive ability (CP)
Methods of problems solution	Appreciation of the ways in which problem solutions were exposed (PE)
Ability to adopt solutions	Contemplation of the ability to generate solutions automatically (GSA)
Solution change ability	Observation of the possibility of adapting or manually altering the solution generated by the system (ASS)
Local use	Use of servers installed in the client company (UL)
Cloud usage	Use of servers installed in the company providing the system (UC)
Integration allow for import and exportation of data	Import and export of data in different formats (IIED)
Permission to integrate with other software	Integration of the system with other software (IOS)

Integration between systems is another relevant factor, and most of these integrations will be centralized in ERP. In this way, it is important that the software guarantees all communication efficiently and is essential to keep all the technologies aligned in a robust and reliable platform, capable of achieving the expected results [15].

Regarding the level of importance of each criterion, this varies according to the size of the company, that is, a certain criterion for a microenterprise may not have the same importance that it has for a large company. For example, for a microenterprise, the "Cost" factor will have a much greater weight when deciding which system to adopt when compared to a large enterprise.

In a percentage scale of 0 to 100, weights (percentage values) were assigned to each criterion, considering the type of company (micro, small and medium enterprises and large companies), totaling 100% in each type. The degree of importance for each selection criterion was also defined in the various company contexts, according to Table 2, represented in the last column of the table. Such value represents the total weight of the criterion, in percentage, resulting from the application of Eq. (1).

$$X = (PM + PPM + PG)/3. \quad (1)$$

Where: "X" represents total weight selection criterion, in percentage; "PM" represents the weight of the selection criterion for microenterprises; "PPM" represented the weight of the selection criterion for small and medium enterprises; "PG" represents the weight of the selection criterion for large companies.

Table 2. Weight/importance of defined selection criteria.

Selection criteria and parameters	Microcompany	Small & medium business	Big companies	Total weight
Cost (CS)	20	15	10	15
Friendly features/interface (UI)	10	5	5	7
Versatility in the planning module (FMP)	5	5	5	5
Ease of use (CP)	15	10	5	10
Scheduling methods (EP)	10	10	10	10
Other problem solving methods (PE)	10	15	15	13
Solution change capacity (ASS)	5	10	15	10
Local use (UL)	10	5	5	7
Cloud usage (UC)	5	5	10	7
Integration allow for data import and export (IIED)	5	10	10	8
Permission to integrate with other software (IOS)	5	10	10	8

It is notorius that for a large company, the most important criteria are the "Capacity to adopt solutions" and "Capacity to change solutions".

It is also possible to verify that the factor "Cost", due to its sensitive nature in the phase of adopting software, is the criterion with greater total weight in relation to the other criteria. Next, we highlight the "Capacity to adopt solutions", that is, the ability to generate solutions automatically, an increasingly important factor in "Industry 4.0", which is basically ruled through automation.

3.2 Correlation Between Selection Criteria

Regarding the selection criteria defined above, the possible existence of validations is evident, since some criteria may be influenced or interdependent of others. By observing the "Cost" factor, this can corelate with "Versatility in the planning module", and the cost may change due to the number of functionalities in the planning module. In turn, "Versatility in the planning module" can be correlated with "Ease of use", and the more functionalities the system adopts, the greater the complexity in terms of its use. The "Cost" factor can also be correlated with "Solution Capability" and "Solution Change Capability", and enabling these capabilities is a fundamental aspect of the current competitive requirements of "Industry 4.0". Thus, the factor "Cost" may fluctuate according to the existence or not of these capacities.

Table 3. Model of features and specifications and results obtained.

Features & specifications	SAP PP	GenSYS	Prodsmart
Configuration of product structures (Materials):			
Possibility of product structures contemplating alternatives	x	x	x
The need for articles to contemplate the possibility of substitution	x	x	x
Operative ranges			
Possibility of the operative ranges contemplating alternatives	x	x	x
Possibility of aggregation of products to facilitate planning	x	x	
Costing			
Disaggregation by type of materials	x	x	x
Disaggregation by type of waste	x		x
Subcontracting of products	x		
Collaborator/operation runtime	x	x	x
Runtime machine	x	x	x
Distribution of departmental costs (general manufacturing expenses) by specific criteria	x		
Cost per product	x	x	x
Cost per product/line	x	x	
Cost line	x	x	
Productivity collaborator	x	x	x
Productivity line	x	x	
Productivity line/product	x	x	
Planning			
Relation operation/execution time	x	x	x
Possibility of automatic production optimization	x	x	
Possibility of optimization simulation	x	x	
Graphical display of loads per line	x	x	x
Graphical display of loads per operation	x	x	x
Graphical display of loads by operator	x	x	x
Graphical display of overloads	x	x	x
View in calendar monitored operations by line/operation/operator	x	x	x
MES			
Integrated add-on with ERP remainder	x	x	
Graphical and intuitive graphical environment	x	x	x
Web based technology or APP	x	x	x
Optical scanning (barcode)	x	x	x
Connecting to barcode printers	x	x	x
Parametric and multi-language product design labels	x	x	x

(*continued*)

Table 3. (*continued*)

Features & specifications	SAP PP	GenSYS	Prodsmart
Possibility to connect with other equipment	x	x	
Possibility of selecting manufacturing orders to be executed on each production line	x	x	x
Association of the employee to the line and the operation and exchanges of lines and operations	x	x	x
Typical stops reports	x	x	x
Quality checks by quantity, by time, by operation and combinations	x	x	x
Association of files to the operations (videos, PDF, images)	x	x	x
Association of files with manufacturing orders	x		x
Association of files to articles to be produced	x	x	x
Possibility of selecting and viewing videos and previous files	x	x	x
Quantities produced	x	x	x
Time spent per line	x	x	x
Time spent per operation	x		x
Materials consumed	x	x	x
Real-time line state	x		x
Real-time order status	x	x	x
Real-time general productivity	x		x
Real-time line productivity	x		x
Real-time collaborator productivity	x		x
Delays compared to original real-time planning	x	x	x
Using a kanban system	x	x	
Ability to handle high diversity and quantity of articles	x	x	x
Real-time analysis of production status	x	x	x
Connection with machines	x	x	
OEE (Overall Equipment Effectiveness)	x		x
Analysis and representation of non-productive operations	x	x	x

4 Results and Discussion

The obtained information regarding the proposed model, based on main defined functions and specifications, is shown in Table 3, as well as the obtained data about the criteria and selection parameters used, presented in Table 4. These data was obtained through surveys and semi-structured interviews conducted directly with company employees of the respective software, which were employees who hold senior positionsat the corresponding companies or are expert users.

Table 4. Practical systems analysis

Selection criteria/softwares	SAP PP	Prodsmart	GenSYS
Cost	€ 300,000 + € 1500 per user + € 100 per hour of assistance	€ 1,599 month by 10 users + € 99 month per extra user	€ 200,000 + maintenance contract
Friendly features/interface	Yes	Yes	Yes
Versatility in the planning module	Yes	Not specified	Yes
Ease of use	Not very intuitive	Yes	Not very intuitive
Troubleshooting methods	Yes	Not specified	Yes
Ability to adopt solutions	Yes	Not specified	Yes
Solution change ability	Yes	Not specified	Yes
Local use	Yes	No	Yes
Cloud usage	Yes	Yes	No
Integration allow for data import and export	Yes	Yes	Yes
Permission to integrate with other software	Yes	Yes	Yes

By analyzing the data provided, there are visible discrepancies in terms of functionalities among the systems, however, SAP software stands out for its comprehensiveness, covering all the requirements of the developed model.

The GenSYS and Prodsmart software do not include some functionalities, and in general, do not include "Subcontracting of products" and "Distribution of departmental costs (overhead costs) by specific criteria".

There are some criteria where it was not possible to obtain information, however, as the Prodsmart system does not calculate the material requirement planning (MRP) and, since the evaluation parameters are linked to the MRP, it is assumed that it does not comply with the criteria without information.

Considering the factor "Cost", a factor of greater general importance, this presents a high complexity of calculation since the companies' present different and differentiated needs. However, some values regarding software implementation costs were calculated and, from these intervals, the cost for a large company was estimated.

Regarding the duration of the implementation and testing phase, for both SAP PP and GenSYS software, this can exceed 12 months, however, Prodsmart software only requires 2 months for its implementation. Considering all the data, Prodsmart is expected to have a significantly lower cost than the other systems.

Given the weight of the selection criteria for a large company, these are of major importance and are satisfied with SAP PP and GenSYS software. On the other hand, observing the lower values, SAP PP software and GenSYS proved to be equivalent, however, the Prodsmart system stands out in terms of "Ease of use".

In general, the Prodsmart system, despite being a management system, for analysis and optimization of industrial production processes, it does not meet the needs of a large company, and is a more appropriate system for small to medium enterprises. The remaining software is robust and capable of increasing the competitiveness of a large company, providing optimized and controlled production as well as other inherent positive aspects for management processes support. Thus, the "Cost" factor will be preponderant for decision-making regarding the system to use, and in this regard, GenSYS software stands out being the best suited one.

5 Conclusion

The use of robust and complete software in prouction management that correctly terminates costs and enables a clear view of business productivity is currently considered to constitute a fundamental pillar of process automation in the industrial companies.

The system developed by GenSYS, after analyzing the results obtained, is the most advantageous solution for the production sector with the underlying companies and software analysed, being capable of satisfying the needs of a large company. Moreover, is stand out to be an intelligent, flexible, powerful and fully integrated solution capable of creating solutions to guide a manager thorugh decisions based on a production planning and control system. However, for all its features, utilities and efficiency, GenSYS is currently unable to compete closely with the SAP system. SAP is so possant and is so rooted in the market that it becomes difficult for other software to compete with it, and there is even the general idea a existing corelation between the quality of management in a company through the use of this system that turns out to put SAP as a softwar in the market that acts as a kind of "brand image" of quality, efficiency and sovereignty, which is very hard to overcome by other production management software.

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