DOI: 10.5902/ 19834659 29154

IMPROVING PRODUCTION PERFORMANCE INDICATORS IN A SMALL ENTERPRISE BY IMPLEMENTING A FREE ERP SYSTEM

Received on: 22/09/2017
Approved on: 02/08/2018

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ABSTRACT

Inserted in a highly competitive market scenario, micro and small enterprises face numerous obstacles to remain in the market. Data surveyed reveal that 98% of Brazilian companies are micro and small, which shows their importance to the national economy. Thus, it is necessary for managers to effectively manage the work routine in order to improve the management and consequently the performance of these enterprises. Aiming to improve the management of the productive process of a small company, the present study aims to implement a free ERP management system focused on the improvement of production performance indicators. The research is classified as action research, with a qualitative and quantitative approach, having as procedure the case study. As results, indicators were verified before, during and after the implementation of the ERP system, and it was concluded through the measurement that the implemented system brought improvements to the performance of the researched organization.

Keywords: ERP systems; PCP; Micro and Small Business.

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1 INTRODUCTION

Improving the management process is necessary and occurs daily in enterprises. Managers base their actions on information about the organizational routine, seeking to adjust the procedures in search of improved results and of not succumbing to the competition pressures (MARQUES; OLIVEIRA, 2008).

The management of performance indicators is a strategy employed to optimize processes, focusing on the quantitative control of their result, observing the improvement or not of the operations using numbers. Thus, for industrial companies, it is essential to extend indicator management to the shop floor. Defining what must be measured and evaluated is a complex task considering the actions performed in a given sector may impact several areas of the company, thus demonstrating the interconnection between the sectors (CALLADO; CALLADO; ALMEIDA, 2007).

In addition to managing indicators, ensuring the productivity of an industrial company also depends on Production Planning and Control (PPC). According to Vollmann et al. (2006), PPC is a planning and control system that seeks to idealize the influence of all production aspects among themselves and the external environment, including materials management, machine programming, people management, and coordination of suppliers and customers.

Santos (2013) argued that PPC is responsible for the flow of information in several areas of the productive system, focusing on optimizing the employment of materials and personnel, which makes it a business activity that involves vast amounts of information capable of influencing the direction of the enterprise.

Turban et al. (2010) and O'Brien and Marakas (2013) explained that the type of information system most used for industrial enterprise management is the Enterprise Resource Planning (ERP), stemming from the fact that it covers material management and production costs. We note that the ERP comes from the Material Requirement Planning (MRP) system, which is responsible for performing the computerized control of the needs for raw materials and production inputs.

O'Brien and Marakas (2013) explained that the ERP system is an evolution of the MRP composed of a set of applications capable of integrating the enterprise processes of finance, logistics, supplies, manufacturing, sales, and human resources into a single information system. Therefore, it is possible to record data in the same storage location, producing real-time information by interconnecting the data.

Turban et al. (2010) considered that the costs and risks involved in the process of implementing ERP systems are high and that these systems are complicated. Therefore, such obstacles must be analyzed when deciding to deploy this type of system.

Micro and small enterprises (MSEs) have been prominent in several countries due to their economic relevance, especially concerning job and income generation in a scenario of global economic slowdown (TEIXEIRA, 2017).

For the author, MSEs have few funds to apply in management, so it is often impossible to adopt paid management systems due to their financial restrictions, which make it impossible for them to assume high fixed costs and high-risk ventures.

Hence, to improve the results of the production process in a small industry without generating additional costs, we decided to implement a free ERP system in a small company focused on improving its production performance indicators.

This study is justified because the application of ERP systems may help develop and consolidate small enterprises. From the scientific point of view, this study progresses the theoretical-conceptual deepening regarding the employability of free management systems and automated management processes in small industries using information systems, bringing greater clarification on how and if there is an impact of information management on company results.

2 LITERATURE REVIEW

In this section, we present the concepts and definitions that were the theoretical background necessary for developing this work.

2.1 MICRO AND SMALL ENTERPRISES (MSEs)

Microenterprises and small companies, generalized herein by the term micro and small enterprises (MSEs), are differentiated by the number of employees and by the annual revenue volume (TEIXEIRA, 2017).

MSEs stand out in the global economic scenario and are characterized by the creation of new jobs, thus contributing to the local socio-economic development. Therefore, MSEs are crucial elements for the financial growth of their cities, as well as help create jobs, transforming the reality of the region where they are installed (SANTINI et al., 2015).

Table 1 presents the classification criteria adopted by the Brazilian economy to define micro and small enterprises in Brazil.

Table 1: Criteria to define the size of Brazilian companies by the number of collaborators

SIZE	SECTORS	
	INDUSTRY	COMMERCE AND SERVICES
Microenterprise	Up to 19 employees	Up to 9 occupied people
Small enterprise	From 20 to 99 employees	From 10 to 49 occupied people
Medium enterprise	From 100 to 499 employees	From 50 to 99 occupied people
Large enterprise	500 or more occupied people	100 or more occupied people

Source: SEBRAE (2013).

One may notice that the reality of Brazilian MSEs is quite challenging due to the precariousness of their management and financial constraints. They operate with low capital amounts, reducing their bargaining power with the customers, suppliers, and funding agencies. They also suffer from complementarity and subordination relationships with large enterprises, living in the light of the decisions made by such large groups. Due to their limited payment capacity, they also have difficulties accessing working capital financing and long-term investment loans (SANTINI et al., 2015).

The authors also observed that the capital constraint results in little investment in technological innovation, which negatively influences their development. Hence, MSEs tend to stay on the sidelines of improvements such as process automation, productivity gains, and the possibility of expanding the types of products and services offered.

Moreover, MSEs have high birth and mortality rates, which characterize the vulnerability of this type of enterprise, classifying them as a high-risk investment for entrepreneurs (MACHADO, 2010; SALES; BARROS; PEREIRA, 2011).

Nascimento et al. (2013) found that the problem of high mortality rates for micro and small enterprises is complex. Often, there is no distinction between the entrepreneur's finances and those of the business in both accounting and economic terms (private individual and legal entity), and this financial relationship impairs the measurement of the operating profit or loss of the business. Also, accounting records are inadequate, hiding the actual outcome of the venture. Another management problem is the active involvement of the owners, which centralizes decision-making and narrows the bond between partners, causing management to be emotional than rational.

A common challenge for MSEs is the employed workforce. The use of family members in management is commonplace, even if such individuals lack the required qualifications for the positions. This fact is due to the restricted budget for paying wages that are adequate to the market, thus reducing the productivity of the enterprise.

Despite the challenges mentioned above, information collected on MSEs corroborates the fact that countless Brazilian citizens are entrepreneurs and expressively move the country's economy.

Table 2 shows that, of the total number of formalized enterprises in Brazil, 98% are MSEs. However, they account for only 27% of the country's GDP.

Table 2: Representativity of MSEs in the Brazilian economy

VARIABLE	ECONOMIC REPRESENTATIVITY
Number of enterprises	98%
Job creation	59%
Revenues	28%
GDP	20%
Number of exporting enterprises	29%
Value of exports	1.7%

Source: FGV (2013).

FGV (2013) stated that small enterprises employ 59% of the formal labor force in Brazil and account for 40% of the country's wage bill, thus confirming the relevance of MSEs to the economy, helping create jobs and economic movement in Brazil. Unfortunately, the data demonstrates the low profitability of these companies, showing there is a need to improve their management.

2.2 ERP SYSTEMS

The tendency in information systems is not to visualize the enterprise in sectors or isolated actions, but rather to see it as a whole to improve its performance (PADILHA; MARINS, 2005). Based on this premise, ERP systems emerged with the appeal of integrating enterprise information and of agility in executing and controlling processes.

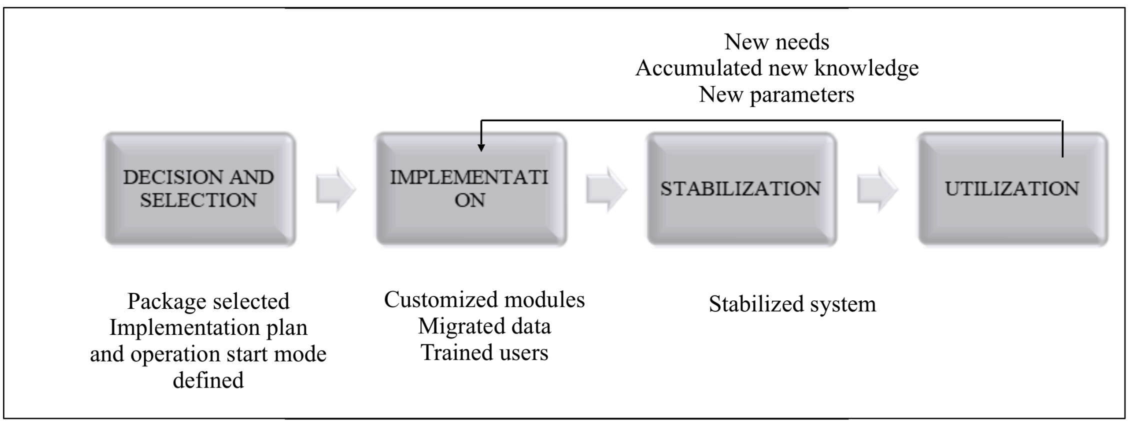
Esteves and Pastor (1999a) conceptualized ERP systems as a package of information systems composed of various operating modules such as production, sales, finance, and human resources which are integrated using a database with information on all these processes, interconnecting them and generating real-time information. Modules may be customized to meet user needs.

Chopra and Meindel (2003) explained the ERP system as an integrated system that enables a single, continuous, and consistent flow of information across the enterprise, under a single database. It is an instrument to improve business processes such as production, purchasing, or distribution, generating and registering information in real time. In summary, the system allows the complete visualization of the transactions carried out by the enterprise, drawing a broad scenario of its business.

Regarding the impact of ERP systems on the enterprises, Davenport (1994) referred to them as the most significant development in the corporate use of information technology in the 1990s. The author explained that the ERP consists of operational modules where data is stored in a central database, which may be manipulated by information from all modules when there is interaction among the processes.

ERP systems have a life cycle that consists of the various stages through which a project for developing and using them passes. To describe this cycle, we employed the model by Esteves and Pastor (1999b), later rebuilt by Zwicker and Souza (2003), who used four cycle development stages. First, there must be a decision to implement an ERP system as a solution to the information needs of the enterprise. Figure 1 shows the cycle of an ERP system.

Figure 1: Life Cycle of an ERP System



After the decision to employ the ERP and the software selection, one must plan the implementation, which includes establishing the objectives, project scope, goals, metrics, responsibilities, and the strategy for developing the project. The implementation strategy involves defining the operation start mode, the tasks that will be carried out, and the schedule, which must include considerations about deadlines and resources (ZWICKER; SOUZA, 2003).

The actual implementation is the second stage in the ERP lifecycle. It is one of the most critical due to profound changes in organizational processes and labor relations (WOOD; CALDAS, 1999; NORRIS; HURLEY, 2001; ZWICKER; SOUZA, 2003).

Upon implementation, the system modules are put into operation for the first time, so it is necessary to map and adapt the enterprise processes to the software, making the required customizations. This procedure is called parameterization. During parameterization, data conversion and the load of initial information are also performed, generating the hardware and software settings. This stage includes the tasks ranging from the end of the elaboration of the implementation plan until the beginning of the operation of the ERP system, when it becomes the definitive information management tool for the enterprise (PADILHA; MARINS, 2005).

Zwicker and Souza (2003) explained that as soon as the system begins operation in the enterprise, the stabilization stage begins. At this point, the ERP becomes a concrete object and part of the enterprise's routine. Stabilization is the moment when the biggest efforts in terms of management and techniques are made, given that it is during this stage that the greatest doubts arise and a multitude of errors occur which are generally still unknown by the operators. Hence, users understand the process as a whole and realize that the enterprise depends on the system for its activities, which increases pressure for problems to be solved quickly.

The last stage is utilization, which means that the ERP system becomes an intrinsic part of the enterprise's operations. Having the system running does not mean the users are completely or correctly employing it. However, the operators can distinguish their responsibilities on the tasks and the adjustment needs. Using this tool, managers understand the routine work procedures and get to know the value chain of the enterprise, thus acquiring more information to support decisions (ZWICKER; SOUZA, 2003).

3 METHODOLOGY

This section explains the set of norms, procedures, and rules established for performing this study. Initially, we employed the bibliographical research, since it supports the choice of the problem and determined objectives, as well as substantiates the justification for the proposed theme using materials published in books, magazines, journals, and electronic networks (GIL, 2010).

This work is a case study, given we performed a thorough and exhaustive investigation of the reported process, producing detailed knowledge with the purpose of perceiving "how" and "why" things work. It is an empirical analysis that sought to understand the phenomenon in its context (YIN, 2010).

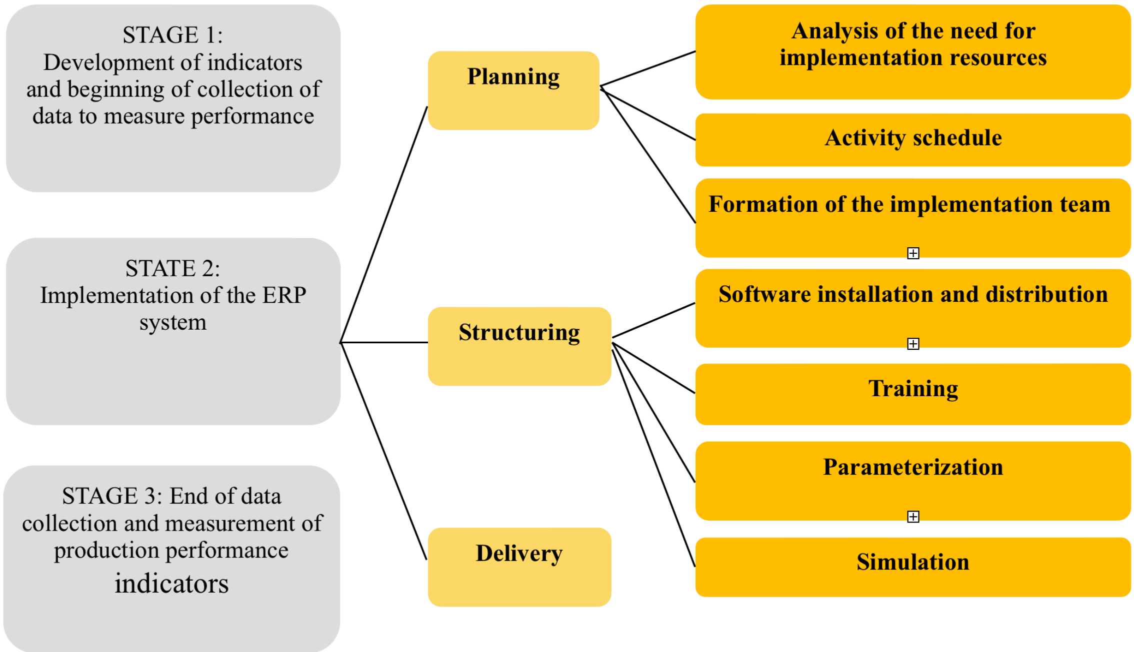
Regarding its nature, this work is an action-research, since practice has been improved by exploring the process and acting on it. In action research, the research agent is also one of its actors, modifying its results and the local reality (TRIPP, 2005; TOZONI-REIS, 2007).

As for the objectives, we consider this study as exploratory and descriptive, since we sought to explore and narrate the characteristics of a given process and the establishment of variable relations, as well as assist in solving problems, improving their practices (THOMAS; NELSON; SIVERMAN, 2007).

We employed a qualitative approach to mapping processes and delineating the research problem, as well as quantitative analysis to establish the efficacy of the applied method. For Fleury (2012), quantitative research uses numbers to translate opinions and information, analyzing and classifying them using numbers. Qualitative research is characterized by obtaining specific data on a large number of variables, giving the reader the opportunity to examine the experience reported in the study (STAKE, 2013).

For collecting data, we used documental research, participant observation, and structured management tools, as well as non-standardized conversations and interviews with those responsible for the progress of the study. Figure 2 shows how we structured the method.

Figure 2: Research method



Source: Research, 2015.

To achieve the study's objectives, we detailed in Figure 2 its progress in three stages. We initially developed the performance indicators that served to establish the efficiency of the ERP system's implementation. We calculated such indicators during the development of the study, with the purpose of creating a history of measured indices and evaluate their evolution.

In the second stage, the longest and most complex of this study, we implemented the chosen information system. In the final phase, we completed data collection and analysis to establish the efficacy of the implemented management system. As the object of the study, we used a small enterprise of the mechanic metal industrial sector from the central region of the state of Rio Grande do Sul, Brazil. The company has over twenty years of activity in the area and has nineteen collaborators in its labor force.

4 RESULTS AND DISCUSSION

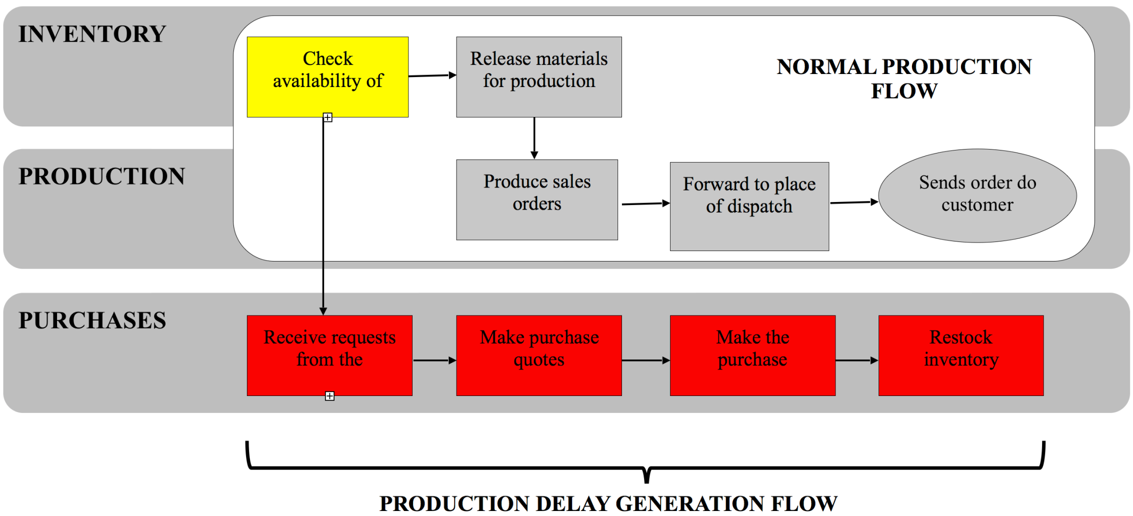
We first mapped the processes to understand the operation of the sectors, the performance of employees, the production procedures, and the management techniques used by the enterprise.

In the production department, we observed the absence of a specific information system that integrated the tasks related to product manufacturing and management of production inputs. Through documentary research, we diagnosed the existence of an information system that served the financial sector but did not cover planning and production control. The documents generated by the financial system were adapted for production management up to the development of this study. The adaptation took place as follows: the document called the "sales order" was sent to the factory manager when a product was sold. With it, the manager made the production planning of the products ordered by the customers. However, this form did not have data on the items that make up the structure of the product to be manufactured, nor did it describe the production operations, presenting only data specific to the commercial sector, such as product model, quantity, customer, value, and term payment.

Hence, the production sector was deprived of critical information about the manufacturing of the products, given that the exact amount of raw materials needed to produce a specific model was unknown and there was no automated control over the availability of the materials in the inventory. The manufacturing process depended on the enterprise's older industrial assemblers, who knew the production steps and the materials needed to build each product.

The lack of automated control of materials contributed to the creation of a time gap between the production order and the effective start of the manufacturing process, because the person responsible for the inventory sector did not have a prior planning of the items that should be in stock to meet the demands of products for a given period. This caused production delays since everything was only organized at the moment a customer bought a product, and the raw materials needed to begin production often took over ten days to arrive at the installations of the studied company. Figure 3 shows the timing of the delay in production start within the flow of the processes related to the PPC.

Figure 3: Mapping of the flow that generates the order delays.



Source: Research, 2015.

The system used also did not record the output of items from the inventory at manufacturing time. This situation invalidated the automated control of item movements since the products did not go out of inventory unless a reduction was done manually, which the operators of the old system did not do.

We also established using unstructured interviews that the studied enterprise used to employ a paid ERP system in years previous to this study. However, the company that provided the software was incorporated by a global information systems organization (TOTVS) and the software became too expensive, with over 300% increases to the monthly fees and annual upgrades. Thus, the company chose to discontinue the use of paid ERP systems, losing the automated controls of materials management and production processes. The fact that the company had previously used an ERP system facilitated the adoption of this study's theme by since the users of the program recognized that some benefits were lost when the paid ERP system was abandoned and, therefore, supported the application of this study to improve business management.

After the analyses, we established there was a real need for enhanced management of material resources and production processes, defining as the purpose of this study to implement a free ERP system focused on improving the production performance indicators.

Due to the time constraints to carry out this study, we limited the scope of implementation to a single product chosen from the company's portfolio and three modules of the chosen ERP system. Among the company's over 200 models of different products, we selected the antenna model "PV215027" because it represented the highest billing percentage in the previous twelve months of operation (between 2014 and 2015). For implementation, we selected the ERP system's manufacturing, inventory, and purchase modules, established by the researcher as those most oriented towards the management of production and materials within an ERP system.

Then, we proceeded to develop the production performance indicators and create the data collection instrument. Such indicators emerged from ideas compiled in a brainstorming meeting with sales, production, and inventory staff. Most employees cited production delays as the company's most critical problem. Thus, we developed two indicators that aimed to measure the production delay (in days) and the number of delayed orders (in percentage), in both cases considering delays due to lack of materials in the inventory. Table 3 shows the performance indicators created in this study.

Table 3: Production indicators

PERFORMANCE INDICATOR	CALCULATION METHOD
Average production delay time	Total days of delay / total delayed orders for the month
Average number of delayed orders	Total delayed orders / total orders for the month

Source: Research (2015).

We measured the indicators as follows: the person in charge of the inventory sector was given a spreadsheet listing all necessary components of the PV215027 antenna. With each order of this antenna, the inventory manager would write down the date the order entered production and then proceed to separate the items in the inventory. When a component of the antenna was in stock at the time of manufacturing, it was indicated on the spreadsheet, which was immediately sent to the purchasing sector so the missing item would be purchased.

When the missing item arrived at the company, the inventory manager would write the date of arrival on the spreadsheet. Then, we measured the time gap between the order input and the arrival of necessary materials, thus measuring the delay of the effective start of the production process as well as the number of orders delayed due to lack of materials. This data collection took place for each order of model PV215027 antennas during an eight-month period (between March and October of 2015).

Concomitantly with data collection, specifically from June to August of 2015, we implemented the ERP system at the company. We chose a free information system, following the purpose of the study. The implementation occurred in three stages: planning, structuring, and delivery. During planning, we listed the tasks required to fulfill the scope of the project, as shown in Table 4.

Table 4: Tasks for implementing the ERP system

PROJECT STRUCTURING	TASKS
Installation	Install database and software on the company server
	Register accesses (key and password) for the operators
	Examine the modules and match to the scope processes
	Study the operation of the modules
	Schedule the training sessions according to the available schedules
	Perform user training
Parameterization	Review overall features of the materials used (physical, chemical, brand, ...)
	Group the products by family of materials and stock groups
	Structure the codes and product registration nomenclature
	Register the products and other related records
	Gather and register the structure of the PV215027 antenna materials
Simulation	Relate the implemented modules and run the simulation of each one
	Simulate a complete operation cycle of all the modules together and review errors

Source: Research (2015).

We chose the OpenERP software because, in addition to being free, it is used by renowned companies such as Danone. Another factor for this choice was that this system has a community on the Internet that shares tutorials and user experiences which served as the basis for its installation and the training in the studied company. This choice of ERP system was also because OpenERP has a Portuguese version, making it more comprehensible and intuitive to users.

We soon formed a team to execute the implementation, assigning responsibilities for each collaborator within the project. The company directors determined that the implementation tasks should not require more than two hours a day for each person involved so not to interfere with their routine work activities. Thus, five people were allocated to compose the implementation team: IT manager, production manager, purchasing manager, production sector intern, and the researcher, which totaled 720 hours of work for the project. The deadline for implementation was June to August of 2015, accounting for a total of three months.

The first action of the system implementation was the installation of the ERP database on the server. To do so, we used the tutorials downloaded from the Internet provided by the developer of OpenERP. The IT manager registered and classified the users according to the hierarchy of responsibilities of each one, dividing them into administrators and operators. Administrators have access to all areas of the system, while operators are restricted to the modules they operate or need access to.

The restrictions were not fully specified at this stage, as there was no precise information about each user's work within the system yet. Once the accesses were defined, the operational modules were installed, and the operators were registered, we began the stage of training for the system, which was under the responsibility of the researcher and occurred between the fourth and ninth weeks of the project. For the training planning, the content was divided and destined to each user according to the number of hours each had available for the ERP implementation.

The next task was to match the project processes (production, manufacturing, and purchasing) with the operational modules of the chosen ERP system. We studied the system functionalities checking which modules corresponded to the three processes defined in the scope of the study. Thus, we started the parameterization, transcribing the operations performed in the work routine into the program, which required analysis of the result of each intervention performed.

The parameterization was the period when we adjusted the functionalities, aligning the ERP system with the requirements and characteristics of the company. First, we performed a documental survey of the products in inventory with the intention of classifying them. This step was necessary because OpenERP uses categories to classify products, so it is necessary to create them in order to manage the materials.

For this, we divided the inventory groups by features such as the type of raw material, structure, shape, employment, measurement unit, and durability. We obtained the data on the materials from the purchase invoices and physical inventory reports.

Finishing the development of the hierarchy of materials, we assembled the nomenclature and the codes for the items bought and manufactured. To differentiate the materials, we created a standard nomenclature model which standardized the process of naming the products, given that each material must have a name and a code for its entry and movement within the system. Table 5 presents the formation of the hierarchy of materials.

Table 5: Formation of the Hierarchy of Materials

INVENTORY GROUPS	DESCRIPTION	PRODUCT CATEGORIES
RAW MATERIALS	Purchased materials that directly integrate the product manufactured by the company or fast wear tools	Metals / Fasteners / Seals / Surface Treatments / Cables / Welding / Oils / Cutting Gases / Inserts / Milling Cutters / Quick Wear Tools
CONSUMABLES	Materials used to support the production processes, but that do not compose the manufactured products	Forklift Gas / Lubricating Oils / Lubricants / Greases / Alcohol / Sandpaper / Saws / Brushes / Cloths / Thermal Pastes / Case Material / Cleaning Material
FINISHED PRODUCT	Products manufactured by the company	Antennas / Jumpers / Surge Suppressors / Power Dividers
INTERMEDIATE PRODUCTS	Byproducts that integrate the final product manufactured by the company	Supports / Lines / Reflectors / Pins / Bushings / Connectors / Dipoles
PERMANENT ASSETS	Goods and rights of permanent nature that are used to maintain the company's activities	Tables / Chairs / Computers / Installations / Vehicles / Software / Machinery & Equipment / Durable Tools / Real Estate

Source: Research (2015).

Table 6 details the standard nomenclature model, citing four examples of material name formation. The standard nomenclature model linked the type of material with the raw material used, the product dimensions, and some specific feature.

Table 6: Standard material nomenclature

CATEGORY	TYPE OF MATERIAL	RAW MATERIAL	DIMENSIONS	SPECIFIC FEATURES
MP – Metals	Round tube	Aluminum	1 1/4” x 1/16” x 6000 mm	LG6351-T6
	Sheet	Aluminum	1.5 x 1200 x 1500 mm	5052-H34
MP – Fasteners	Screw	304 stainless steel	M4 x 12mm	Cylindrical head
	Screw	304 stainless steel	M3 x 16mm	Philips flat head

Source: Research (2015).

The examples cited in Table 6 show that, although there are inputs with different functional features, it was possible to form a standardized name.

To form the codes for the materials, we used a five-digit model whose first two digits are letters of the product’s category name, and the three others are sequential numbers. Once the modeling of the grouping and nomenclature of the materials was finished, they were physically coded within the inventory for the correct movement of items (stock entry and exit) when they are set apart for production.

Once the groups and encodings were created, we registered the PV215027 antenna and its components into the system, as well as the production operations involved (welding, assembly, painting, and packaging). These registrations completed the parameterization process of the inventory and manufacturing modules.

To complete the proposed scope of this project, we configured the purchasing module. The parameterization of this module consisted of some accounting registers and supplier registry. Regarding the accounting records, although this module is not part of the scope, it was necessary to perform the parameterization of the accounting accounts to direct the inventories of purchased materials within the inventory books generated by the OpenERP software. Since the system has interconnections between the modules, some registers become prerequisites for the proper functioning of the operational cycle, so they must be performed.

We began simulations as soon as the general registers were finalized. Thus, by operating the information system, we observed the movements generated by the emissions of documents called “production orders”, “purchase quotations”, and release of invoices for the supply of inputs. The purchasing module simulations consisted of creating the quotations by the system with the raw materials, emitting the document through the system, and forwarding it by e-mail to the suppliers. Once the purchased materials arrived, the manager entered the invoices into the program, which generated records of entry movements in the inventories.

In the manufacturing module, we performed the simulations creating “production orders”. The documents emitted with the antenna items and their manufacturing processes show the movements in the inventory modules. We observed a reduction of the raw materials that are listed in the production order at the time the antennas are manufactured and the entry of the finished product into the inventory when the production order is closed in the system.

After the simulations, we held a meeting with the operators to visualize the complete operational cycle of the modules. Such cycle consisted in each user performing their key activity within the ERP system and analyzing along with the others the interactions that occurred between the modules from a performed task, as well as the sequence of operations when a production order arises. For the collaborators, it was important to demonstrate the complete operational cycle since this facilitated the understanding of the importance of each one’s work within the ERP system.

At the end of the simulations, we reviewed the tasks to verify the accomplishment of the goals and check the execution of the delegated tasks. We provided forms for each user with predefined assignments, demonstrating the actions that each of them should execute along with their respective deadlines. Thus, we developed a checklist linking the macro-tasks of the project to the people in charge of them, to verify the developed actions and assure the success of the operation. Table 7 illustrates the task checklist.

Table 7: Task checklist for System Delivery

TASK	PERSON RESPONSIBLE	STATUS
Loading data into the system	Each user is responsible for their module	100%
Conference of delegated tasks	Researcher	100%
Individual simulation	Researcher and users	100%
Joint simulation	Researcher and users	100%
Analysis of simulation dissonances	Each user notes what is missing so that their area complies with the system default	100%
Corrective actions	Key user correct the errors	100%
Review of the corrective actions	Researcher checks for errors after corrective actions	100%

Source: Research (2015).

After checking the tasks in the checklist, we closed the implementation stage and initiated the ERP system stabilization phase. At this moment, the system became part of the work routine of the employees and was considered delivered by the researcher.

After the implementation of the ERP system, the production order (PO) became the document that governs the production management, automating the process of checking materials (previously performed by visual inspection), as it triggered in the inventory module the reservation of the items that compose the PV215027 antenna when POs are issued, checking if they are available in the inventory.

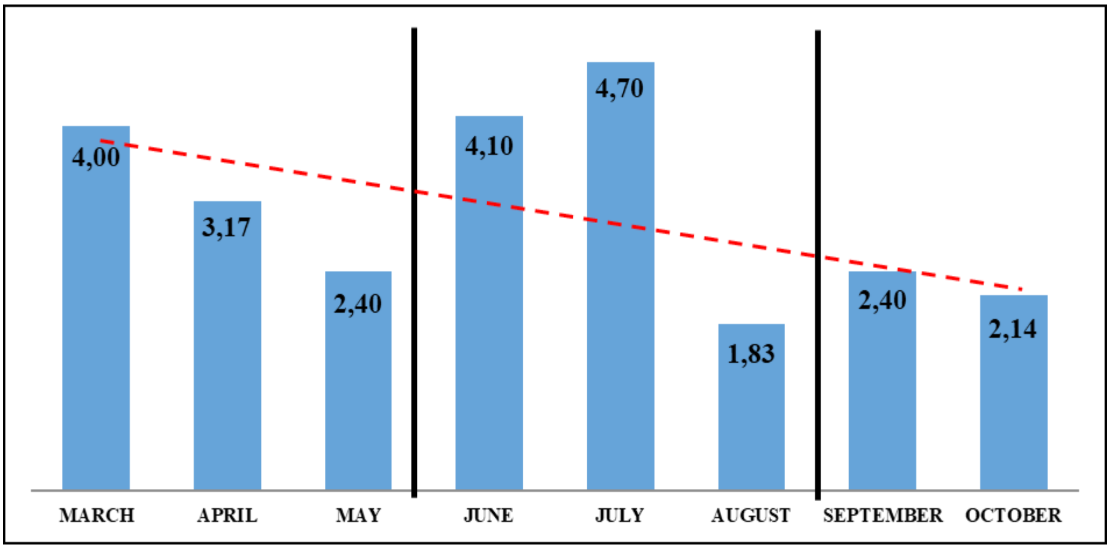
In the final stage of the study, we performed the analysis of quantitative data which consisted of ending data collection and tabulating it to measure the production performance indicators. In this analysis, we identified the behavior of the indicators during the eight months for which the collection instrument was applied, aiding the understanding of the impacts of the process of implementing the ERP system on the production management of the company.

For data tabulation, we used a Microsoft Excel® spreadsheet (2013 version), with which we analyzed the progression of the production performance before, during, and after the implementation of the ERP system, with the purpose to visualize if there was an improvement in production performance, evidencing the effectiveness of the system on enterprise management.

As a result, we observed that in March, of the total number of orders of the PV215027 antenna, production was delayed four days on average. In April and May, the average delays dropped to 3.17 and 2.4 days, respectively, due to the organization of the company's processes during the development of this study, which made production more efficient.

However, in June and July, the delays increased, reaching the maximum peak of 4.7 days of average monthly delay. This increase was a response to the beginning of the system implementation process, which extended in June, July, and August, using the company's employees' time due to the necessary adaptations to ERP implementation and making production more inefficient. Figure 4 shows the measurement of the average delay in production time.

Figure 4: Average Production Delay Time (in days)



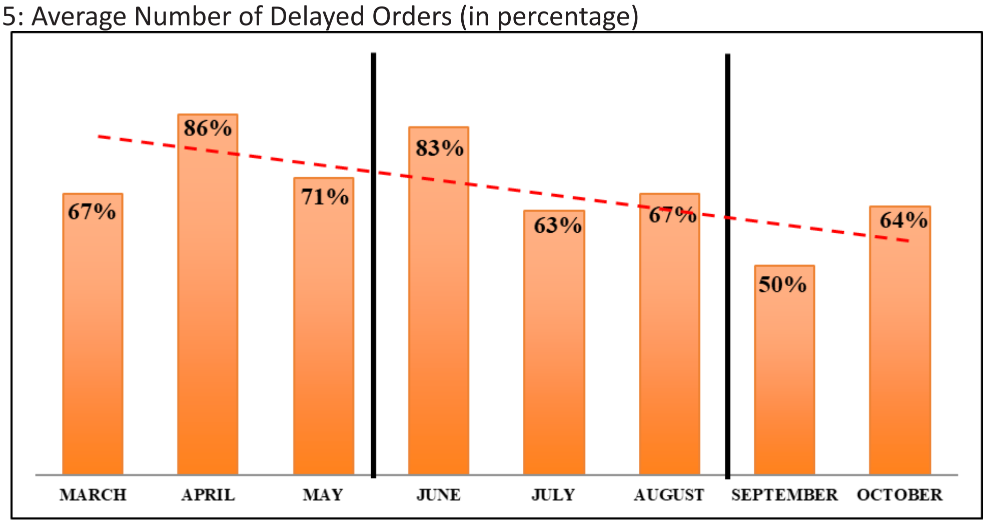
Source: Research (2015).

In the following months, the indicator dropped, which meant that the average order delays decreased with the implementation of the ERP system. In September and October, orders were delayed, on average, 2.4 and 2.14 days, respectively, representing a significant reduction relative to the beginning of the application of this study and generating a two-day productivity gain for the company.

The overall average of days of production delay due to lack of materials in inventory was of 3.04 days. The managers of the company were unaware of this number and, using the data from this study, stipulated the goal to get zero days of delay on production orders, tracing actions to improve the management of processes related to the PPC.

Regarding the number of delayed orders, Figure 5 shows that, of the total orders for the PV215027 antenna in March of 2015, on average 67% had their production delayed due to lack of items in the inventory.

Figure 5: Average Number of Delayed Orders (in percentage)



Source: Research (2015).

In the following months, the percentages of delayed orders rose to 86%. One of the hypotheses formulated for this 19% increase is that, in addition to the ineffectiveness of the process, there was also an increase in the volume of orders for this product, hampering the index. In the months following the implementation of the ERP system, the indicator improved, which is signaled by the decreasing trend line in Figure 5. In September, the delay reached a minimum peak of 50% of the total number of orders for the month, which still represents an alarming indicative of inefficient management of materials.

It is evident by the measured indicators that the ERP system contributed positively to the company, resulting in a 36% decrease in the number of delayed orders and days of production delay due to the management of materials. Therefore, it is correct to infer that, in this case, the ERP system complied with the purpose of assisting in enterprise management, as it yielded improvements to the proposed indicators.

Another gain for the company with the implementation of a free ERP system was the direct savings on monthly fees and upgrades. We estimate that the company avoided spending R$78,000.00 annually relative to monthly payments it used to pay when using the TOTVs proprietary system, with upgrade costs in the range of R$30,000.000 per year.

5 CONCLUSIONS

The implementation of the free ERP system was advantageous to the studied company, generating valuable information for planning, controlling, and optimizing the production tasks, automating the data, registering it, and distributing it at each occurrence of the activity for all users of the system.

It became evident that we reached the proposed objective of this study, which consisted of implementing a free ERP system in a small company to improve production indicators. The results of the measured indicators pointed to a decrease of up to two days in the production delays after the implementation of the ERP system, as well as a reduction of up to 36% in the number of delayed orders. Hence, one may conclude that implementing the system optimized the company's productivity.

Regarding qualitative analyses, the fact of implementing a bolder and innovative management model than the previous one also represented a development in the management of the studied enterprise. As for the impacts of improving production management on the company's results, the increase in operational productivity yielded benefits beyond the factory floor lines such as improved customer satisfaction due to reduced delays in product delivery, impacting the company as a competitive advantage.

The improvement in productivity also resulted in increased profitability for the company, since the reduction of the delay yielded a higher flow of manufactured products, improving the company's billing as well as reducing the overall cost of manufacture.

Another benefit generated is the employee gains, since the company has a policy of commissioning on invoiced products. Thus, a greater productivity represents a larger turnaround in manufacturing and a consequent increase in sales, which in turn results in higher salaries for the employees. Therefore, making the benefits of the ERP system clear helped the users to support the implementation and motivated the cultural change in the organization, facilitating the implementation of the ERP system.

In summary, the optimization of the company's productivity via the implementation of the ERP system yielded multiple benefits in the case of the studied company and is an example that may be followed by other micro and small enterprises in Brazil. Considering that 98% of Brazilian enterprises are organizations classified as MSEs, we may infer that the implementation of free ERP systems aid the economic development of the country since they help the organizations to improve their management and consolidate in the market.

The importance of this study for the academic and business environments is evident since it serves as a basis for the development of new research studies deepening the knowledge on the management of ERP systems in small enterprises and the use of such free information systems as an alternative for companies with strong budget constraints.

As limitations of this study, we highlight the time constraint in which the activities were carried out, forcing the researcher to reduce the scope of the implementation project to a single product and three operational modules of the ERP system, as well as the lack of budget to invest in consulting to improve the training and development of the team.

To continue this study, we propose to expand its scope of implementation to the other products manufactured by the studied company, as well as extending to additional functionalities of the system such as the financial, accounting, costs, and people management modules. Another suggestion is implementing free ERP systems in other small enterprises, comparing the results among different types of business and organizational cultures.

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