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Analysis of the relationship between Information Technology, Lean Manufacturing Practices and Operational Performance

Análise da relação entre Tecnologia da Informação, Práticas de Lean Manufacturing e Desempenho Operacional

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Resumo
O principal objetivo deste estudo foi examinar como as empresas estão aplicando as práticas de manufatura enxuta (LM) combinadas com as características da Tecnologia da Informação (TI), a interação entre TI e LM e os resultados obtidos em termos de desempenho operacional. A aplicação da TI e os princípios da manufatura enxuta foram vistos por alguns autores como mutuamente exclusivos, mas há outros estudos indicando que ambas as abordagens são cada vez mais interdependentes. Assim, há necessidade de estudos complementares analisando essa inter-relação de recursos de TI e práticas Lean. Esta pesquisa foi desenvolvida com uma abordagem qualitativa aplicada através do método multicaso. O estudo contribui para a teoria, fornecendo uma indicação de quais propriedades de TI trazem efeitos significativos para a implementação de práticas Lean; O estudo também oferece várias recomendações para gerentes de implantação enxuta em suas organizações.

Palavras-chave: Manufatura enxuta; Tecnologia da informação; Desempenho operacional; Manufatura enxuta.

Abstract
The main objective of this study was to examine how companies are applying the lean manufacturing (LM) practices combined with the features of Information Technology (IT), the interaction between IT and LM and the results obtained in terms of operational performance. The application of IT and the principles of lean manufacturing have been seen by some authors as mutually exclusive, but there are other studies indicating that both approaches are increasingly interdependent. Thus, there is a need for complementary studies analyzing this interrelation of IT resources and *Lean* practices. This research was developed with a qualitative approach applied through the multicase method. The study contributes to theory by providing an indication of which IT properties bring significant effects for implementing Lean practices; the study also offers several recommendations to managers for lean deployment in their organizations.

Keywords*:* Lean manufacturing; Information technology; Operational performance; *Lean manufacturing.*

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1 Introduction

Companies need to make the most of available resources for better performance in business. One of the strategic initiatives that help manufacturers to remain competitive is the lean manufacturing, a philosophy that is based on productivity, as discussed by several authors such as Ward and Zhou (2006), Godinho Filho and Barco (2015), Godinho Filho et al. (2016). Additionally, Information Technology is an important resource that can also positively impact the company's performance. The systematic application of lean practices and the capabilities of Information Technology can improve the organization's efficiency (Ward and Zhou, 2006; Powell, Riezebos, Strandhagen, 2012).

Although the importance of Information Technology (IT) and Lean practices is recognized, some authors have seen these resources as mutually exclusive, but both approaches are increasingly being considered interdependent, as discussed by Cottyn et al. (2011). Khanchanapong et al. (2014) complement the problem on technology and lean manufacturing discussing complementary effects of production technologies and lean practices on the operational performance of manufacturing; thus, they indicate the need for further studies addressing this topic. Convergently, Ghobakhloo and Hong (2014) discuss if the application of IT and lean practices are complementary and interdependent. The authors mention that investments in IT are minimum requirements for implementation of Lean practices and emphasize that further studies (such as on how to incorporate IT dimensions) are needed to assess how to use IT in order to benefit the implementation of Lean Manufacturing practices. Benitez-Amado and Walczuch (2012) emphasize the importance of studying the relationship between information technology, organizational issues and business performance because it is a research topic that has been understudied in the IT field.

From the context discussed by Riezebos et al. (2009), Cottyn et al. (2011), Moyano-Fuentes et al. (2012), Khanchanapong, Teerasak, et al. (2014), Ghobakhloo and Hong (2014), it is possible to notice a theory gap that can be worked on: trying to understand the relationship of information technology and the practices of lean manufacturing with the purpose of improving the operational performance of companies. Thus, the following research question was here formulated, which guided the development of the study.

How does information technology contribute to the lean manufacturing practices and their impact on the operational performance of the company?

Based on this discussion about IT, lean manufacturing and operational performance, the general aim of this paper consists of analyzing the alignment of IT to the practices of lean manufacturing, in order to understand this relationship and its respective contribution to the improvement of operational performance.

2 Theory

The lean manufacturing approaches and IT are increasingly interdependent and complementary (Riezebos et al. 2009). Authors such as Benitez-Amado and Walczuch (2012) highlight the "IT-enabled capabilities" perspective. Thus, it becomes important to define Lean practices and Information Technology and their interactions, which can allow the effective implementation of Lean Manufacturing.

2.1 Lean Manufacturing

Shah and Ward (2003, 2007) and Browning and Heath (2009) showed that Lean Manufacturing (LM) is not a singular concept and may not be limited only to Just in Time (JIT) or Total Quality Management (TQM). These authors discuss a set of practices associated with the Lean, such as just-in-time, continuous improvement, Kanban system, total productive maintenance (TPM), 5S, and total quality management for implementation in companies.

Ghobakhloo and Hong (2014) analyze the LM concept from the perspective of implementation of customer engagement, implementation of human resource management practices, Total Productive Maintenance – TPM, as well as JIT and TQM. Sakakibara et al. (1997) describe the practices of infrastructure (quality management, workforce management, manufacturing strategy, organizational characteristics, product design) and JIT practices (setup time reduction, schedule flexibility, maintenance, equipment layout, kanban, and JIT supplier relationships). Bevilacqua and De Sanctis (2016) highlight the following practices: Just-in-Time (JIT), Total Quality Management (TQM), Supplier Management (SM) and Human Resource Management (HRM).

2.2 Interaction between Lean and Information Technology

Different authors, such as Au and Choi (1999), Ward and Zhou (2006), Ghobakhloo et al. (2013), Pullan, et al. (2013). Ghobakhloo and Hong (2014), Powel and Strandhagen (2011) Cottyn (2011), Tallon (2010), Perez-Arostegui, et al. (2012) discuss the importance of IT on implementing Lean practices. In the next section, papers related to the interaction between LM and IT will be analysed.

2.2.1 Lean Manufacturing and ERP Systems

Lean manufacturing and ERP systems are considered two of the strategies used in companies in order to improve their performance, but there is a paradox that is discussed by the authors Powel and Strandhagen (2011), as shown in Table 1.

Table 1 - Summary of the paradox between Lean and ERP

Lean manufacturing	ERP
Consumer-based production (pulled)	Production based on predictions and using machines (pushed)
Decentralized control and empowerment (bottom-up approach)	Centralized planning and control (top-down approach)
Production of different models based on frequency	Batch production lagged in time.
Focuses on maintaining material flow	Focuses on monitoring material movement

Source: adapted from Powel and Strandhagen, 2011.

Some ERP systems are now offering lean manufacturing tools, such as the possibility of integrated use of *Electronic Kanban*, which allows immediate signs of real customer demand throughout the supply chain. Wan et al. (2007) describe a web-based *Kanban* system for sending data, tracking and performance monitoring. Bell (2005) describes it as the ideal solution to meet the standard working procedures.

2.2.2 Manufacturing Execution Systems and *Lean Manufacturing*

According to Cottyn (2011), the ME Systems were designed to support lean manufacturing practices. In the 1990s, MESA (*Manufacturing Execution Systems Association*) (Meyer, 2007) conducted several surveys in more than 100 companies, from different sectors, that had fully implanted ME Systems in their facilities, to assess the achieved benefits.

Sedano et al. (2011) define the MES as an information technology system that is used for managing and planning resources, equipment, employees, and inventory. Often this system integrates the shop floor operations with the *Enterprise Resource Planning* (ERP).

According to Saenz et al. (2009), the traditional internal structure of most MES solutions is designed in a modular, so that each system can be integrated and configured as desired, depending on the complexity of the manufacturing operations analysis. According to Meyer (2009), it can be said that an ME System in place is a prerequisite for achieving the goals of Lean Manufacturing. The MES also ensures the standardization of processes in which operators are guided with electronic information that significantly contributes to improving productivity (Meyer, 2009).

Real-time data collection and ease of access to such data are necessary for the rapid decision-making (Zhang, et al.(2015). Additionally, this visually displayed information (KPIs) support the development of ongoing strategies, engagement and implementation (Jaca et al. ,2014 and Bateman and Warrender, 2016). Moreover, deviations are immediately recognized by the real-time control of all parameters which influence the production process, thus measures may be taken as needed. Shop-floor connectivity and technologies that enable connected sourcing, order flows, and production planning and control in real time are important resources to implement LM.

2.2.3 Interorganizational Systems (company and supplier)

Among the impact levels of IT on the organization, there is the impact on organizational processes. For Tallon (2010), IT firstly influences inter-organizational processes (relations with suppliers and customers, sales and marketing support etc.) as well as intra-organizational processes (operations and production, improved product/service etc.). The impact on organizational level follows the impact on processes (Tallon, Kraemer and Gurbaxani, 2007; Tallon and Kraemer, 2007).

2.2.4 Strategic IT Alignment

Henderson and Venkatraman (1993) argue that the Strategic Alignment of IT is not an event, but a continuous process of adaptation and change, and that to achieve it we need a substantial change in managerial thinking about the role of IT in the organization, as well as an understanding of the IT strategy and its importance, both in support as in business strategy decisions. They do not directly associate the strategic alignment of IT with organizational performance but claim that the lack of alignment is one of the causes of the questions about the results of the investments made in IT. The authors affirm that the strategic alignment of IT is based on: (1) strategic fit between the organization's positioning and IT in the market (external environment) and the appropriate administrative infrastructure to support such positioning (internal

environment); and (2) functional integration between the business and IT areas, both at the strategic level and at infrastructure and processes.

According to Hwang (2006) and Saenz et al. (2009), the key to the successful implementation of lean manufacturing and maintenance can be found in the manufacturer's ability to actually change a process.

2.3 Operational performance

The implementation of lean manufacturing is complex, time-consuming and requires the allocation of a substantial amount of resources by companies (Lian; Van Landeghem, 2007). Bhasin (2008) analyzes the need for organizations to adopt an approach that seeks to understand the phenomena in its entirety, comprehensively, for performance measurement (Neely, 1999 and 2006). The benefits of lean manufacturing are not always obvious when the traditional accounting method is used, but it is essentially through the management and improvement processes coupled with customer and employees relations that the financial perspective will advance accordingly. A number of factors have been used in the literature to measure operational performance, such as the flexibility and delivery, as discussed by Hallgren and Olhager (2009). Mackelprang and Nair (2010) argue that Lean practices can be evaluated according to the returns from the operational effectiveness and reduced costs.

The researchers of lean manufacturing (Womack; Jones, 1996; Bicheno, 2004; Liker; Meier, 2006) defend that it brings the following benefits:

- shorter cycle time;
- shorter deadlines;
- lower process material;
- faster response time;
- lower cost;
- greater production flexibility;
- higher quality;
- best customer service;
- increase in revenue;
- higher income; and
- increase of profit.

2.4 Theoretical Model

From the theory review, a referential framework was devised for the development of field research. Table 2 presents the variables that were researched, considering three constructs: Lean Practices, Information Technology, and operational performance.

Table 2 - Theoretical framework

Construct	Variables	Authors
Manufacturing Lean	LM1 – Pulled System – *Kanban* LM2 – Continuous improvement - *Kaizen* LM3 – 5S LM4 – Total productive maintenance – TPM LM5 – Value Stream Mapping LM6 – Decreased *setup* time LM7 – Standardized work LM8 – *Heijunka*	Womack, Jones and Roos (1992); Womack and Jones (1996). Shah and Ward (2003,2007), Browning and Heath (2009)
Information Technology	TI1 – Use of ERP TI2 – Use of MES TI3 – Strategic Alignment TI4 – Inter-organizational Systems	Henderson and Venkatraman (1993); Hwang (2006); Meyer (2009); Powell and Strandhagen (2011); Saenz, Artiba and Pellerin (2009); Sedano et al. (2011); Tallon (2010); Tallon and Kraemer (2007); Wan and Chen (2007); Ward and Zhou (2006); Womack, Jones and Roos (1992).
Performance Operational	DO1 – Security DO2 – Quality DO3 – Delivery DO4 – Cost DO5 – Inventory	Womack, Jones and Roos (1992). Bicheno, 2004; Liker; Meier, 2006

Source: Prepared by the author.

3 Research Methodology

The method adopted for the development of this research was the case study (Yin, 2010), which was applied to deepen the understanding of the interaction between IT and Lean practices. Two industrial plants located in Brazil were chosen for the study, since they were in the process of implementing lean manufacturing, with similar levels of Lean implementation (the level of implementation was evaluated through the standard SAE J4000 Society of Automotive Engineers). Additionally, the process of choosing the companies for the case study also used the Strategic Grid (Mcfarlan,1984). The grid allows visualizing the strategic positioning of IT on the organizational structure and how IT is managed. The grid is divided into four quadrants, each representing a situation for the Organization (Factory, Support, Turnaround, and Strategy) according to the business impact of IT present and future applications.

The chosen companies are located in the Support and Turnaround quadrant. The comparison enables the understanding of how companies with similar levels of LM implementation can use TI differently from the perspective of Mcfarlan's strategic grid (1984).

3.1 Respondents' Profile

The primary data were collected through direct observation, analysis of files provided by the organization and semi-structured interviews. The interviews were performed in the companies with industrial managers, factory supervisors, production leaders, and managers of information technology of each unit. A variety of information was obtained, providing a broad discussion on triangulation with the logical grounds between the evidence, casting the contents according to the outlines of Yin (2010). The interviews were all recorded and later transcribed.

Table 3 - Profile of respondents

Hierarchical Level	Case A	Case B
Industrial Manager	1	1
IT Manager	1	1
Supervisor/Leaders	2	3
Quality	1	1

Source: the authors.

3.2 Cases

Description Case # A

Brazil unit is a manufacturer of shutters, blinds curtains, which provides only for the local market through resellers. The company operates in Brazil since 1991 and has 300 employees, 150 of which are in the production area. There are a total of 14 production lines, and the pilot line of lean manufacturing implementation has the largest production volume. The company plans to spend other 2 years for full implementation. In Brazil, 75% of raw material suppliers are the other factories of the Group, located in Asia, China, Europe and Latin America.

Lean manufacturing and information technology # case A

The idea of implementing lean manufacturing appeared in 2006, but the pilot project was only ignited in September 2013, based on the "Roller" product line, on a concept of continuous flow operation, visually controlling waste and productivity; the company did not have a culture of visual management until that time. During this period, between the need for implementation and the beginning of the pilot line, the company did not have people dedicated to lean manufacturing.

Implemented lean manufacturing tools:

- ✓ Pull system
- ✓ Kaizen continuous improvement
- ✓ 5S – started with the training of *lean* multipliers.
- ✓ Quick setup
- ✓ Standardized Work
- ✓ Heijunka

The investment in IT is limited to 1.5% of revenues. The IT manager is also responsible for operations in Latin America. It has two separate

teams, 5 employees giving support to the Brazil unit and another team to support Latin America, with 6 more people. All employees are enabled with training in the area. The IT department supports all areas of the company, aligned with the strategic vision of the company. The IT investment is a priority in the company because they're starting a process of integration of the factories in Latin America.

After the implementation of lean manufacturing, there was a great reduction of the inventory in the process. Previously, the transfer of the raw material to the process was done through a production, that is, running the system with the needs of a certain period (about 1,500 pieces/day) and automatically transferring the total material needed for the production line - which lacked the capacity to execute the production batch (daily production of 600 to 700 pieces/day). This led to an accumulation of orders on the production line. With the implementation of lean manufacturing, production is carried at the pace of customer demand, avoiding the accumulation of material in the line.

Operations and IT management for each Latin American factory have a local team that reports to the Brazilian manager in the matter of implementation of lean manufacturing and information technology. This is due to the pioneering and good results obtained by the Brazilian factory in the implementation of the techniques of lean manufacturing and information technology.

The responsible for the implementation of lean manufacturing points out that:

> *"Typically, a project is not initially automated so as not to automate waste. The project is executed manually to identify the wastes and to fix the concepts; the next step is the use of IT, which comes to simplify the new process." (Production Manager)*

Among the information technology projects implemented on the shop floor that aid lean manufacturing, can be mentioned: the introduction of information collectors in production lines, the use of computers by cell leaders in obtaining real-time management information, the new *kanban* pointing and monitors with indicators of tak time and productivity in the lines that determine the production rhythm. These products were developed by the local IT team. Related to data-collection and monitoring solutions are supporting manufacturing operations management to see, analyze and quickly act upon time-sensitive data coming off the shop floor. According to manager, the data collected from the processes is being used in different ways to analyze business performance, improvement areas and track process change effects.

In addition, creation of a knowledge base among Latin American companies on lean manufacturing implementation projects. It will form the basis for future study of implementations for the trendsetters to train the personnel involved in the process.

Description Case # B

The company has factories, development centers, and commercial offices in the United States, England, Germany, Switzerland, France, Australia, China, Japan, India, Brazil and Mexico. The group's annual turnover is $ 3.5 billion, and the finishing technology segment represents $ 264 million. The company analyzed is located in Brazil and has been growing in recent years, reducing its costs and verticalizing the manufacturing process.

Lean Manufacturing and Information Technology Case # B

The implementation of lean manufacturing started in 2012 with the change of industrial management, through the implementation of lean management tools in the factory, although there is evidence of the use of some quality tools since 2001. In early 2015, the companies were acquired by a group whose philosophy is lean manufacturing, aiming at the continuous improvement of processes and the verticalization of production processes.

Implemented lean manufacturing tools:

- ✓ Pull system
- ✓ Kaizen continuous improvement
- ✓ 5S:
- ✓ TPM – partially.
- ✓ Quick Setup – initial stage
- ✓ Standardized Work – partly
- ✓ Heijunka – initial stage

The IT area does not have prominent placement in the company's hierarchy, with low influence on the current and future business strategies. The person responsible for IT is also responsible for the fiscal and financial area of the company. The current focus of IT is administrative support.

Among the information technology projects implemented on the shop floor that support lean manufacturing, we can mention the reports developed with daily indicators in each sector, the use of computers by cell leaders in obtaining real-time management information, new service order note, and billing procedure. These products were developed by ERP consultants with the support of the productive area.

The process of placing orders and invoicing has been modified. To add a customer's request in the ERP system, it is available for the production area, which sends tags for each item in the order, every 2 hours. The information in these tags is the order number, item, product ID, quantity, customer, delivery time and product addressing. The tags pull the production, removing the product from supermarkets in productive areas, or start the pull manufacturing of the item. After separation or termination of the productive process, the products are packed, identified with the tags and forwarded to the shipping sector. Upon entering this area the system is informed that the merchandise is ready, from reading the barcodes on the tags. This information is available in the system for production areas, which check the pending items to complete the customer's order, shipment, the shipment order when it is complete, factory supervision, which uses them for decision making (partial issuance of the order or prioritization of the production process), and sales, which informs the customer about the position of their order. This information is obtained in real-time through custom reports that are printed or displayed on the employees' monitors. The daily meetings at the beginning of the shifts are used to prioritize activities and find measures to improve the production process.

Another project is the use of the inventory management module that was parameterized to assist in the review and determination of quantities of parts in the production kanban. In addition, the ERP has an asset control module that assists in managing the TPM.

The responsible for the implementation of lean manufacturing points out that:

> *"Information technology is being used as a tool for analysis and information extraction from production data that serves to validate the improvements that are being implemented with the advancement of lean manufacturing".*
>
> *(Industrial Manager)*

Table 4 presents a summary of the cases, highlighting the IT tools adopted, Lean Manufacturing practices and LM and IT relationship.

Table 4 - Summary of the results

Case	Manufacturing Lean	Information Technology (IT)	Relationship LM and IT	Operational Indicators
A	*Adopted tools:* Pull system; Standardized Work. *Implementation tools:* Kaizen; Quick setup; Heijunka. *Tools not adopted:* 5S; TPM; Value stream mapping.	*ERP:* Totvs, migrating to Microsoft Dynamics. *BI:* Does not use. *IT Staff:* Local development team. Information collectors	Introduction of information collectors and sensors in the production lines that update the operation stage in real time; Use of computers by the cell leaders to obtain real-time management information; New pointing of *kanban* and monitors with time tak and productivity indicators in the lines that determine the production pace.	*Quality:* 35% reduction in customer complaints. Managers underscore the leverage of results with IT *Delivery:* deadline meeting from 80-85% to 95-99%. Impact with use of IT *Cost:* Reduction of workforce, although it is not relevant. *Inventory:* Reducing of in-process inventory, mainly with the use of IT *5S:* Only on the pilot line.
B	*Adopted tools:* Pull system; Kaizen; 5S; Value stream mapping; Heijunka. *Implementation tools:* TPM; Quick setup; Standardized Work.	*ERP:* Omega from ABC71 *BI:* SADIG *IT Staff:* ERP consultants and outsourced personnel.	Inventory management module from ERP assists in the preparation and review of *Kanbans*; Utilization of the fixed asset module from ERP for TPM management assistance; Management of operational indicators through reports developed on ERP and BI queries; Use of computers by the leaders to obtain information, such as customer service requests and real-time performance indexes.	*Quality:* Reduction of complaints index (76 ppm). Improvement of indicators with use of IT *Delivery:* Delivery time took from 30 to 45 days; it now takes 3 days. *Cost:* Productivity is 24.5% higher than the previous period. *Inventory:* Inventory reduction from 2.9 to 2.2 months. *5S:* Weekly audit obtained 250 square meters of available area as a result.

Source: the authors.

4 Results Discussion

According to Riezebos, Klingenberg and Hicks (2009), the lean manufacturing and information technology approaches are increasingly interdependent and complementary and can bring a difference in terms of performance. The cases analyzed indicate that IT aided the implementation of lean manufacturing practices, which leveraged some of the companies' operational indicators.

For Powell and Strandhagen (2011), lean manufacturing and ERP systems are considered two of the strategies widely used in companies with the aim of improving their performance. However, there is a paradox between ERP systems and lean manufacturing. It was noted that both companies have ERPs that are used to integrate their areas and have implemented lean manufacturing. Both ERP packages are based on pushed (not pulled) production, so both companies have adapted their industrial management and inventory modules and automated information collection on the shop floor with barcode readers.

Company A highlights the necessity of relationship between information technology and lean manufacturing practices. The first helps to integrate all areas and automates the activities and processes, reducing its runtime, while the latter promotes the best production practices, seeking continuous improvement. As a result, the managers noticed that the interaction has enhanced the operational performance of the companies (Khanchanapong et al., 2014).

Case B adopted the SADIG tool in the analysis of daily activities, assisting the control of operational performance indicators used in the control of lean manufacturing implementation, as cited by White (2006).

A common point between them, on the implementation of lean manufacturing tools, is that both companies started applying the pull system in their productive process. With company A there was a major change in the productive process; for this reason, the company works heavily on the implementation of a pull system and standardized work. In company B, in addition to the focus on the pull system, the use of *Kanban cards* and *Heijunka boxes*, there is a great effort in the implementation of indicators to assist in the control and measurement of improvements made by *Kaizen events.*

Information technology is present in both companies with the implementation of ERP systems by integrating all areas. Company A has a local development team, while company B utilizes outside consultants.

Through the analyzed cases, it was observed that both companies' collaborators and managers have the perception that information technology helps in the implementation of lean manufacturing. Company A's implementation philosophy is first teaching and applying the lean manufacturing tool, and only after the concept is well established, studying the automation and application of information technology to improve processes. In company B, information technology is used by collaborators and managers as a tool that helps the implementation of lean manufacturing by increasing the analytic capability. As examples, there is the calculation of Kanban and Heijunka cards, and the changing of the order entry system and billing of the classic implemented ERP, that pushes production to a pull system.

The operational indicators of both companies improve after lean manufacturing, which uses

information technology for its implementation, process automation, and production process management.

Bringing the discussion to the strategic alignment of IT and business, it is observed that company A differs from company B with regard to the aspect of the IT's role. Company A has a local team focused on the alignment of business processes and information technology. For Company B, IT has a role of administrative support and there is not a local team for development of tools. One could observe that the industrial manager influences the use of IT resources for the implementation of Lean, but this influence is not corporative.

The IT tools that are being worked on by companies A and B provide real-time information on the productivity and the quality of what is being produced. In case A, the visual management performed by monitors reports productivity and quality failures in real-time to prevent the spread of "error". With real-time notes, the factory has instantly updated information of quantity produced, time and forecast completion, allowing for corrective actions and the execution of lean manufacturing objectives. Company A repots improvement results with use IT emphasizing shop-floor connectivity.

5 Conclusion

The principles and practices of LM can be applied without the use of IT; however, according to the analyzed cases, the use of IT is indispensable for the LM's high level of sophistication. The study contributes to theory by providing an indication of which IT properties bring significant effects for implementing Lean practices; the study also offers several recommendations to managers for lean deployment in their organizations.

Theoretical contributions

An interrelationship was analyzed in this study bringing three theoretical contributions to the Lean manufacturing implementation process. The first is to implement Lean practices considering the interaction with information technology since IT is an important resource to promote the maintenance of Lean tools in organizational routines. Companies look for a series of quick approaches that provide short-term benefits but which are not sustainable in the long term; that is one of the reasons for the failure of lean practices. Implement the Lean aligned to IT resources from the perspective of IT and Business strategic alignment may be the key to the lean manufacturing maintenance, for the manufacturer's ability to actually change a process. The second contribution aims at the Information Technology management theory, more specifically for the assimilation of ERP systems, because the interaction of IT and Lean practices promotes customizations in the integrated systems, which contribute to the process of assimilation of the ERP in the routines of productive systems. The third contribution of this study on the relations among IT, LM and performance relates to including the variable that is related to the IT positioning in the organization and its management in an LM implementation process. It needs to have a prominent position in the company's hierarchy, since it has greater influence on current and future business strategies, as investments in IT and development of applications are directed to achieve organizational objectives, aiming to make it more competitive.

Managerial Contributions

There has been careful introduction and dissemination of the concepts of lean manufacturing, as well as the company's cultural

change caused by the implementation of the new philosophy. However, the alignment of IT and Lean objectives started, automating and simplifying the new processes based on lean manufacturing, only after the collaborators understood these LM concepts. The local development of IT tools to achieve the objectives was an advantage, giving greater agility and incorporation of customized Lean tools in the organizations. A productive system such as Lean Manufacturing is highly dependent on the accuracy and timeliness of the data produced and collected during the production processes.

As a suggestion for future studies that may improve this research, it is possible to expand and accomplish the comparison between the implementation of lean manufacturing and the application of information technology in companies located in other quadrants of McFarlan's strategic grid (1984); e.g., comparing the benefits obtained with Lean implementation by companies in the strategy and support quadrants.

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