https://dx.doi.org/10.22161/ijaers.6718 ISSN: 2349-6495(P) | 2456-1908(O)

Application of a Model in the Evaluation of Competitiveness in Sustainability in Factories of the Pharmaceutical Sector

Luís Henrique Rodrigues[1], Sérgio Ricardo Lourenço[2], Ricardo Reolon Jorge[3]

[1]Department of Mechanical Engineering, State University of Campinas, Brazil
[2]Department of Production Engineering, ABC University, Brazil
[3]Department of CECS, ABC University, Brazil

***Abstract*—** *The competitive scenario for companies has been changing over time, by increasing competitiveness in terms of cost, quality, reliability, agility and, more recently, environmental issues. The aim of this paper is to evaluate the sustainability competitiveness of companies in the pharmaceutical sector by applying a model that relates the adoption of lean manufacturing practices and practices in environmental management in production processes. The model grouped the companies into clusters, distributing them in quadrants according to the quantity of produced waste and residues in their manufacturing processes. It was applied to a sample of 32 pharmaceutical processing industries in Brazil, in the states of São Paulo, Rio Grande do Sul and Paraná. The work is classified as applied, exploratory and qualitative and the survey method was used in order to collect data. The results show that most of the companies surveyed (53.13%) adopt practices for waste and residues reduction in their manufacturing processes, promoting to these companies a competitive differential in reliability of delivery, flexibility, quality and cost of their products. Thus, this research contributes to the pharmaceutical companies, giving them a better understanding of their competitive state in sustainability, from the adoption of practices in lean manufacturing and environmental management in their manufacturing processes.*

***Keywords*— Competitiveness, Environmental management, Lean Manufacturing, Pharmaceutical industry.**

I. INTRODUCTION

The search for improving operational efficiency has been a vital requirement for companies that wishes to stay alive in a competitive market. The performance improvement in production processes has been one of the many strategies applied by companies in order to stay competitive in our increasingly globalized market (ALVES, ALVES, 2015). Furthermore, the pursuit of leadership is often an ambition of most companies in the Market nowadays. In past times, one of the conceptions of business leaders was to have their profit at maximum level, without concerning for other important factors to the final customer. A few years ago, these concepts changed, then for a company to reach the level of leadership, it is necessary to provide other conditions which go beyond profit and cost reduction, such as: increase in the product quality, reliable supply and service, increase the speed of deliveries, and activities related to pre-sale and after-sale (AGOSTINHO, 2014). These new conditions represent great challenges for companies. In this way, manufacturing itself has an important role in this complex and competitive environment. One approach that manufacturing can have, in order to play the leading role in the competitiveness of companies, is to relate and apply projects of lean production and environmental management in their manufacturing processes themselves. Therefore, it is necessary to have a greater sense of sustainability that implies a decrease in waste and residues and provides a better visibility of added value for the market. To overcome these challenges, many manufactures are focused on lean manufacturing. Thus, manufacturing contributes to the competitiveness of companies with the reduction of waste in their manufacturing processes (BHAMU; SANGWAN, 2014). Environmental management is another important issue in this analysis of competitiveness. Environmental protection and improvement are the new key strategies of companies for competitiveness nowadays (JORGE; MADUEÑO; MATINEZ-MARTINEZ; SANCHO, 2015).

In this scenario, this paper aims to present a classification and a competitive evaluation of companies that implemented lean manufacturing and environmental management in their manufacturing processes. The research was performed using a sample of 32 companies in the pharmaceutical industrial sector. According the 2018 annual activity report from Sindusfarma, there are 427 factories producing medicines for human use in Brazil. The logistics chain in the pharmaceutical sector in Brazil consists of suppliers of raw materials,

https://dx.doi.org/10.22161/ijaers.6718 ISSN: 2349-6495(P) | 2456-1908(O)

manufacturers of medicines (manufacturing industries), distributors, and consumer markets (hospitals, health centers, pharmacy networks, etc.). Then, the research presented in this paper has its outline in medicine manufacturers.

The present work is classified as applied, exploratory and qualitative, and the survey was used in order to collect data through the application of a research questionnaire.

To reach these objectives, this paper initially presents a relevant bibliographical context, addressing aspects related to lean manufacturing, environmental management and competitiveness. The exploratory analysis with the discussion of the results of the research is done through the data resulted from the application of a model that related competitiveness to the adoption of practices in lean manufacturing and practices in environmental management in the production processes (RODRIGUES; AGOSTINHO, 2018). For the classification, the method used in this paper grouped companies into clusters for lean manufacturing and environmental management and attributed a correspondence with competitiveness.

The contribution of this research comes from the assumption that there are not much scientific literature that relates the competitiveness of pharmaceutical companies with adoptions of techniques of lean manufacturing and environmental management in the manufacturing processes.

II. LITERATURE REVIEW

The market is the major driver of internal changes in companies and it plays an important role in terms of external pressure on the innovation process, overcoming organizational inertia, stimulating creative thinking and mitigating management problems.

The starting point is to address the competitiveness of companies within their marketplace and thereby enable companies to expand or keep a sustainable market position on a sustainable basis, with the ability to continually review their competitive strategies(AGOSTINHO; BATOCCHIO; SILVA, 2008). In order to obtain a good competitive performance in its market, a company may reach a good performance internally, reconfiguring its internal and external competences (HART; DOWELL, 2010). Internally, through the determination of their competitive capacities, with the effectiveness of the flow of values throughout the processes of transformation (SILVA and FONSECA, 2010). Companies that adopt the structure of resource productivity, achieve external competitive advantage in cost, product quality, reliability, production rate and flexibility of product and process, aiming to adapt to customer needs (SINGH; GARG; SHARMA; GREWAL, 2010, JABBOUR, JABBOUR, GOVINDAN, TEIXEIRA, FREITAS, 2013, FULLERTON, KENNEDY, WIDENER, 2014, BÜYÜKÖZKAN, KAYAKUTLU, KARAKADILAR, 2015).

Companies implement lean manufacturing in order to keep their competitiveness against their competitors by improving the productivity of their manufacturing systems (ROHANI and ZAHRAEE, 2015). Lean manufacturing is one of the support elements to achieve productivity and then competitiveness (KOVACH; STRINGFELLOW; TURNER; CHO, 2005). The adoption of practices in lean manufacturing by companies, in manufacturing processes, aims to reduce waste and the activities that do not add value (CUA; MC KONE; SCHROEDER, 2001; SHAH; WARD, 2003; LANDER; LIKER, 2007; PIL; FUJIMOTO, 2007; SINGH; GARG; SHARMA; GREWAL, 2010; DÜES; TAN; LIM, 2013; JABBOUR; JABBOUR; GOVINDAN; TEIXEIRA; FREITAS, 2013; WALTER; TUBINO, 2013; ROOSEN; PONS, 2013; ROHANI; ZAHRAEE, 2015). In processes, waste and activities that do not add value to products lead to decreased productivity and increased manufacturing costs (ABILAASH; ARAVINTHKUMAR; SATHISHKUMAR, 2016).

The practices in lean manufacturing that lead to the reduction of waste and the activities that do not add value refer to: (i) just in time and pulled production system (CUA;MC KONE; SCHROEDER, 2001; SHAH; WARD, 2003; HOPP; SPEARMAN, 2004; SHAH; WARD, 2007; DÜES; TAN; LIM, 2013; WALTER; TUBINO, 2013), (ii) reduction of inventories in process (KING; LENOX, 2001; HOPP; SPEARMAN, 2004; DE TREVILLE; ANTONAKIS, 2006; JABBOUR; JABBOUR; GOVINDAN; TEIXEIRA; FREITAS, 2013), (iii) production in small batches (CUA, MC KONE, SCHROEDER, 2001, SHAH, WARD, 2003, DE TREVILLE, ANTONAKIS, 2006), (iv) reduction of the variability in the manufacturing process (HOPP, SPEARMAN, 2004, DE TREVILLE, ANTONAKIS, 2006), (v) autonomation with processes free of errors and defects (KING; LENOX, 2001; DE TREVILLE; ANTONAKIS, 2006; ROTHENBERG; PIL; MAXWELL 2009; WALTER; TUBINO, 2013), (vi) continuous improvement (CUA;MC KONE; SCHROEDER, 2001; SHAH; WARD, 2003; TOWILL, 2007; WALTER; TUBINO, 2013), (vii) reduction of the set-up in the operations (CUA; MC KONE; SCHROEDER, 2001; SHAH; WARD, 2003; SHAH; WARD, 2007; WALTER; TUBINO, 2013) and (viii) reduction of the manufacturing

https://dx.doi.org/10.22161/ijaers.6718 ISSN: 2349-6495(P) | 2456-1908(O)

lead time (HOPP; SPEARMAN, 2004; SHAH; WARD, 2007; DÜES; TAN; LIM, 2013). These practices are achieved with the application of a variety of tools such as heijunka, six sigma, kanbans, first in first out (FIFO), value streaming mapping (VSM), takt time, single minutes dye exchange (SMED) and five-S principles: these tools are vital components to define the lean culture (ROOSEN; PONS, 2013).

Lean manufacturing provides low-cost production, faster production speed, flexibility and reliability to the manufacturing processes. In this way, manufacturing reaches competitive outputs in cost, quality, reliability, speed of production and flexibility of products and processes in order to be adaptable to the needs of the customer (SINGH; GARG; SHARMA; GREWAL, 2010; JABBOUR; JABBOR; GOVINDAN; TEIXEIRA; FREITAS; 2013, ROOSEN, PONS, 2013, FULLERTON, KENNEDY, WIDENER, 2014, BÜYÜKÖZKAN, KAYAKUTLU, KARAKADILAR, 2015).

According to Dias (2017), "[...] cost, quality of products and services, level of quality control, human capital, technology and capacity for innovation are elements that, when interlinked, dictate the level of competitiveness of companies. Recently, environmental management has been strongly inserted in this context due to the competitive advantages of its application ". In essence, lean manufacturing aims to keep value within companies, maximizing productivity by reducing waste in their manufacturing processes (ROOSEN, PONS, 2013).

Bánkuti and Bánkuti (2014) affirm that environmental management becomes a strategic factor for companies due to the globalization and the care with the environment.

When it comes to strategy in the environmental management, the economy versus ecology struggle should be eliminated as the adoption of environmentally correct practices is not related to the mere increase in costs (PORTER, VAN DER LINDE, 1999 apud BÁNKUTI; BÁNKUTI, 2014, p. 173). There are many benefits that come along with a corporate environmental management, such as cost optimization of the used resources, profit increase due to product innovations and market share increase, improvement of the company's image, product portfolio increase, among others (ORSATO 2002 apud BÁNKUTI; BÁNKUTI 2014).

According to Andrade (1997) apud Bánkuti; Bánkuti (2014) for companies to adapt to the standards of competitiveness, contemplating environmental postures needs, they need to establish three stages of strategies: (i) reactive strategy: taking into account environmental legislation and targeting environmental aspects as costly and without financial return; (ii) offensive strategy: seeking to be ahead of competitors in relation to the optimization of pollution and environmental resources, not only those imposed by law and then obtaining a competitive advantage; (iii) innovation strategy: preventing environmental impacts, seeking environmental excellence, renewing products and processes involving environmental issues and corporate strategy.

According to Medeiros et al. (2015), "... companies that implement the environment as a competitive advantage need to adopt an environmental management model, since the strategy itself cannot ensure competitiveness. When a company adopts a socio-environmental strategy, it establishes a political decision that involves the whole organization, involving its principles and values throughout its manufacturing process, leading to a risk reduction in the production process. This strategy is good when it eliminates the risks exploiting the opportunities and recovering the deficiencies. "

Environmental management allows possibilities of value and competitive advantage through public understanding and cost savings, reducing damages to the environment due to manufacturing processes. Furthermore, it brings benefits when using clean technologies (Porter, 1992 apud MEDEIROS et al., 2015) and generates a differential factor of competitiveness, since with its protection to the environment, that will lead to positive results for future investments (MEDEIROS et al., 2015). Environmental performance has a direct and significant influence on the competitive performance of small and medium-sized enterprises (SMEs), according to studies performed by Jorge; Madueño; Martinez; Sancho (2015). Environmental preservation has been recognized as a competitive advantage by companies (ALVES; ALVES, 2015).

According to Dias (2017), it is possible to mention some competitive advantages that are perceptible when environmental management is applied, such as: (i) the environmental performance and a more effective growth; (ii) the use of environmental requirements in order to develop product design, making it more adaptable to manufacturing process; (iii) reduction of energy generator devices use, resulting in a reduction of the manufacturing costs; (iv) reduction of raw material costs and/or production resources; and (v) the use of renewable materials, reducing the use of energy due to their recycling processes.

Practices in lean manufacturing and environmental management are synergistic when the goals are the

https://dx.doi.org/10.22161/ijaers.6718 *ISSN: 2349-6495(P) | 2456-1908(O)*

reduction of waste and inefficiencies. In the manufacturing processes of companies it is possible to develop a management system that involves both principles of lean manufacturing and environmental principles (ALVES, ALVES, 2015). This will lead companies to a better performance in the markets (YANG; HONG; MODI, 2011).

The Fig. 1 illustrates a synthesis of the literature review, which relates the practices in lean manufacturing and environmental management to the competitiveness of companies, taking into account the reduction of waste and residues in manufacturing processes.

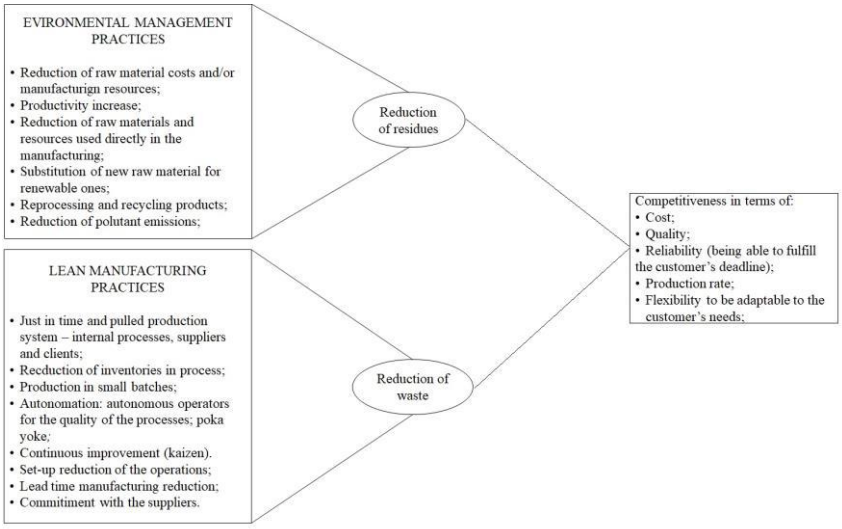

Fig. 1 - Summary of theoretical reference: practices in lean manufacturing, environmental management and competitiveness

Lean manufacturing practices reduce waste and activities that do not add value to processes inside companies. Environmental management practices result in reduced waste and limited use of manufacturing resources. In this context, from the perspective of manufacturing, these two concepts are complementary and lead companies to gains in their competitiveness.

III. METHODOLOGY

The model applied in this work is based on the conceptual construction developed by Rodrigues and Agostinho (2018), which relates the adoption of lean manufacturing practices and practices in environmental management taking into account the manufacturing system to achieve competitiveness in a company's sustainability, as shown in Fig. 2. The model integrates the concepts of lean manufacturing and environmental management and aims to evaluate manufacturing companies as being more competitive from a sustainability perspective, reducing waste and residues in their manufacturing processes.

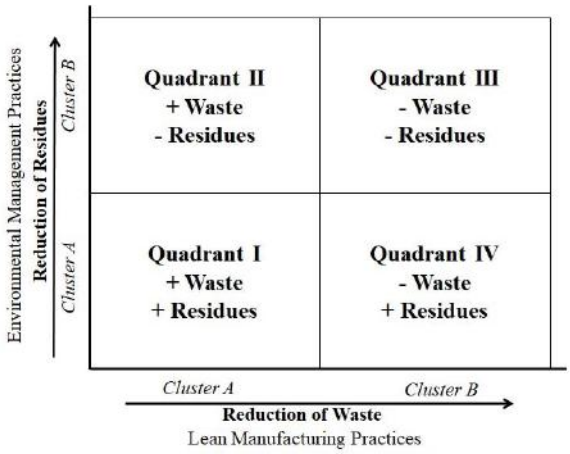

Fig. 2 - Model: environmental management practices and lean manufacturing practices. Critical factors of competitiveness in sustainability. Source: adapted from Rodrigues and Agostinho (2018).

The application of the model agglutinates companies in clusters that conjugate similar practices in lean manufacturing and environmental management.

On the axis of environmental management practices, Fig. 2, the companies grouped into cluster B produce less residues in their manufacturing processes while cluster A companies produce more residues. The same approach is done to the axis of lean manufacturing practices: the waste in the manufacturing processes of the companies

https://dx.doi.org/10.22161/ijaers.6718 ISSN: 2349-6495(P) | 2456-1908(O)

grouped into cluster A is smaller than it is in the companies grouped into cluster B.

The definition of which companies belong to each cluster is the result of a grouping analysis. In this case, each company was identified as an object. The cluster analysis is an exploratory data analysis, which provides an empirical and objective method to perform object classification and characterization (JR, HAIR, 2005). It aims to organize the data by dividing them into groups, or classes, making the understanding and interpretation of them easier. The variables are the questions that constitute the questionnaire applied to the respondents of the pharmaceutical companies.

In the groupings of pharmaceutical companies, the variables identify the internal practices adopted by the manufacturing system in management of lean manufacturing (two clusters - A and B) and environmental management (two clusters - A and B). For each variable (question) the Likert scale is applied, with values between 1 and 5. This scale requires respondents (interviewed) to indicate their degree of agreement or disagreement with statements to the factors measured.

The technique of non-hierarchical grouping was used for the formation of the clusters, this technique belongs to the multivariate statistics for data grouping analysis field (JOHNSON; WICHERN, 2007). Non-hierarchical grouping techniques are designed for groups of objects in a set of k clusters. The number of clusters, k, can be determined before or during the clustering process. In this model, for the constitution of clusters of pharmaceutical companies we specified the value of k as 2.

The collected data at the interview stage were fed in the statistical software Python in order to perform the grouping of them into clusters.

From the formation of clusters in environmental management (k = 2) and management of lean manufacturing (k = 2), the companies (object) were allocated in the respective quadrant defined in the model. The main goal was to identify which companies were allocated in cluster B for environmental management practices and lean manufacturing (cluster III), cluster A for environmental management practices and lean manufacturing (cluster I), cluster A for lean manufacturing practices and cluster B for environmental management (quadrant II) and finally which companies were cluster B for lean manufacturing practices and cluster A for environmental management practices (quadrant IV).

The results of the exploratory analysis of the features of the companies in environmental management and lean manufacturing into quadrants are presented in section 5 of this paper. Before the results are presented, a presentation of the methodology used in this paper is presented in section 4.

IV. RESEARCH METHODOLOGY

The methodology developed in this paper is important to demonstrate the logical sequence (step by step) of the research development, as shown in Fig. 3. The architecture of the methodology is divided into seven stages:

(i) Elaboration of the applied questionnaire, with questions distributed in the groups of environmental management and lean manufacturing;

(ii) Selection of the companies in the sample;

(iii) Field survey (data collection through questionnaire);

(iv) Clustering the pharmaceutical companies into clusters,

(v) Exploratory analysis of the companies allocated into the quadrants, done by the adopted model, in relation to the implementation of lean manufacturing and environmental management (Fig. 2);

(vi) Results and discussions and

(vii) Conclusions.

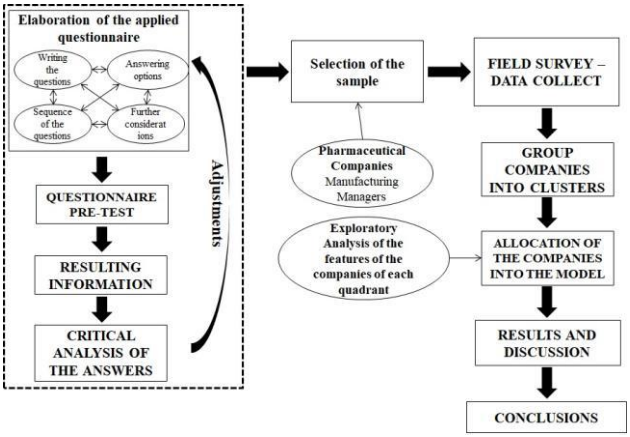

Fig. 3: Step-by-step of the study.

The questions that compose the questionnaire are the variables for the exploratory analysis of the results. The variables and their respective groups are identified in the Chart 1. The variables that characterize the environmental management were named as Environmental Preservation System (EPS), Environmental Strategy (ES), Product Project (PP) and Manufacturing Process (MP). For the management of lean manufacturing the variables were

https://dx.doi.org/10.22161/ijaers.6718 ISSN: 2349-6495(P) | 2456-1908(O)

named as Customers (C), External Suppliers (ES), Just In Time (JIT) and Autonomation (A).

Chart 1: Variables of the questionnaire – pharmaceutical industries.

	Variable	Code of the Variable	Practices
Environmental Management	Environmental Preservation System - EPS	P7 – P12	- continuous improvement in environmental management; - environmental legislation; - visual management;
	Product Project - PP	P13 – P22	- recycled materials; - raw materials; - consuming of natural resources; - manufacturing lead time; - residues and pollutant emissions;
	Manufacturing Process - MP	P23 – P35	- environmental management and manufacturing process; - manufacturing lead time; - recycled material; - environmental criteria and selection of suppliers;
	Environmental Strategy - ES	P36 – P45	- pollution prevention and competitiveness; - investment; - environmental improvements in the long term; - strategic management;
Lean Manufacturing Management	Just In Time - JIT	P46 – P67	- pulled production system; - kanban management; - family of products; - visual management; - setup; - takt time;
	External Suppliers - ES	P68 – P78	- relationship with suppliers; - pulled production system; - qualifying criteriacritérios;
	Customers - C	P79 – P85	- demand forecasting; - relationship with customers; - just in time; - performance KPIs;
	Autonomation – A	P86 – P93	- assured quality in the process; - poka yoke; - autonomy; - autonomous maintenace;

V. RESULTS – EXPLORATORY DATA ANALYSIS

The data collected from the questionnaire that 32 pharmaceutical companies (object) answered loaded in the Phyton statistical software in order to define cluster A and cluster B for practices in environmental management and lean manufacturing. The clustering results are shown in Fig. 4. The clustering process allowed the allocation of the companies in the quadrants, as defined in the model adopted according to Fig. 5.

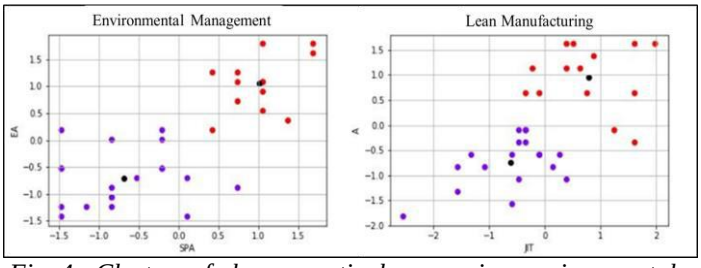

Fig. 4 - Clusters of pharmaceutical companies: environmental management and lean manufacturing practices.

The first and second columns of the Table 1 and Table 2 represent, respectively, the clusters in which the pharmaceutical companies were classified and the numerical identification of each company. The other

https://dx.doi.org/10.22161/ijaers.6718 ISSN: 2349-6495(P) | 2456-1908(O)

columns of the tables are the variables, which were distributed in:

• Table 1: Environmental Preservation System (EPS), Product Project (PP), Manufacturing Process (MP) and Environmental Strategy (ES).

• Table 2: Just In Time (JIT), External Suppliers (FE), Customers (C) and Autonomation (A).

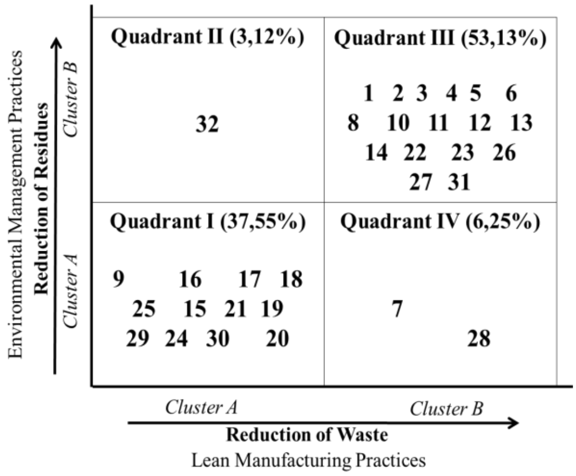

Fig. 5 - Allocation of companies in the quadrants

The frequencies (fashion values) of the answers given by the pharmaceutical companies were analyzed for each set of variables grouped in the clusters. The fashion obtained for each variable, for the sustainability competencies, were plotted on the radar chart shown in Fig. 6. The distribution of the fashion for clusters of environmental management and lean manufacturing allowed the exploratory analysis of data and the characterization of each group of companies in the quadrants I, II, III and IV, as shown in Fig. 5.

The characteristics of the companies in clusters A and B of environmental management are presented in Chart 2. Chart 3 describes the companies of clusters A and B in management of lean manufacturing.

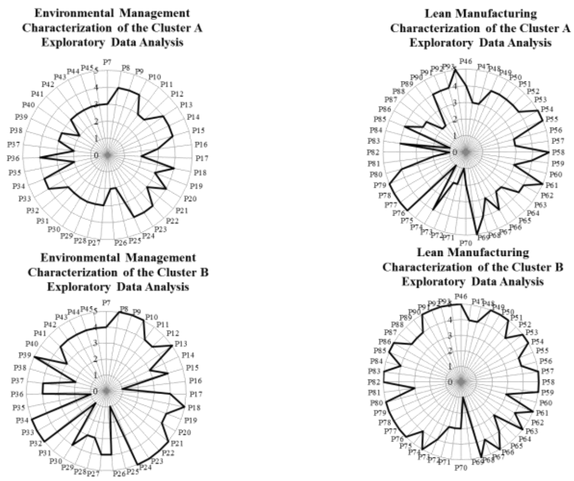

Fig. 6 - Characterization of the clusters for exploratory analysis of the variables

Table 1

Environmental Management

Variáveis

		EPS						Product Project										Manufacturing Process													Environmental Strategy									
Cluster	Company	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	P24	P25	P26	P27	P28	P29	P30	P31	P32	P33	P34	P35	P36	P37	P38	P39	P40	P41	P42	P43	P44	P45
A	1	4	5	4	5	3	3	4	4	4	4	3	4	4	4	3	4	4	4	3	2	4	4	3	4	5	2	5	5	5	4	2	5	3	3	3	3	2	4	2
A	2	3	4	4	5	3	4	4	4	3	3	1	4	5	4	3	4	4	4	2	3	4	3	2	3	4	2	4	4	5	4	2	4	4	2	3	4	3	3	3
A	3	4	4	5	5	4	4	4	4	4	3	1	3	5	4	4	4	5	4	3	2	3	4	3	4	5	3	5	5	4	3	2	4	3	3	3	3	2	4	3
A	4	2	4	4	4	2	3	3	4	4	2	1	4	5	3	3	4	4	4	2	2	2	4	3	4	4	2	4	5	5	4	2	5	3	1	3	3	3	2	2
A	5	2	4	4	4	2	3	4	4	3	1	2	3	5	4	4	4	4	4	2	3	3	3	2	3	5	3	4	4	5	5	2	4	4	3	3	3	2	3	3
A	6	4	4	4	5	4	3	4	4	3	1	1	4	5	3	4	4	4	4	2	2	2	4	3	4	5	2	4	5	5	4	2	3	2	1	3	3	3	4	2
B	7	3	4	4	4	3	5	5	4	4	3	2	4	5	5	4	4	5	4	3	3	3	4	3	4	4	2	4	5	4	4	2	5	4	3	3	3	3	4	4
A	8	2	4	4	4	2	3	4	4	4	4	3	4	4	4	4	4	4	4	4	4	3	4	3	3	5	4	4	4	3	4	3	5	4	3	3	3	3	3	5
B	9	4	5	5	5	3	3	5	5	4	5	4	4	4	5	5	5	5	5	4	4	4	4	5	4	5	4	5	4	4	5	4	5	5	3	4	4	4	4	4
A	10	3	4	4	4	3	4	4	5	4	5	3	3	3	3	3	4	3	4	3	3	3	3	4	2	4	3	5	2	4	5	3	3	3	2	4	3	3	2	3
A	11	3	4	4	3	3	2	4	4	4	4	2	4	3	4	4	4	4	3	3	2	3	4	3	3	4	4	4	1	3	4	2	2	3	3	3	2	2	3	3
A	12	4	4	4	4	2	3	5	4	5	3	3	4	2	3	4	3	3	4	2	2	2	3	4	2	5	3	4	1	2	3	2	3	4	2	4	3	3	3	2
A	13	4	4	4	4	2	3	4	3	4	4	3	3	3	3	3	4	4	4	3	3	1	4	5	3	3	2	4	2	2	4	2	3	3	1	4	2	3	3	3
A	14	3	4	4	3	3	2	4	4	4	3	2	3	2	4	3	4	5	4	3	2	2	3	3	4	3	3	4	3	1	4	2	4	4	2	4	2	3	4	3
B	15	4	5	5	4	4	4	5	4	4	1	4	5	3	3	3	5	5	4	1	3	3	3	3	3	1	5	5	5	1	5	5	3	5	4	5	4	4	3	4
B	16	4	5	5	4	5	4	4	3	3	1	3	5	3	3	5	3	5	4	1	3	3	3	3	3	1	5	4	5	1	4	5	2	5	4	5	3	4	5	3
B	17	4	5	5	5	4	4	4	3	3	1	3	5	4	4	4	5	5	5	1	4	4	3	4	3	1	5	5	4	1	5	4	2	4	3	3	4	4	5	4
B	18	3	5	5	4	4	4	4	3	3	1	4	5	4	4	3	5	3	4	1	4	4	3	3	4	1	4	5	5	1	5	4	2	4	3	3	3	4	5	3
B	19	4	5	5	4	4	4	5	4	4	1	3	5	3	4	5	4	4	5	1	1	3	3	3	4	1	4	5	5	1	4	5	3	5	4	4	3	3	5	3
B	20	5	4	4	5	5	5	4	3	3	1	3	5	4	4	4	3	5	5	1	2	3	3	3	3	1	4	4	5	1	4	5	2	5	4	4	3	3	4	3
B	21	5	4	4	5	4	5	5	3	4	1	4	5	3	3	5	4	5	5	1	3	3	3	4	4	1	5	4	5	1	4	5	3	4	5	4	4	4	4	4
A	22	3	4	4	4	4	4	4	4	4	3	2	3	4	4	4	4	5	4	2	3	3	3	4	4	3	3	4	4	2	4	4	4	4	2	3	4	3	4	4
A	23	3	4	3	4	3	3	4	3	3	3	2	3	2	3	3	3	3	3	2	2	2	3	3	2	3	3	3	3	2	3	2	3	3	2	3	3	3	3	3
B	24	4	5	4	5	4	4	5	4	4	4	3	3	4	4	4	3	5	4	4	3	4	3	4	4	4	4	4	5	2	4	4	4	5	3	4	4	4	4	5
B	25	4	5	5	5	5	5	5	5	4	4	4	4	4	5	5	5	5	5	4	4	4	4	5	4	4	5	5	5	4	5	4	5	5	3	5	4	4	4	5
A	26	3	4	4	4	3	3	4	4	4	2	2	3	3	3	3	3	4	4	2	3	3	3	3	3	3	3	4	4	2	4	2	3	3	3	3	3	3	3	3
A	27	3	4	4	4	3	3	4	3	3	2	2	3	3	3	3	3	4	4	2	3	2	3	3	3	3	3	4	4	2	4	2	3	3	2	3	3	4	3	3
A	28	3	5	4	5	3	3	4	4	4	3	3	4	3	4	4	4	5	4	3	4	3	4	4	4	4	3	4	4	3	4	4	3	4	2	3	3	3	3	3
B	29	4	5	5	5	4	4	4	5	4	4	3	4	4	4	4	4	5	5	4	4	4	4	4	4	4	4	5	5	3	4	4	4	5	3	4	4	4	4	5
B	30	4	5	5	5	5	5	5	5	4	4	4	5	4	5	5	5	5	5	4	4	4	4	5	4	5	5	5	5	4	5	4	5	5	4	5	4	4	4	5
A	31	3	4	4	4	3	3	4	4	4	4	3	4	3	4	3	4	4	4	3	3	3	3	4	3	4	4	4	4	3	4	3	4	4	2	4	3	4	3	4
A	32	3	5	4	5	5	5	1	3	4	1	4	4	4	5	4	5	4	4	1	4	4	2	2	2	2	2	2	2	2	5	2	3	5	5	5	5	5	5	5

https://dx.doi.org/10.22161/ijaers.6718 ISSN: 2349-6495(P) | 2456-1908(O)

Table 2

		Lean Manufacturing																																															
		Variables																																															
		Just In Time																						External Suppliers											Customers							Autonomation							
Cluster	Company	P46	P47	P48	P49	P50	P51	P52	P53	P54	P55	P56	P57	P58	P59	P60	P61	P62	P63	P64	P65	P66	P67	P68	P69	P70	P71	P72	P73	P74	P75	P76	P77	P78	P79	P80	P81	P82	P83	P84	P85	P86	P87	P88	P89	P90	P91	P92	P93
A	1	5	4	3	5	4	3	4	3	5	5	3	4	5	4	3	4	5	4	3	3	5	1	4	4	3	1	2	3	4	1	5	5	5	5	4	2	1	5	1	5	3	3	3	2	4	4	5	5
A	2	5	3	2	4	3	4	5	4	5	4	4	3	5	5	4	4	4	5	2	2	4	2	4	5	2	1	3	4	3	1	5	5	5	4	4	2	2	4	1	3	4	4	1	3	4	5	5	5
A	3	5	4	1	5	5	3	4	3	5	5	5	5	5	4	2	4	3	5	1	3	3	2	4	5	3	1	1	2	5	1	5	5	5	4	3	3	1	4	2	5	3	3	2	1	4	4	5	5
A	4	4	4	2	5	5	5	4	2	5	5	4	4	5	3	2	5	5	4	3	4	5	4	5	4	4	1	1	2	4	2	5	5	5	5	4	2	1	5	1	4	3	3	1	2	5	4	4	5
A	5	5	5	1	5	5	4	4	4	5	5	5	3	5	4	4	5	4	5	1	2	4	3	4	5	3	2	1	3	3	1	5	5	5	4	3	4	1	4	2	4	3	3	3	2	4	5	4	5
A	6	5	4	1	5	5	5	5	3	5	5	4	3	5	4	2	4	5	1	2	4	4	3	3	5	2	1	3	3	3	1	5	5	5	5	4	2	1	4	1	4	4	4	2	2	4	4	5	5
B	7	5	5	3	5	5	4	5	5	5	5	5	5	5	5	3	5	4	5	3	3	5	4	5	5	3	1	2	4	4	1	5	5	5	4	5	2	1	5	1	5	2	4	2	2	5	5	5	5
A	8	4	4	3	4	5	4	3	4	5	4	4	3	4	5	4	5	5	3	3	2	4	3	4	5	3	1	3	3	4	2	5	5	5	5	4	3	2	4	3	4	3	4	3	2	4	4	4	5
B	9	5	4	4	5	5	4	4	4	5	5	4	4	5	5	4	5	4	4	4	4	4	4	5	5	4	2	4	4	5	3	5	5	5	5	5	3	1	5	2	5	4	4	2	1	5	5	5	5
A	10	4	4	3	4	4	3	5	5	5	5	3	4	5	4	4	5	3	4	3	3	4	3	5	4	4	1	3	3	4	4	5	5	5	5	5	2	1	3	1	5	3	3	2	3	4	5	4	4
A	11	4	3	3	4	5	2	3	4	5	5	4	2	5	5	4	5	4	3	3	3	4	3	4	5	3	1	3	2	4	1	5	5	5	5	4	1	1	3	1	5	4	4	3	3	4	4	4	5
A	12	4	3	2	3	3	3	3	4	5	5	3	3	4	5	3	4	5	3	2	3	3	2	3	5	2	1	2	3	3	1	5	5	5	4	4	1	1	3	2	4	3	4	4	2	3	5	3	5
A	13	4	4	3	4	4	4	4	3	4	4	3	3	5	4	4	5	5	4	3	2	2	4	3	5	2	1	1	3	4	2	5	5	5	5	3	2	2	4	1	4	2	4	4	3	4	4	4	5
A	14	4	3	2	4	3	3	4	4	5	4	3	2	4	4	3	5	4	4	2	4	3	3	4	4	3	2	2	2	4	3	5	5	5	5	3	2	2	3	1	4	2	3	3	3	4	4	4	5
B	15	2	5	4	5	5	5	5	5	5	5	4	3	3	5	5	5	4	5	5	5	5	4	5	1	3	4	3	1	4	4	4	4	3	2	4	3	5	4	4	4	5	4	4	4	4	4	4	5
B	16	1	4	3	3	4	3	4	4	4	4	4	5	5	4	3	3	4	5	3	4	5	5	4	1	2	3	1	4	5	5	5	5	3	3	4	1	4	5	4	4	4	4	5	5	5	4	4	5
B	17	1	4	1	4	3	3	5	5	5	5	4	3	3	5	5	5	4	5	5	5	5	4	4	1	1	3	3	4	5	5	4	4	3	1	5	3	4	5	3	3	5	5	4	4	4	5	5	4
B	18	2	5	4	5	4	3	5	4	4	4	4	5	5	4	3	3	4	5	3	4	5	5	4	1	3	5	3	3	5	4	5	4	4	2	4	3	4	5	4	4	5	5	5	4	5	5	5	4
B	19	1	5	4	5	5	5	4	4	4	4	4	5	5	4	3	3	4	5	3	4	5	5	4	1	2	3	1	4	5	4	4	3	3	3	4	3	5	5	4	5	4	4	5	5	4	5	5	4
B	20	2	4	3	3	5	5	4	5	4	4	4	5	5	4	3	3	4	5	3	4	5	5	5	1	1	4	3	3	4	5	5	4	4	3	5	1	5	4	5	5	5	4	4	5	5	5	5	5
B	21	2	4	1	4	5	5	4	5	4	4	5	4	4	4	3	3	4	5	2	4	3	4	5	1	3	4	1	3	5	4	4	5	3	2	5	1	5	4	4	4	5	4	4	4	3	4	5	5
A	22	4	3	3	4	4	4	4	4	5	4	4	3	3	5	3	4	4	4	2	3	4	3	4	4	2	1	2	2	4	4	4	4	4	2	4	1	2	4	2	3	3	3	2	2	3	4	3	5
A	23	2	3	3	3	3	3	3	3	5	4	3	2	2	4	2	3	4	3	2	2	4	2	3	2	1	1	2	2	3	3	4	4	4	2	3	1	1	1	1	2	3	3	2	2	3	4	3	4
B	24	3	4	4	5	5	5	5	5	5	4	4	4	3	5	3	5	4	5	3	3	5	3	5	4	3	2	3	4	5	4	5	5	5	3	5	3	2	5	3	5	4	4	4	3	5	5	4	5
B	25	5	4	4	5	5	5	4	5	5	5	4	5	5	4	4	5	4	4	4	5	4	4	5	5	4	2	3	3	5	5	5	5	5	5	4	3	3	5	3	5	5	5	4	4	5	5	5	5
A	26	2	3	2	3	3	3	4	4	4	4	3	3	3	4	3	4	4	4	3	3	4	3	3	3	2	1	1	1	4	4	4	4	5	4	4	1	1	2	2	4	3	3	2	2	4	4	5	5
A	27	3	3	2	3	3	3	4	4	4	4	3	2	3	4	3	4	4	4	3	3	4	3	3	3	2	1	1	2	4	3	4	5	4	4	5	1	1	1	1	4	3	3	2	2	4	4	4	4
A	28	3	4	3	3	4	4	4	4	5	5	3	2	4	5	3	5	5	5	3	4	4	3	3	4	3	2	2	2	4	4	5	5	5	4	4	2	2	2	1	5	4	4	4	3	5	5	4	5
B	29	4	4	3	4	4	4	5	5	5	4	4	4	4	5	4	5	5	4	4	4	4	4	4	5	4	2	3	3	5	4	5	5	5	5	5	2	3	3	4	5	5	4	4	4	5	5	5	5
B	30	5	4	4	5	5	5	4	5	5	5	4	5	4	5	5	5	5	4	4	4	5	5	5	5	4	3	3	3	5	5	5	5	5	5	5	2	3	5	4	5	5	5	4	4	5	5	5	5
A	31	4	3	2	4	4	4	4	4	4	5	4	3	3	4	3	5	4	4	3	3	4	3	4	4	2	1	2	2	4	4	5	5	5	4	5	1	1	3	2	4	4	3	3	2	4	4	4	5
A	32	2	2	4	4	4	4	4	4	5	4	4	3	5	5	4	3	3	5	3	4	3	3	4	5	4	2	2	3	1	1	4	5	4	3	2	2	1	2	1	1	4	4	2	3	5	5	3	5

Chart 2 - Characterization of companies in clusters A and B regarding environmental management.

Environmental Management		
Characteristic	***Cluster* A**	***Cluster* B**
Frequency of implementation of kaizen/circle of quality control for practices of continuous improvement in environmental management.	Moderate	Frequently
Level of information of employees regarding environmental legislation.	Less than 50%	Greater than 80%
Visual management for information on negative environmental effects caused by failures or positive environmental effects caused by improvements in processes.	Being implemented	Being implemented
Development of products with materials (raw materials, components, etc.) that are recyclable or less harmful to the environment.	Being implemented	Currently implemented and leader in the industrial sector
Development of processes to reduce the quantity of materials needed to manufacture products. Environmental management aimed at more efficient use of inputs/raw materials.	Being implemented	Being implemented
Development of products and processes to reduce the consumption of resources such as energy, water, auxiliary products, components, etc.	Implemented	Currently implemented and leader in the industrial sector
Reduction of material flow time in processes by simplifying or removing unnecessary activities in manufacturing operations. Minor lead time.	Planning the implementation	Currently implemented and leader in the industrial sector
Development of products that use recycled materials or materials that cause less damage to the environment	Being implemented	Currently implemented and leader in the industrial sector
Actions aiming at the reduction of electric energy consumption for the manufacturing of products.	Neutral	Agree
Environmental management is predominantly linked to the production processes of the manufacturing system.	Agree	Strongly Agree
The environmental management in manufacturing processes is directed to actions that aim at the reduction of virgin raw materials use.	Not considered	Planning the implementation
The manufacturing system applies environmental criteria in the selection and qualification of suppliers.	Rarely Applies	Frequently Applies
Indicating which degree of pollution prevention is important for the competitive performance of the company.	Important	Important
Percentage of the company's investments destined to the prevention of pollution in the processes of the manufacturing system.	Up to 10% of the Investments	From 25% to 50% of the Investments
Strategic planning that results in a written mission, goals and actions for the implementation of long-term environmental improvements.	The company has an informal environmental planning, which is not very well defined. Meets 25% of the goals.	Strategic environmental planning is formal, defined by the high level managers of the organization and the guidelines are passed on clearly and comprehensibly to all levels of the organization. Meets 50% of goals.
Environmental management as a competitiveness strategy.	The environment is seen as a further constraint on the company's activities. It only complies with the regulations in force.	Environmental management is seen as an element of extra cost competitiveness, with the purpose of prospecting and developing new business opportunities.
Support of the high level managers to ensure the understanding of the whole organization about the commitments to environmental issues.	Neutral	Agree

With the features shown in Charts 2 and 3, it is possible to determine which practices in lean manufacturing and environmental management are adopted by pharmaceutical companies distributed in the quadrants I, II, III and IV, as shown in Fig. 5.

The results indicate that, in the sample of 32 pharmaceutical companies, 53.13% of them adopt practices in lean manufacturing and environmental management aiming to reduce waste and residues, which give them a competitive differential in terms of cost, quality, reliability to meet customer deadlines, speed of production and flexibility in the manufacturing process and products. As a deduction, the other companies, that

https://dx.doi.org/10.22161/ijaers.6718 ISSN: 2349-6495(P) | 2456-1908(O)

Chart 3 - Characterization of the companies in clusters A and B management regarding lean manufacturing

Lean Manufacturing Management		
Characteristic	**Cluster A**	**Cluster B**
The processes on the shop floor adopt a pulled production system, using kanban.	Some implementation. By 40% of the processes	Advanced implementation and, in some cases, implemented
The suppliers' and customers' processes on the shop floor are located close to each other. Production resources are grouped together to produce product families in a continuous flow of materials.	Advanced implementation	Implemented
Visual management with production, quality and maintenance indicators.	Some implementation. By 40% of the processes	Implemented
The key leadership (directors, managers, supervisors, bosses) of the various departments of the organization work to encourage JIT (Just in time) production.	Strongly Agree	Strongly Agree
The operators of the manufacturing system are trained and adopts techniques to reduce setup time in operations.	Advanced implementation	Implemented
The manufacturing system meets the production schedule and completes the daily production plan.	Neutral	Agree
The manufacturing system adopts takt time, to establish the pace of production.	50% of the processes	100% of the processes
Feedback process to suppliers regarding to the quality of products delivered and their delivery performance.	Advanced implementation	Implemented
Implementation of actions aiming at the commitment of suppliers in the reduction of costs of resources and materials.	Low implementation	Advanced implementation
The manufacturing system of the company adopts the pulled production system with its suppliers, for the supply of raw materials and/or components.	The manufacturing system of the company do not adopt the pulled production system, using kanban, with its suppliers	Yes, between 50% and 70% of the listed suppliers
Ensured quality, reliability of delivery and costs of the inputs are qualifying criteria of the suppliers.	Strongly Agree	Strongly Agree
Customers are actively and directly involved in the supply of current demand and future businesses.	Not involved	Strongly involved
Implementation of Just in Time (JIT) working with the manufacturing system in the customer	No implementation	Advanced implementation
Improvement of product quality, scrap and rework costs indicators	No change in the previous 3 years	Improvement above 20% in the previous 3 years
Productivity of the manufacturing processes.	Increased from 1% to 20%	Increased from 40% to 80%
The crossing time of the materials passing through the manufacturing process (from the raw material to the finished product).	Decreased from 1% to 20%	Decreased from 40% to 60%
The operators of the manufacturing processe are responsible for the quality of the product and they have autonomy to interrupt the process when a problem occurs.	Fom 50% to 70% of the operators	From 70% to 100% of the operators
The machines and/or equipments in the manufacturing processes are provided with "error-proof", or "poka yoke", devices.	From 50% to 75% of the machines and/or equipments have "error-proof" devices installed.	From 75% to 100% of the machines and/or equipments have "error-proof" devices installed.

make up 46.87% of the sample, have to improve their practices in environmental management and/or lean manufacturing management to achieve a more favorable competitive condition. Between the good practices of improvements in environmental management, can be highlighted: the reduction of material flow time along the manufacturing processes, the development of products that use recycled materials or materials that cause less damage to the environment; processes that reduce the emission of pollutants and consume less resources such as electricity, water, raw materials and labour; and establish environmental management as a competitive strategy.

Regarding to the best practices in lean manufacturing, the companies contained in these 46.87% should implement a pulled production system and extend it to their suppliers' and customers' manufacturing systems; reduce setup time; increase the quantity of poka yoke devices; improve quality indicators, as well as reduce scrap and rework; intensify the feedback with suppliers concerning the indicators of quality and reliability of delivery of the resources supplied.

VI. CONCLUSION

Finding a way to improve the performance of manufacturing processes has been a challenge for many manufacturing companies that face a Market which consistely increases its competitiveness.

The manufacturing processes contribute to the company's competitiveness based on the continuous increase of productivity, making the system more efficient.

The main goal of lean manufacturing is to reduce waste, minimizing the environmental impact caused by the manufacturing processes. Therefore, lean manufacturing leads companies to a competitive advantage and environmental management, a differentiated strategy based on the reduction of impacts caused to the environment.

Both the reduction of waste, promoted by the practices in lean manufacturing, and the reduction of residues, with the practices in environmental management, give companies a differentiated competitive ability.

The model proposed in this paper provided adherence to the analysis of companies in the pharmaceutical sector, with the objective of exploring the reduction of waste and residues in their manufacturing processes, supported by the application of lean manufacturing and environmental management practices.

The results pointed out that approximately half of the companies surveyed need to advance in the adoption of practical actions that establish positive outputs in the reduction of wastes and residues in their manufacturing processes, and then they can reach a better competitive

https://dx.doi.org/10.22161/ijaers.6718 ISSN: 2349-6495(P) | 2456-1908(O)

condition. The results also provided a better understanding about which practices companies need to improve in lean manufacturing and environmental management in order to achieve a more competitive condition in their markets.

The inference of the results refers only to the companies surveyed. It can not be extended to the whole population of pharmaceutical manufacturing companies.

It is suggested to extend the application of this study to other industrial sectors, with the objective of elaborating an analysis of the distribution of the companies between the considered sectors. In this way, comparative exploratory analyzes should be performed between the various segments.

REFERENCES

[1] ABILAASH, A.; ARAVINTHKUMAR, A.; SATHISHKUMAR, K. Development of Web Application Framework for Lean Assessment Approach. International Journal of Advanced Engineering Research and Science v.3, p.81-87, 2016. https://dx.doi.org/10.22161/ijaers/3.10.16

[2] AGOSTINHO, O. L. Sistemas de Manufatura. v I. Capítulo 4: Competitividade Externa. Universidade Estadual de Campinas. Faculdade de Engenharia Mecânica, 2014.

[3] AGOSTINHO, O. L.; BATOCCHIO, A.; SILVA, I. B. Technology and Business Strategies Methodology for Correlation and Prioritization Using Knowledge Management. The Third European Conference on Mangement of Techonology, Nice-France Euromot, 2008.

[4] ALVES, J. R. X.; ALVES, J. M. Production Management Model Integrating the Principles of Lean Manufacturing and Sustainability Supported by the Cultural Transformation of a Company. International Journal of Production Research. v.53, p.5320-5333, 2015 https://doi.org/10.1080/00207543.2015.1033032

[5] BHAMU, J.; SANGWAN, K. S. Lean Manufacturing: Literature Review and Research Issues. International Journal of Operations & Production Management. v.34, n.7, p. 876-940, 2014. DOI: 10.1108/IJOPM-08-2012-0315

[6] BÁNKUTI, S. M. S.; BÁNKUTI, F. I. Gestão ambiental e estratégia empresarial: um estudo em uma empresa de cosméticos no Brasil. Gestão & Produção, São Carlos, v. 21, p.171-184, 2014. Retrieved from: <http://www.scielo.br/pdf/gp/v21n1/a12v21n1. pdf>. Accessed on: April 21st, 2018.

[7] BÜYÜKÖZKAN G.; KAYAKUTLU, G.; KARAKADILAR, I. S. Assessment of Lean Manufacturing Effect on Business Performance Using Bayesian Belief Networks. Expert Systems With Applications, v.42, n.19, 2015. https://doi.org/10.1016/j.eswa.2015.04.016

[8] CUA, K. O., MCKONE, K. E., SCHROEDER, R. G. Relationships Between Implementation of TQM, JIT, and TPM and Manufacturing Performance. Journal of Operations Management, v.19, p.675–694, 2001. https://doi.org/10.1016/S0272-6963(01)00066-3

[9] DE TREVILLE, S., ANTONAKIS, J. Could Lean Production Job Design be Intrinsically Motivating: Contextual, Configurational, and Level of Analysis Issues. Journal of Operations Management, 2006, v.24, p.99-123. https://doi.org/10.1016/j.jom.2005.04.001

[10] DIAS, R. Gestão Ambiental: Responsabilidade Social e Sustentabilidade. 3. ed. São Paulo: Atlas, 2017.

[11] DÜES, C. M.; TAN, K. H.; LIM, M. Green as the New Lean: How to Use Lean Practices as a Catalyst to Greening Your Supply Chain. Journal of Cleaner Production, v.40, p.93-100, 2013. https://doi.org/10.1016/j.jclepro.2011.12.023

[12] FULLERTON, R. R.; KENNEDY, F. A.; WIDENER, S. K. Lean Manufacturing and Firm Performance: The Incremental Contribution of Lean Management Accounting Practice. Journal of Operation Management, v.32, 2014. https://doi.org/10.1016/j.jom.2014.09.002

[13] HART, S. L.; DOWELL, G. A Natural-Resource-Based View of the Firm: Fifteen Years After. Journal of Operation Management. On-line publication on Dec. 10th, 2010. DOI: 10.1177/0149206310390219

[14] HOPP, W. J.; SPEARMAN, M. L. To Pull or Not to Pull: What is the Question? Manufacturing & Service Operations Management, v.6 (2), p.133-148, 2004. . https://doi.org/10.1287/msom.1030.0028

[15] JABBOUR, C. J. C.; JABBOUR, A. B. L. S.; GOVINDAN, K.; TEIXEIRA, A. A.; FREITAS, W. R. S. Environmental Management and Operational Performance in Automotive Companies in Brazil: The Role of Human Resource Management and Lean Manufacturing. Journal of Cleaner Production, v.47, p.129-140, 2013. https://doi.org/10.1016/j.jclepro.2012.07.010

[16] JOHNSON, R. A.; WICHERN, D. W. Applied Multivariate Statistical Analysis. 6ª ed. New Jersey: Prentice Hall, 2007.

[17] JORGE, M. L.; MADUEÑO J. H.; MARÍNEZ, D. M.; SANCHO, M. P. L. Competitiveness and Environmental Performance in Spanish Small and Medium Enterprises: Is There a Direct Link? Journal of Clean Production. v.101. p.26-37, 2015. https://doi.org/10.1016/j.jclepro.2015.04.016

[18] JR. HAIR, J. F.; et al. Análise Multivariada de Dados. 5ª ed. Porto Alegre: 2005.

[19] KING, A. A.; LENOX, M. J. Lean and Green? An Empirical Examination of the Relationship Between Lean Production and Environmental Performance. Production and Operations Management, 10 (3), p. 244-256, 2001. https://doi.org/10.1111/j.1937-5956.2001.tb00373.x

[20] KOVACH, J.; STRINGFELLOW, P.; TURNER, J.; CHO. B. R. The House of Competitiveness: The Marriage of Agile Manufacturing, Design for Six Sigma, and Lean Manufacturing with Quality Consideration. Journal of Industrial Technology, v. 21, n.3, p.1-10, 2005.

[21] LANDER, E.; LIKER, J. K. The Toyota Production System and Art: Making Highly Customized and Creative Products the Toyota Way. International Journal of Production Research, v. 45, n.16, p. 3681–3698, 2007. https://doi.org/10.1080/00207540701223519

[22] MEDEIROS, M. S. B. et al. Gestão Ambiental e Sustentabilidade: Um Estudo de Caso na Agência do Banco do Brasil de Alagoa Nova/PB. Revista Eletrônica em Gestão, Educação e Tecnologia Ambiental, Santa Maria, v. 19, p.256-273, dec. 2015. Retrieved from: <https://periodicos.ufsm.br/reget/article/view.File/18864/pdf>. Accessed on: April 23rd, 2018.

[23] PIL, F. K.; FUJIMOTO, T. Lean and Reflective Production: The Dynamic Nature of Production Models. International Journal of Production Research, v.45, n.16, p.3741-3761, 2007. https://doi.org/10.1080/00207540701223659

[24] RODRIGUES, L. H., AGOSTINHO, O. L. Proposta de Modelo para Análise da Competitividade em Sustentabilidade Ambiental em Empresas do Segmento Automotivo. GEPROS. Gestão da Produção, Operações e Sistemas, v.13, n.2, p.132-160, 2018, DOI: 10.15675/gepros.v13i2.1853.

[25] ROHANI, J. M.; ZAHRAEE, S. M. Production Line Analysis Via Value Stream Mapping: A Lean Manufacturing Process of Color Industry. Elsevier Procedia Manufacturing v. 2, p. 6–10, 2015. https://doi.org/10.1016/j.promfg.2015.07.002

[26] ROOSEN, T. J.; PONS, D. J. Environmentally Lean Production: The Development and Incorporation of an Environmental Impact Index into Value Stream Mapping. Journal of Industrial Engineering 2013, http://dx.doi.org/10.1155/2013/298103

[27] ROTHENBERG, S.; PIL, F. K.; MAXWELL, J. Lean, Green, and the Question for Superior Environmental Performance. Production and Operations Management, v. 10, n. 3, p. 228-243, 2009. DOI: 10.1111/j.1937-5956.2001.tb00372.x

[28] SHAH, R.; WARD, P. T. Lean Manufacturing: Context, Practice Bundles, and Performance. Journal of Operations Management, v. 21, p. 129–149, 2003. https://doi.org/10.1016/S0272-6963(02)00108-0

[29] SHAH, R.; WARD, P. T. Defining and Developing Measures of Lean Production. Journal of Operations Management, v. 25, p. 785-805, 2007. https://doi.org/10.1016/j.jom.2007.01.019

[30] SILVA, C. L. M.; FONSECA, V. S. Competitividade Organizacional: uma Tentativa de Reconstrução Analítica. Revista de Administração Contemporânea. Curitiba, art. 2, pp. 33-49, 2010. http://dx.doi.org/10.1590/S1415-65552010000600003

[31] SINGH, B.; GARG, S. K.; SHARMA, S. K.; GREWAL, C. Lean Implementation and Its Benefits to Production Industry. International Journal of Lean Six Sigma, v. 1 n. 2, p. 157-168, 2010. https://doi.org/10.1108/20401461011049520

[32] TOWILL, D. R. Exploiting the DNA of the Toyota Production System. International Journal of Production Research, v.45, n.16, p.3619–3637, 2007. https://doi.org/10.1080/00207540701223436

[33] WALTER, O. M. F. C.; TUBINO, D. F. Métodos de Avaliação da Implantação da Manufatura Enxuta: Uma Revisão da Literatura e Classificação. Gestão da Produção, v. 20, n. 1, p. 23-45, 2013. http://dx.doi.org/10.1590/S0104-530X2013000100003

[34] YANG, M. G.; HONG, P.; MODI, S. B. Impact of Lean Manufacturing and Environmental Management on Business Performance: An Empirical Study of Manufacturing Firms. Int. Production Economics. v.129, p.251–261, 2011. https://doi.org/10.1016/j.ijpe.2010.10.017