Systems & Management 13 (2018), pp 196-208

ANALYSIS OF THE ADOPTION OF LEAN PRACTICES IN BRAZILIAN COMPANIES: AN EXPLORATORY STUDY

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ABSTRACT

This article investigates the adoption of Lean Production in Brazilian companies based on the premises of the Lean Manufacturing Model.

The work was developed considering the Lean Production construct by means of 65 (sixty-five) variables that characterize Lean grouped in 8 (eight) dimensions of analysis: costs, production control, continuous flow, setup, leveling and balancing of production, process autonomy, standardization of operations and people. The stage of adoption of lean in companies was identified from the survey with directors, managers, supervisors, engineers in charge and analysts. For the study, a structured questionnaire was used to collect data, not disguised as assertive, contemplating several aspects of the Lean model. The degree of agreement with the assertion was signaled using the scale resulting from a combination of the Stapel scale with the Likert scale with 10 (ten) points. The data obtained were analyzed using descriptive statistics.

Keywords: Production Strategy; Lean; Descriptive Analysis.

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DOI: 10.20985/1980-5160.2018.v13n2.1353

Electronic Journal of Management & System
Volume 12, Number 2, 2018, pp. 196-208
DOI: 10.20985/1980-5160.2018.v13n2.1353

1. INTRODUCTION

Efficiency in production and thus in the management of production systems has challenged countries and companies, since greater productivity, with reduction of losses, ensures well-being to the people. For humanity to live more and better, it is fundamental to use raw materials and other production resources efficiently, mitigating waste.

In order to become competitive, companies are adopting techniques to improve the production process. In the Brazilian case, the impacts and results obtained, with some exceptions, are still insignificant in the vast majority of cases.

A study developed by the Brazilian *Confederação Nacional da Indústria* (CNI - National Confederation of Industry) in January 2015, called Competitiveness Brazil 2014, analyzed Brazil's competitive capacity based on the relative position of the country, considering a set of countries selected by the economic-social aspects and nature of the market share. This set of countries included South Africa, Argentina, Australia, Canada, Chile, China, Colombia, South Korea, Spain, India, Mexico, Poland, Russia and Turkey.

The comparison considered eight factors: availability and cost of labor, availability and capital cost, infrastructure and logistics, tax burden, macroeconomic environment, microeconomic environment, educational level and technology and innovation.

The study ranked Brazil in the penultimate position among 15 selected countries, ahead only of Argentina.

The favorable position of the country, among the eight factors studied, is obtained only in labor availability and cost (fourth in 14) and the worst position in relation to availability and cost of capital (15th). The result obtained in terms of labor availability and cost is mainly due to the better position of Brazil in the variable participation of the Economically Active Population (EAP), in the population (2nd) and the worse performance in terms of availability and cost of capital, is due to the fact that the country has the highest real short-term interest rate and the highest spread of the interest rate. It should be emphasized that Brazil would have obtained a superior position in labor availability and cost, were it not for the low productivity of labor in industry. The country is in 12th place among 14 competitors in this variable.

Another study published by CNI in 2015 showed that productivity grew less in Brazil than in 11 other countries between 2002 and 2012. In the period, the average growth rate of the index that measures how much is produced per hour worked per year was 0, 6%, the lowest of the comparison made by CNI. South Korea appears at the other end with a raise of 6.7% a year. In the US the increase was 4.4%. In Brazil, the accumulated growth between 2002 and 2012 was 6.6%. In the first two quarters of 2015, even with the adoption of measures to stimulate demand, industrial production fell by 6%.

Tax disbursement, subsidized credits, increased public spending, lower interest rates and, between 2011 and mid-2013, a strong intervention in the foreign exchange market in order to weaken the real against the US dollar were the main measures used to unleash demand; however, the results were not significant. Even with these measures, Brazilian industry remains uncompetitive and this is not only due to factors external to the factory, as some experts say. Brazilian industry, with few exceptions, is uncompetitive both inside and outside the factory because of its great wastes.

The main ones are waste due to problems of cost control, production control, continuous flow, high set-up time, lack of leveling and production balancing, low process autonomy, gaps in the standardization of operations, and personnel development and management.

The adoption of the Lean Model presents itself as an alternative for efficient production, so that it is possible to mitigate the risks of the operation and reduce losses.

2. LEAN MANUFACTURING STRATEGY

Production strategy

The study of production strategy starts from the point of view of its content with Skinner's pioneering work (1969), when he identifies production as an important source of competitive advantage.

The production strategy refers, therefore, to the establishment of policies and plans that allow the efficient use of resources, so as to ensure the achievement of the company's objectives.

Using a market-based approach to operations strategy, a company makes decisions considering the markets and customers it wants to conquer (James, 2011).

Production strategy can be analyzed in several ways, according to Skinner, regarding the importance of production for company strategy (Cohen *et* Lee, 1985; Swamidass *et* Newell, 1987; Anderson *et al*., 1989; Gyampah

Electronic Journal of Management & System
Volume 12, Number 2, 2018, pp. 196-208
DOI: 10.20985/1980-5160.2018.v13n2.1353

et Boye, 2001). Manufacturing tasks, or strategic priorities, as some authors prefer, were first identified by Skinner (1969) as productivity, service, quality, and return on investment. According to Garvin (1993), most publications are focused on four main competitive priorities: cost, quality, delivery and flexibility. To these four competitive priorities, the author adds another one that he calls services and presents them in a very detailed way.

In addition, Slack et al. (2010) identify five operational performance objectives that are part of all types of operations: quality, flexibility, speed, reliability and cost.

The objective of the production strategy is to provide a consistent set of decisions regarding the production process, providing the company with guidance on how best to use the resources in order to support a competitive advantage.

According to Hayes et Wheelwrigh (1988), decision areas can be classified into two categories according to their nature: structural and infrastructural. Structural decisions are those whose impacts occur in the long term, are difficult to reverse or modify and require significant capital contributions. In the first group, decisions on capacity, facilities, technology and vertical integration are classified.

Infrastructure decision-making areas relate to more operational aspects of the business. The results obtained from the decisions taken in this context are short, medium and long term, but capital investments in general are smaller than those required in the structural areas and the reversal of decisions is easier, although it results in losses for the company. The areas of decision of infrastructural nature indicated in the bibliography are: human resources, quality, planning and control of production/materials, new products, measures of performance and organization.

The production strategy can also be explained as referring to the establishment of policies and broad plans to use the resources of a company, aiming at better sustaining its competitive strategy in the long term. The production strategies are developed taking into account the so-called competitive criteria that allow a better analysis on the positioning of products and goods.

Usually four basic competitive criteria are used: *costs*, *quality*, *delivery* and *flexibility*.

Paiva et al. (2004) identify five competitive criteria in the area of production management that relate to the organization's business strategy, namely: costs, quality, delivery performance, flexibility and innovation. The last criterion, innovation, "is traditionally defined as the ability of the company to launch new products and/or services in a short time" (Paiva *et al*., 2004).

Lean Production

The origin of Lean Manufacturing is related to the production system of the Toyota Company. This concept emerged in Japan after the end of World War II. However, the term Lean Manufacturing became known after the publication of the book The Machine that Changed the World, of Womack, Jones and Roos, in 1990.

Lean designates an operations management approach focused on the elimination of waste and overproduction, representing an alternative way to intensive capital mass production with large size lots and losses (Hines *et al.,* 2004).

Lean is a management system focused on eliminating the types of wastes identified by Ohno (1988) and other wastes related to internal and external variability and supply chain variations (Shah *et* Ward, 2007).

When it emerged in Japan, the Lean Production philosophy was conceived as a set of challenges that Toyota found in the Japanese market. The labor force in Japan by then was not so simple to be achieved and managed, besides the country being with a very precarious technology, compared to the great technological centers.

Nowadays, companies are adopting lean management methods aiming at eliminating waste and achieving significant cost savings. However, there is no guarantee of maximization of costs and efficiency in the simple implementation of lean management methods by the company. Savings maximization must be achieved only through a long-term process of lean management (Rohac *et* Januska, 2014).

Lean Manufacturing can be conceptualized as a set of recommendations that companies should continue to aim to become more agile and more competitive (Womack et Jones, 2004).

According to Cusumano (1994), lean manufacturing includes the following principles: just-in-time, minimized inventories, geographic concentration of assembly and component manufacturing, "pulled" production, level production, short set ups, standardization of labor, fail-safe equipment, multifunctional operators and an incremental and continuous improvement of processes.

Lean production encompasses a wide range of practices, which include, above all, a quality system, work in teams and combined manufacturing cells in an integrated system. The manufacturing cell is one of the tools that contribute to the objectives of the LP (Fritzen *et* Saurin, 2014).

Lean practices must permeate the entire enterprise from the development, procurement of raw materials and com-

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ponents, manufacturing and distribution (Karlsson *et* Ahlstrom, 1996).

Lean production minimizes unnecessary variations in the production process consisting of a set of tools plus a philosophy.

Among the main assumptions of the Lean model is the reduction of the seven wastes in the companies that must be identified and eliminated, namely: overproduction waste, wasted material waiting in the process, wasted transportation, wasted production of defective parts and waste of stock.

The production strategy and the lean model

By studying the correlation between Lean Production tools, competitive priorities and operational performance objectives, it is possible to establish the analogies presented in Figure 1.

The fundamentals of Lean Production can be found in competitive/strategic priorities: productivity, service/delivery, quality and return on investment and operational performance objectives: quality, flexibility, speed, reliability and cost.

Competitive Priorities	Operational Performance Objectives	Dimensions of the Reduced Model
Return on Investment	Cost	Production Costs Production control
Quality	Quality	Process autonomy Standardization of operations People
Delivery/service	Reliability	Production control Process autonomy Standardization of operations
Flexibility	Flexibility	Production control Leveling and balancing of production
Productivity	velocity	Production control Continuous flow Setup

Figure 1. Analogy between competitive priorities, operational performance objectives and dimensions of the Lean model surveyed
Source: The authors

Production costing has become a guiding principle to monitor the efficiency of all activities performed, as well as linking process performance to the organization's overall profitability (Sobreiro et al 2008). "Thus, costing of production assumes an important position in support of decision-making in the functions of management and control of companies" (Almeida et Werner, 2015, p.508).

According to Viceconti et Neves, costs are all expenses related to the activity of producing a good or service, one can cite as an example the raw material while in stock (2003).

Production costs include direct and indirect costs. The direct costs are related to the manufactured product. There is a way to measure its consumption in the manufacturing process. The direct costs, therefore, are related to the products and can be measured by means of a measure of consumption. Raw materials consumed, quantity of labor used, quantity of packaging used, and freight are direct costs. Indirect costs are those that are not directly related to the products and, therefore, it is not possible to obtain an objective measure, and it is necessary to use some form of apportionment to distribute these costs among the products manufactured. Rental, maintenance of facilities, and equipment can be considered indirect costs.

According to Viceconti et Neves (2003), indirect costs depend on apportionments, estimates and calculations to be appropriate to the different products.

Production control manages, monitors, and evaluates performance to ensure that production plans are executed in the way they were designed.

According to Zacarelli (1987), production control is the function responsible for planning, directing and controlling the material supply and process activities of a company, so that specific products are produced by specific methods to fulfill an approved sales program, and these activities are carried out in such a way that the available labor, equipment and capital are used with maximum utilization.

Production control is the last step of the PCP, based on data collected and analyzed in order to ensure the effective continuity of production, identifying and taking corrective measures that are useful to the organization (Tubino, 2017).

Autonomation of processes, Autonomation or even Jidoka consists in assigning the operator the autonomy to interrupt the machine or production in situations of defect or when an abnormality is detected. What is recommended in the autonomation is to ally automation with the human decision, that is, the machine stops in situations of defect for operator interventions, thus preventing defective parts from being produced.

The autonomy allows paralyzing the production or process to prevent future errors (Todorova; Dugger, 2015).

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In order to be considered in the Lean approach, the autonomy should dispense with the inspection of the process, since it does not add value to the product and is therefore characterized as waste.

Standardization of operations is fundamental to achieving productivity and competitiveness, as it is one of the premises of modern management. It consists in establishing, through discussions, the most appropriate procedure, defining it as the standard to be followed.

Standardization of operations can be defined as an effective and organized method of producing losses (Ghinato, 2000). Such a method seeks the maximum productivity of each employee, eliminating all types of losses from their operations. All steps are recorded so that they are uniformly repeated by all workers at an established production rate that satisfies the demand. Standardization is important because it allows the operator to repeat the cycle consistently over time. The determination of a standard routine of operations prevents each operator from randomly executing the steps of a particular process, reducing the fluctuations of their respective cycle times (Ghinato, 2000).

Thus, standardization of operations and accurate knowledge of productive capacity have a direct influence on the effectiveness of the PCP by the achievement of some of its objectives, such as: reduction of production lead times, possibility of meeting deadlines, compliance and agility of response of changes in demand. Empowered and committed people are key to eliminating waste and implanting the Lean model.

Another important dimension in the lean model is people. Seeking to reduce losses means involving people in the productive process, motivating them and committing them to use their creativity in order to contribute to the improvement of processes.

The leveling of production to demand is a tool of JIT, just in time, in the scope of production planning and control, whose function is to adapt production to meet variations in demand and reduce inventory. The leveling of production allows the flexibility of production as, instead of manufacturing large batches of a single product, it produces many varieties of small batches, responding to the need of the market, effecting the prompt delivery of products and reducing inventories in the process.

The balancing of the production deals with the leveling of the times, methods and volumes aligned to the need or demand of production. The focus is on optimizing operational resources, which improves quality, productivity and productive efficiency. The balancing of the operations seeks to divide the workload among the operators in a production line in order to meet the takt time, that is, to produce synchronously, following the demand. The takt time can be defined as the elapsed time between two successive units of a product produced by a production cell; this can also be interpreted as the production rate needed to meet a given demand (Pound, Edward S. Bell. Jeffrey H., M.L. Spearman, 2014).

Continuous flow means ensuring that production will occur continuously. Obtaining the continuous flow in the pulled processes is one of the main objectives of the Lean Production, since, from it, it is possible to reduce the main losses in the productive processes, to better meet the needs of customers, to smooth the demand for all productive processes and to reduce product inventories.

Unlike the Fordist model, Lean adopts the continuous flow system, that is, it produces in small batches and thus avoids the maintenance of stock of material in process.

Continuous flow is characterized by the ability to produce only what is needed for the moment. What is important in this production approach is that waste is eliminated (Tapping *et* Shuker, 2003).

Lean adopts the one piece flow system, which reduces the amount of material for a component on the workstations. In this way, the operator traverses the stations carrying the component that is completely assembled.

One-piece flow describes the sequence of products and activities in the process, one unit at a time.

The adoption of the one-piece flow system increases productivity, without the need for additional investments, mitigating the risk of errors during assembly, since, with this work system, the operator will have a comprehensive view of the production process.

The setup is the change of production from one item to another on the same machine or equipment with the change of tool and/or device. The setup time is between the last unit produced from one cycle to the first unit of the next cycle that is produced with quality.

Another important concept among the dimensions of the lean model is setup time, which can be defined as the time needed to prepare resources, machines and people to perform a task, a job, an operation (Allahverdi et Soroush, 2008).

The lower the set-up time the greater the efficiency of the production process and, therefore, the less waste.

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3. RESEARCH METHOD

Research Context

Considering the object of the study *how to understand the degree of adoption and application of Lean Production practices in Brazilian companies*, the research was exploratory. The exploratory research made it possible to better understand the researched subject, since it is still little known.

For the framework, several taxonomies have been studied since research type is a relatively complex concept, which means that it cannot be described in a unique way.

Research that emphasizes the discovery of ideas and insights can be framed as exploratory. In addition, Zirkmund (2006) states that this type of research is developed with the objective of understanding the ambiguous nature of certain problems, in order to obtain a better understanding of the dimensions involved without, however, producing conclusive evidence.

Procedures for collecting, preparing and analyzing data

Data collection was performed by a non-disguised structured data collection instrument that was applied to professionals who work in Brazil and are involved with the productive process of the companies.

The questionnaire used was of a structured type aimed at standardization in the non-disguised data collection process, since the respondents were informed of the objectives of the study.

The instrument of data collection was elaborated in two parts. The first one consisted of 6 questions to identify the profile of the respondent and the company in which he/she works, including the position/function of the respondent, the activity sector of the company, the region where the headquarters are located, billing and number of company employees.

The second part comprised 65 (sixty-five) assertive assemblies grouped into 8 dimensions of Lean Production: costs, production control, continuous flow, setup, leveling and balancing of production, process autonomy, standardization of operations and people.

The scaling technique used was non-comparative scaling in which each of the (assertive) stimulus objects is staggered independently of the others.

The measurement scale used was also of the interval type. In this type of scale, numerically equal distances in the scale represent equivalent values in the characteristic being analyzed. In the Range Scale, the interval between two points is measured within a constant unit, and the zero point is arbitrarily chosen.

In the present study we opted to develop an item classification scale, resulting from a combination of the Likert scale and the Stapel scale. The scale of item classification presents descriptions associated with each category and the categories are ordered according to the position in the scale.

The Likert scale is a rating scale that requires respondents to indicate the degree of agreement with each of the statements presented.

The Stapel scale is a 10-point unipolar scale without a neutral point.

Seeking to combine the advantages of both, we chose to build a scale that merges Likert with Stapel.

This approach finds support in Malhotra (2001) when he states that "it is clear that non-comparative scales of item classification need not be used as originally proposed, and may take many different forms."

The questionnaire was answered by 351 professionals from the production area of the companies surveyed.

According to Basilevsky (2001), it is recommended that the sample size has, at least, four to five times more observations than the number of variables.

Hair et al. (2009) recommend that the sample be at least five times the number of variables studied, although they say that the most acceptable number is the ratio of ten to one.

Another important analysis to determine the suitability of the sample is the statistical significance. "Factorial loads greater than 0.30 are significant only for sample sizes greater than 350; for a sample of 100 respondents, the factorial load must be at least 0.55 to have an adequate degree of significance; 50 respondents to factorial load should be at least 0.75" (Hair *et al*., 2009).

Considering the 351 questionnaires and the 65 variables included in the field survey, a questionnaire/variable ratio of the order of 5.4 is obtained, which validates the sample size for the intended purpose.

The scale was structured with ten categories. An even number of categories were chosen, avoiding, therefore, that the interviewee assumed neutral positions. The scale was of the balanced type, since there were five alter-

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natives (favorable) and five unfavorable alternatives (of discordance).

The preparation of the data consisted of verifying the acceptable questionnaires. Missing or omitted answers were treated by assigning arbitrary values, in this case a neutral value. This alternative was adequate, considering that the proportion of unsatisfactory respondents was less than 1%.

4. DISCUSSION OF THE RESULTS

Respondent/company profile

In the first part of the questionnaire the profile of the respondent and the company was identified.

Regarding the position/function performed, the majority (37.9%) answered that he/she acts as Manager, as can be seen in Table 1.

Table 1. Distribution of respondents by position/function

Position / Function	Quantity	%
Director	52	14,8%
Manager	133	37,9%
Supervisor	58	16,5%
In charge	23	6,6%
Analyst	42	12%
Other	34	9,7%
Uninformed	9	2,6%
Total	351	100%

Source: The authors

Next, supervisors, 16.5% and directors, 14.8% were surveyed.

In terms of activities of the company, the majority belongs to the services sector 39.6%.

Table 2. Distribution of respondents by sector of activity

Activity Sector	Quantity	%
Wholesale	9	2,6%
Retail business	46	13,1%
services	139	39,6%
Industry	123	35%
Others	31	8,8%
Uninformed	3	0,9%
Total	351	100%

Source: The authors

Next, the industrial sector appears with 35% of the respondents and the retail trade with 13.1%. Of those who reported that they work in industries, the majority, 12.5%, work in the food and beverage sector. This result can be seen in Table 3.

Table 3. Distribution by sector of those who indicated industry

Industrial Activity Sector	Quant.	%
Food and drinks	44	12,5%
Smoke	-	-
Textile	6	1,7%
Clothing & Accessories	-	-
Shoes and Leather Goods	-	-
Wood	3	0,9%
Cellulose, Paper and Paper Products	3	0,9%
Editing, Printing and Reproduction of Recordings	1	0,3%
Oil and Alcohol Refining	2	0,6%
Chemicals	5	1,4%
Rubber and Plastic	1	0,3%
Non-Metallic Minerals	6	1,7%
Basic Metallurgy	2	0,6%
Metal Products - exclusive Machinery and Equipment	1	0,3%
Machines and equipment	4	1,1%
Office Machines & Equipment	1	0,3%
Electrical Machinery, Equipment and Supplies	-	-
Electronic Equipment, Communication Equipment & Devices	2	0,6%
Medical-Hospital Equipment, Opticians Others	3	0,9%
Auto-vehicles	-	-
Other Transport Equipment	1	0,3%
Furniture	6	1,7%
Other	32	9,1%
Uninformed	228	65%
Total	351	100%

Source: The authors

As for the distribution of the headquarters of the companies by region, 41.9% are in the Midwest and 36.5% in the Northeast. The southeast region was mentioned by 16.8% of the respondents as the company headquarters. This result can be seen in Table 4.

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Table 4. Distribution of respondents by region

Headquarters Region/ Main Headquarters	Quantity	%
South	10	2,8%
Southeast	59	16,8%
Midwest	147	41,9%
Northeast	128	36,5%
North	3	0,9%
Not informed	4	1,1%
Total	351	100%

Source: The authors

The southern and northern regions were cited by respectively 2.8% and 0.9%

Figure 2 shows the distribution of respondents by region. All regions of the country were included in the sample.

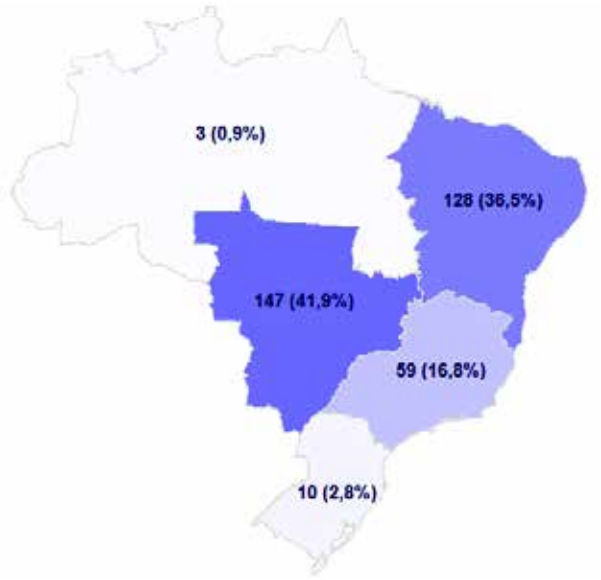

Figure 2. Distribution of respondents considering the headquarters of the companies where they operate.
Source: The authors

The distribution of the companies surveyed by billing can be seen in Table 5.

The highest concentration was verified in companies with annual revenues up to R$ 50 million, which corresponded to 45.6% of the respondents; then, companies with a turnover of more than R$ 150 million per year, which corresponded to 27.4% of the respondents. Regarding the number of employees, the majority of respondents stated that they work in companies with more than 210 employees, 57.5%; then, companies with up to 50 employees, 11.7%.

Table 5. Billing of the researched companies

Revenues	Quantity	%
up to 50 million	160	45,6%
more than 50 to 100 million	56	16%
more than 100 to 150 million	26	7,4%
more than 150 million	96	27,4%
Not informed	13	3,7%
Total	351	100%

Source: The authors

Table 6. Distribution of respondents number of employees of companies

Number of employees	Quantity	%
Up to 50	41	11,7%
51 to 90	38	10,8%
91 to 130	27	7,7%
191 to 170	11	3,1%
171 a 210	26	7,4%
more than 210	202	57,5%
Uninformed	6	1,7%
Total	351	100%

Source: The authors

Adoption of Lean Practices

As mentioned previously, the analysis of the production system of the companies surveyed, taking as reference the Lean model assumptions, was performed from 65 variables representative of aspects of lean production grouped into eight dimensions: costs, production control, continuous flow, setup, leveling and balancing of production, process autonomy, standardization of operations and people.

The result obtained in the research performed by each of the dimensions of analysis can be observed in Figure 3.

It can be observed that the dimensions Costs, Continuous Flow and People obtained a higher level of agreement even though little variation was observed in relation to the other dimensions. This shows that companies, in these dimensions, are more adherent to the Lean.

Then, the analysis of each dimension was made from the variables that compose it.

The costs dimension was studied from seven (7) variables: “products and services with high quality and low costs”, “production cost reductions”, “value aggregation”, “waste elimination”, “delivery performance quality, flexibility, speed and innovation”, “rigorous knowledge of costs”, and “cost reduction programs in non-value-adding activities”. With

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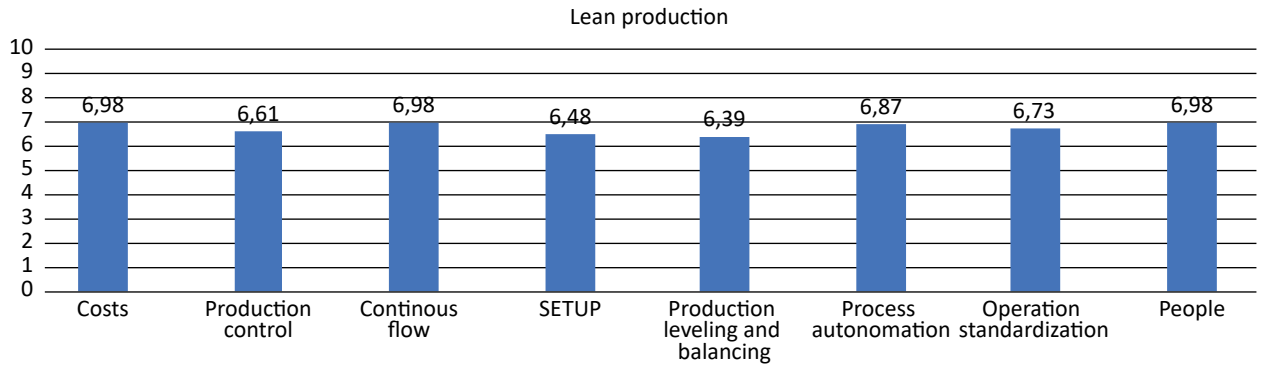

Figure 3. Construct Lean production analyzed from 8 dimensions

Source: The authors

regard to the Costs dimension the result, average of the answers obtained, can be observed in Figure 4.

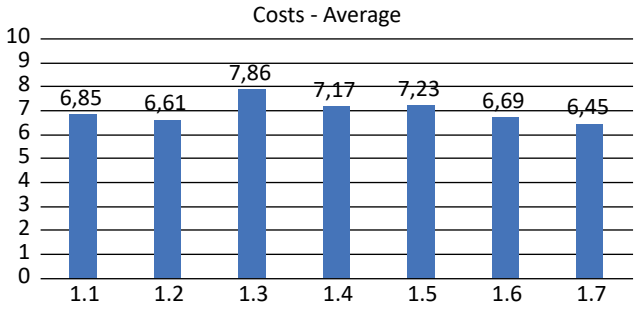

Figure 4. Dimension Costs by average

Source: The authors

The variable with the highest degree of adherence between what is performed in the company and the Lean model is the "value aggregation" with a mean of 7.86. The variable with the lowest agreement refers to the variable "program of cost reduction in activities that do not add value", with 6.45. This shows that although companies seek to reduce costs they do so in isolation and, therefore, do not have a structured program for this purpose.

With regard to Production Control, eight (8) variables "low levels of inventory", "delivery to customers on schedule", "layout", "manufacturing cells", "raw material receiving", "milk -run "(programmed parts collection)," flexible production" and "short production cycles" were studied according to Figure 5.

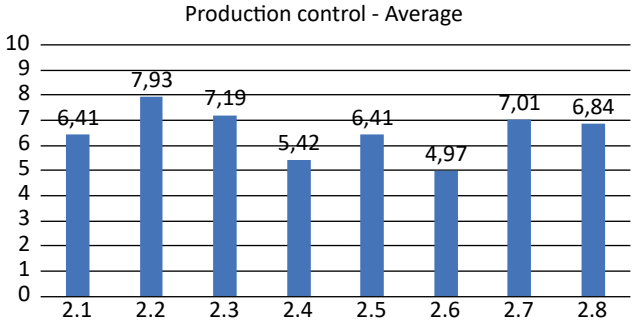

Figure 5. Dimension Control of Production by average

Source: The authors

The variable with the highest degree of agreement was the variable "delivery to customers in the schedule" with 7.93 of agreement. The variable with less agreement was "milk run" with a mean of 4.97, showing that the programmed collection of pieces is little used by the companies.

The Continuous Flow dimension was studied from 10 (ten) variables: "one product at a time", "improvement of the productive flow", "producing what the next stage can process", "pulled production", " regulated productive flow and cycle time", "value flow map", "production process stopped by problems", "standardized tasks", "visual controls" and "reliable and tested technology", according to Figure 6.

The highest degree of agreement was in the variable "improvement of the productive flow" with 7.69. The lowest degree of agreement, 6.03 was obtained in the variable "value-stream map", which was still little disseminated in the companies surveyed.

In the Setup dimension, four variables were studied: "reduced setup time", "reduced lead time", "quick tool change" and "distinction between internal and external setup". The averages of the variables of the Setup dimension can be observed in Figure 7.

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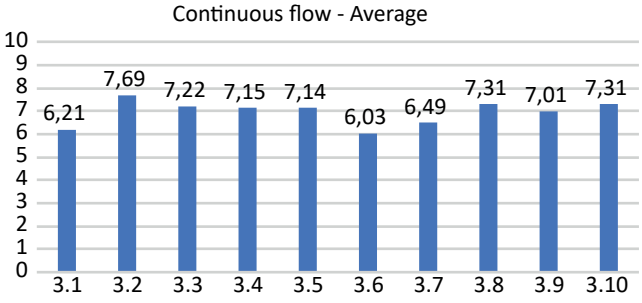

Figure 6. Continuous Flow Dimension by average

Source: The authors

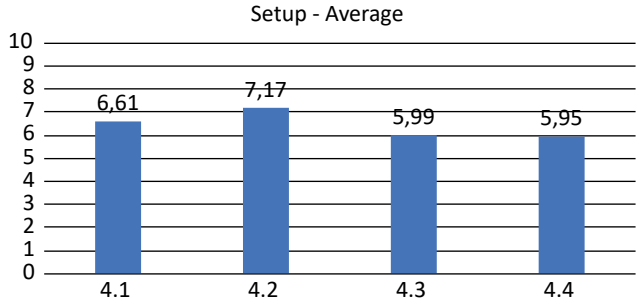

Figure 7. Dimension Setup by average

Source: The authors

The highest degree of agreement occurred in the variable "lead time reduced" with 7.17. The lowest degree of agreement was 5.95 in the variable "distinction between internal and external setup".

In the Dimension and Balance of Production dimension, seven (7) variables were analyzed: "leveling of production of different products", "each process produces the same quantity", "balanced production line", "elimination of excess production", "elimination of waste in transportation", "manufacturing batch sized by daily demand" and "idleness of labor in the production process".

As can be observed in Figure 8, the greater agreement of the respondents was obtained in the variable "balanced production line" with 6.87.

The lowest agreement was in the variable "each process produces the same quantity" with agreement 6.05, which shows the difficulty of balancing production among the various stages of the production process.

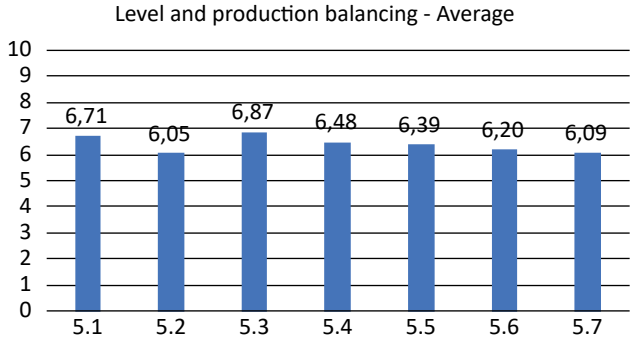

Figure 8. Dimension Level and Production Balancing by the average

Source: The authors

In the Autonomy of Processes dimension, the 9 (nine) variables "systematic looking for greater productivity", "improvements in quality of processes and products", "employees pursue the elimination of waste due to the waiting time of raw material, parts, machinery and materials", "employees pursue the elimination of waste resulting from movements/handling", "continuous production flow", "reducing inventory in process", "preventing errors due to inattention", and "Greater visibility of the productive process". The tabulation of the responses concerning the Process Autonomy dimension can be observed in Figure 9.

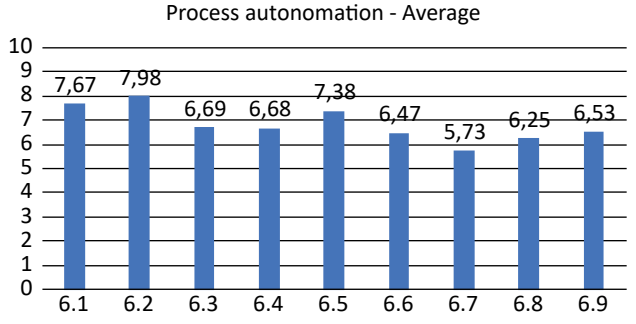

Figure 9. Dimension Process Autonomy by the mean

Source: The authors

The highest degree of agreement was obtained in the variable "improvements in terms of quality of processes and products" with 7.98. The lowest agreement was in the variable "preventing errors due to inattention", 5.73 of the mean, which evidences the poor dissemination of poka yoke devices in the companies surveyed to prevent failures and accidents.

The Standardization of Operations dimension included 8 (eight) variables "adequate system of standardization of processes and procedures", "establishment, maintenance and improvement of standards", "it standardizes its processes and operations", "fail-safe devices (poka yoke)", "organization of the workplace through 5S", "production of items

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is coordinated according to the demand of final products", "stocks of products in process are minimized", and "activities that do not add value are eliminated", as can be seen in Figure 10.

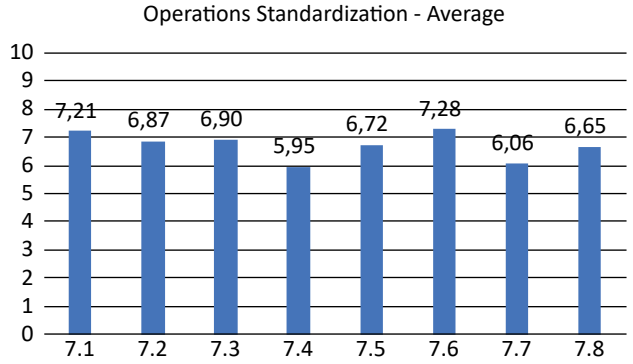

Figure 10. Dimension Standardization of Operations by the mean
Source: The authors

The highest degree of agreement, 7,07.28 occurred in the variable "item production is coordinated according to the demand for products. The smallest variable in the "fail-safe devices (poka yoke)" was 5.95. This result corroborates the low utilization of fail-safe and accident-proof devices in the companies surveyed, which had already been detected in the Process Autonomy dimension in the variable related to preventing mistakes due to inattention.

The last analyzed dimension of the Lean Production construct was the People dimension. It was studied from the twelve (12) variables: "employee involvement in setting goals, objectives and problem solving", "knowledge sharing", "all work is standardized", "training and technical skills of operators and technicians", "work environment is healthy, clean, organized and safe," "operators have autonomy", "each operator was trained to operate more than one equipment", "constant concern of all workers to improve their work", "concern for continuous learning", "decisions are taken by consensus", "development of Lean-minded leaders", and "skilled, trained and multi-tasked workers".

The responses obtained regarding the People dimension can be seen in Figure 11.

The highest degree of agreement of the respondents in terms of what happens in the company in which they work was obtained in the variable "work environment is healthy, clean, organized and safe" with 8.13 of agreement. The lowest agreement, 5,98, was in the variable "operators have autonomy" that shows the low autonomy of the operators in the companies surveyed.

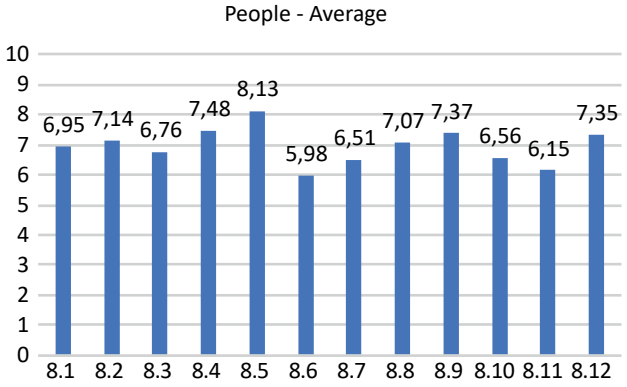

Figure 11. Dimension People by mean
Source: The authors

5. CONCLUSIONS

The purpose of this article was to study the adoption of Lean Production practices in Brazilian companies based on the premises of the Lean Manufacturing Model.

The work was developed considering the Lean Production construct divided into 8 (eight) dimensions of analysis: costs, production control, continuous flow, setup, leveling and balancing of production, process autonomy, standardization of operations and people, which in turn were analyzed by means of 65 (sixty-five) variables that characterize the Lean model.

Based on the analysis of the dimensions and variables, it is possible to verify that the Lean is already relatively disseminated in the Brazilian companies. Most of the interviewees had no difficulty in evaluating the stage of the companies, having as reference the practices contemplated in the research, since companies have sought to achieve quality, flexibility and competitiveness. From the 8 (eight) dimensions analyzed, it can be observed that Costs, Continuous Flow and People obtained a higher level of agreement, although little variation was observed in relation to the other dimensions.

This shows that the companies surveyed are, in these dimensions, more adherent to the Lean Model insofar as they care about control and reduction of costs, to ensure that production occurs continuously with qualified people operating the production.

The dimension production leveling and balancing that deals with the adaptation of the production to meet the variations of the demand and to reduce inventories and the balance of production that deals with the leveling of the times, methods and volumes aligned to the need or production demand evidenced a lower degree of adhesion.

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When analyzing the dimensions from each of the variables it was clear that the variables related to the easiest implementation approaches, related to value aggregation, delivery to customers within the term, improvement of production flow, lead time reduction, line balancing of production and quality of processes and products appear with greater dissemination.

On the other hand, the variables that denote greater refinement in the adoption of Lean practices such as cost reduction, milk run, value flow map, internal and external setup, process balancing, error prevention, adoption of fail-safe devices and greater autonomy to operators were relatively less mentioned. This is due to the fact that the implementation of more sophisticated practices would require greater qualification of employees and process maturity.

In conclusion, it can be seen that the Lean is not fully disseminated in the companies, that is, it was not internalized by the collaborators and translated into actions to obtain improvements. It is still a set of isolated practices and, for this reason, the results achieved do not evidence the adoption of a systemic implantation. For this to happen, it is fundamental to engage everyone in the company, from the strategic to the operational level, with a commitment, above all, to leadership, in order to foster a change in the corporate culture and a constant evaluation and communication of the results achieved with the methodology, in order to ensure its reinforcement and refinement.

ACKNOWLEDGMENTS

This work was partially supported by projects COMPETE-POCI-01-0145-FEDER-007043 and FCT-UID--CEC-00319-2013, from Portugal.

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Received: 09 Sept. 2017

Approved: 06 Mar. 2018

DOI: 10.20985/1980-5160.2018.v13n2.1353

How to cite: Affonso Neto, A.; Lima, R. M.; Afonso, P. S. L. P. et al. (2018), "Analysis of the adoption of lean practices in Brazilian companies: an exploratory study", Sistemas & Gestão, Vol. 13, No. 2, pp. 196-207, available from: http://www.revistasg.uff.br/index.php/sg/article/view/1353 (access day month year).