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**MANUFACTURING PROCESSES AND MANAGEMENT: AN EVALUATION OF  
LEAN MANUFACTURING ADOPTION PATTERNS IN INDUSTRIAL  
ORGANIZATIONS IN THREE EMERGING COUNTRIES**

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## ABSTRACT

Lean manufacturing has existed since the late 1970s. From early on, many companies in industrialized countries deployed lean manufacturing more effectively than others. Successful lean implementation is often attributed to organizational culture. However, organizations may also be influenced by the culture in the countries where they are located. We believe that there may be *comparative advantages* of locating where the national culture is suited to lean. This paper presents the results of a survey of managers in 248 companies in Argentina, Brazil and Romania, considered emerging and transition economies. We measured practices relating to quality, waste reduction, and supplier management, as well as their managerial and HR support practices. We will present patterns of lean implementation among all three countries. The results of this study illuminate the transfer of manufacturing to emerging and transition economies and these may not be reaping the organizational gains as found in the industrialized countries.

Key-words: lean manufacturing, emerging countries, adoption patterns

## INTRODUCTION

Human creativity is the pushing force for development. New ideas and paradigms to address the challenges of globalized markets are customary discussion topic in congresses and other academic or practitioner meetings about production systems (TUBINO, 1999). The high level of worldwide competition has made companies of all different industries to try to increase competitiveness, using strategies that value cost and quality concerns (SHIMIZU *et al.*, 2006). According to Tubino (1999), practice has proved that total quality tools and the just in time system are very effective in improving production systems in terms of quality, cost and delivery

performance. Companies that practice lean production approaches usually develop a competitive edge, when compared to those that use a traditional approach (STEVENSON, 2001). According to Womack *et al.* (2004), in the automotive industry, today, companies and countries adopt lean manufacturing systems as means to survive the global competition. Ferro (2004) argues that the Brazilian industry could have one of the highest growing rates in the world over the next few years, if it were to adopt lean manufacturing principles strongly. Kosacoff and López (2000) say that the Argentinean manufacturing industry is facing a scenario of global challenges and opportunities and claim that the country's performance will depend on the rate of adoption of new world class production standards. Ebert *et al.* (1998) are also concerned with the changes needed in the Romanian industry and emphasize the need for changes in the syllabus of operations management and other engineering subjects taught in the country's schools. Their conclusions result from an extensive survey involving Romania's manufacturers, which are adopting lean manufacturing systems in an attempt to improve their competitiveness, faced with the fierce conditions of the global market.

The word "*lean*", itself, has turned into an "ignition sparkle" for the dialogue between the logistics area and other functions within an organization, according to Levans (2006). For him, large multinationals are not the only companies that started using lean principles, which has also provided significant savings to SMEs.

It is important to highlight the fact that many other authors use different terms to refer to what we call *lean*, in this study. Some of the most common denominations are *world class manufacturing* (WCM) and *supply chain management* (SCM) among others that encompass the management style and the set of operations procedures that are used by organizations that develop a global competitive edge (FLYNN *et al.*, 1997; FLYNN *et al.*, 1999; GLASER-SEGURA *et al.*, 2006). The term *lean*, as used here, should be understood as having this same meaning, involving a broader scope, i.e., as a synonym to the above mentioned expressions.

A lot has been said about the importance and benefits of the implantation of *lean* as a way to improve the performance of the organizations, taking into account the current high level of global competition. In Brazil, Shimizu *et al.* (2006) have been able to prove the superior performance of companies that continuously invest in the implementation of *lean* principles, compared to others, by means of a survey with manufacturers of agriculture machinery that chose to strategically apply *lean*. Another benefit of using *lean* practices concerns the environment. Elias and Magalhães (2003) consider that Brazilian companies can produce in a cleaner fashion, when they use *lean* principles in their operations. In Romania, a paper by Vaisa *et al.* (2006) describes this same possibility, using the expression “*lean and green*”.

The benefits of lean production are also acknowledged in many other sectors, besides the manufacturing industry. Pasqualini and Zawislak (2004) propose its use in civil construction, in an attempt to reduce waste, production costs, quality problems and product delivery delay in that field. They argue that lean production is able to reduce the inefficiencies of civil engineering. Another study, performed by Oliveira and Gomes (2008) with “Samba schools”, groups of street dancers that perform in Rio de Janeiro’s carnival, also in Brazil, reveals that even these less structured and organized organizations rely on just-in-time in order to reduce waste. In Romania, Naruo and Toma (2007) demonstrate that lean principles can be applied to retail commerce, discussing the case of “*Seven-Eleven*”. Another recent work by Muhcina and Popovici (2008) also carried out in that country, describes the success of applying the concepts of supply chain management to tourism agencies. According to those authors, tourism packages rely on many different stakeholders to be developed and implemented, such as hotels, tourism agents, air companies and even the tourists themselves. Thus, similarly to what happens in product manufacturing in an industrial supply chain, service providers join in a value chain that needs to have its activities well integrated and coordinated.

The struggle for the implantation of more flexible, agile and lean production processes in recent years has caused new corporate management practices to arise (FERRO, 2004). Such practices demand deep cultural changes in practically any organization, including those that deliberately implemented them as well as those that have not chosen, at least in an explicit way, to be lean. In Ferro's (2004) opinion, this situation is starting to demand shared evaluation metrics to be developed of the actual effectiveness of any action taken by an organization towards the *lean* philosophy. That is the only way to measure the benefits generated by the implementation of *lean*.

The international research project whose findings are reported here has as its main purpose to evaluate the perception of logistics/operations professionals about the level of adherence of the corporate culture to requirements of lean, with respect to the following issues: 1. Commitment of the company's suppliers to the company, trust and relationship (supplier partnership); 2. Interpersonal relationships (teamwork vs. individual work); 3. Lean practices (just-in-time, TQM, kanban, setups etc.) and 4. Commitment of the company to its suppliers.

The respondents were managers or directors in the operations, logistics, purchasing or quality area in their organizations. The companies that participated in the study are located in three countries that are acknowledged by the OECD as "developing" or "emerging" countries (DE BACKER *et al.*, 2008), namely: Brazil, Argentina and Romania. This sample was chosen mainly due to the feasibility of collecting data, considering that the researchers themselves conducted the survey.

The research could be justified *a priori*, from a practical point of view, due to the possibility of sharing the results and the analysis with participating organizations as well as any other company that could benefit from the recommendations offered in the conclusions' section. The practical value of the research did not depend on its eventual findings, at the end. If the results eventually showed that there is a high level of adherence between the companies' characteristics and those

demanded by *lean* philosophy, it would mean that they are in the right track. However, if the opposite happened and the level of adherence to the demands of the *lean* culture were low, the study could work as a warning for the fact that they still have a lot to do, in order to achieve the benefits promised by *lean*.

From a theoretical point of view, the research was also easily justifiable, because, in spite of being in evidence, *lean* has not inspired a great number of practical studies about its level of adoption by manufacturers in emerging countries (GLASER-SEGURA and ANGHEL, 2003). Studies about the issue are restricted to large automotive operations, whose processes were developed at the companies' headquarters, then imported, and implemented in the local plants (SCAVARDA *et al.*, 2001; LUCHI *et al.*, 2003).

It is important to highlight that it is not the intention of this study to assess the quality of management performed by participating organizations. We only intended to assess the perception of logistics, quality and operations professionals about the level of adherence of their corporate culture to the *lean* philosophy.

In the following sections, after this introduction, we will present the evolution of the *lean* concept. After that, the methodology used to collect and analyze data will be discussed, followed by the presentation of the data and the analysis. The last section brings the conclusions, some recommendations and final considerations that include possible future studies and the limitations of the current one.

## MASS PRODUCTION SYSTEM

The introduction of the concept of mass production is usually assigned to Henry Ford. The creation of the moving assembly line in 1913, in Ford's new factory in Highland Park, Detroit, is

considered an important moment for the evolution of production systems. Womack *et al.* (2004) state that Henry Ford discovered a way of avoiding problems that were inherent to craft production: the new techniques drastically reduced costs, at the same time they increased the quality of the product.

The climax of US-based mass production happened in 1955, when the three major car manufacturers in the United States (Ford, GM and Chrysler) were responsible for 95% of all automobile sales in that country. After that year, a steady growth of Japanese imports started taking place. Mass production would not keep North American companies in the lead anymore (WOMACK *et al.*, 2004).

#### LEAN PRODUCTION SYSTEM - JIT

The expression *just-in-time* (JIT) is used to refer to a production system in which materials move in a much synchronized fashion with the arrival of supplies, which happens precisely at the time they become necessary in the production process. Production usually takes place in small batches. Just-in-time is based on the idea that nothing should be produced until it is required (OHNO, 1997). Eiichi Toyoda and Taiichi Ohno originally developed the JIT approach in Toyota.

The system developed by Ohno (1997) intended to allow the production of several models of cars, in small quantities, but in an efficient and profitable way. JIT involved the continuous flow of single parts to meet customer needs at the right time, right amount and right place, demanding perfect connection and synchronism among all processes, suppliers and distributors. In order to establish efficient communication among processes, clearly indicating when products are needed, *kanban* was then developed (OHNO, 1997; SHINGO, 1996). The *kanban* system consists on “pulling” little batches of parts along the production process when they are needed, in contrast to the traditional methods of production programming that “push” a set of manufacturing (or

purchase) orders (TUBINO, 1999). For Shingo (1996), *kanban* also stimulates the involvement of all workers, because they need to be alert to the production signaling all the time. Ohno (1997), himself, admitted that, in order to make *kanban* work, he had to involve everybody. The system would not have worked if the production manager had understood it, but the workers not.

According to Stevenson (2001), JIT can be analyzed from two different perspectives: in a broader way, it consists on a manufacturing philosophy used to guide managerial actions, but from a more pragmatic point of view, it is a collection of tools and techniques developed to support such philosophy. For Morgan and Liker (2008), it is hard to understand the secret of Toyota's success because such secret does not actually exist. The success results from a lot of hard work, a strong team work culture, optimized processes and simple but very effective tools. Liker (2005) considers that many attempts of western companies to deploy lean production result in troubles, because they overemphasize the use of continuous improvement quality tools without changing the culture and without thoroughly understanding JIT's philosophy. Santos Neto and Silva (2007) present the case of an improvement project in a final assembly line, which only provided minor improvements. Problems were not solved, only transferred along the value chain. The authors admit that the area around the assembly line became cleaner, but the real issues were not addressed. The plant ended up becoming clean but not lean.

## LEAN PRODUCTION

According to Womack *et al.* (2004), the term *lean production* was first used by Krafcik, as a reference to the JIT processes. As previously mentioned, the term *world class manufacturing* was first used by Hayes and Wheelwright in 1984 (FLYNN *et al.*, 1999; GLASER-SEGURA *et al.*, 2006). After that, various authors adopted and expanded the concept.



In 1990, the first edition of “The machine that changed the world” was released (WOMACK *et al.*, 2004), providing extensive explanations on issues such as: product development, suppliers management, customer support, global management systems among others, as developed by leading Japanese manufacturers, also giving plenty of evidence of *lean* superiority (LEI<sup>1</sup>, s. d.). In a recent study, Morgan and Liker (2008) state that Womack’s work demonstrated that Japanese manufacturers were twice to ten times better than their competitors in US and Europe.

## LOGISTICS AND THE SUPPLY CHAIN

Part of the effort of increasing the efficiency of any organization involves the coordination of its activities with suppliers and customers (HARRINGTON, 2005). That is why many companies from different industries now try to improve the way they manage their relationships with external partners. Abrahamsson *et al.* (2003) have realized this possibility of obtaining an edge by means of logistics improvements, after having identified that the most successful organizations in terms of growth and profitability are also those that better integrate to their supply chains. Based on that, they describe, define and exemplify the need for a highly flexible logistics system as a way to increase the profitability and growth rate of any company.

According to Bowersox *et al.* (2006), supply chain management involves the organization of the joint work developed by companies that cooperate in order to improve their strategic positioning and improving the efficiency of their interdependent operations. It is a network of autonomous or semi-autonomous organizations that are responsible for the acquisition, production and release of a certain product or service to the end customer, according to Pires (2003).

## LEAN PRODUCTION IN BRASIL, ARGENTINA AND ROMANIA

*Lean production in Brazil.* Brazil became acquainted with the full potential of mass production late in the 1950's, when Volkswagen, after having performed a huge investment in the country (the largest outside Germany, so far), started manufacturing cars in the Sao Paulo metropolitan area. The investment was successful, which made Ford and GM soon follow. In the 1970's those three manufacturers consolidated their operations in Brazil and mass production as the most efficient manufacturing arrangement (FERRO, 2004; LUCA, 2001). According to Ferro (2004), work relations that were required for mass production in Brazil were gradually built over that period. At the beginning, workers on the automotive industry seemed happy with the transition from the country to the city. However, after some time, they started opposing the managerial methods used by the industrial sector. The intense rhythm of work, monotony and specially the pressure and lack of respect by management generated a crisis in work relations, which reached the worst situation late in the 1970's, when many strikes took place (SALERNO, 2004). Trade unions continued to become stronger for another decade. After 1978, strikes became routine in the Sao Paulo's area, after blue collar workers organized again, after the quiet years that followed the army coup of April 1964. The new trade union movement fought for better salaries and work conditions for the laborers (LUCA, 2001).

The increasing political weakness of the army government accelerated the process of political liberation. In spite of that, it was only in 1985 that the country achieved a democratic government again. According to Antunes (2003), it was around that time that the first signs of the industrial sector's production restructuring in the country started taking place, leading many companies to adopt new organizational and technological standards.

For Salerno (2004), early in the 1980's Brazil's production processes faced a series of changes, at a time the country was facing an economic crisis, political disruption and the strengthening of the trade union movement. In spite of that, it was only after the opening of the Brazilian markets to

international commerce in 1990 that the Brazilian industry started to carry out measures to face its major challenges. From 1990 to 1994, in spite of the opening policies proposed by the government, the dynamics of the local industry did not change in a significant way, except for very specific sectors, such as auto manufacturing and apparel, which started facing direct competition from foreign players (FLEURY, 1997).

In plant shops and other work areas in Brazilian companies, new concepts started to spread, such as automation, quality control circles, kanban, just in time and the involvement of workers (ANTUNES, 2003; SALERNO, 2004). Silva (2008) considers that the interest for lean production increased considerably in Brazil in recent years. That contributed to the increase of academic interest for the issue and for the perception of workers about the changes in the work environment. Antunes (2003, p. 16) highlights that: “new methods were introduced that are more ‘participative’, including mechanisms to enhance involvement and acceptance by the workers of the organizations’ plans”.

*Lean production in Argentina:* democracy was re-installed in Argentina in 1983. The end of ideological-political persecution by the army dictatorship and the elimination of authoritarian controls contributed to the reestablishment of political freedom, university autonomy and other requisites for scientific/technological research to develop normally (CORNEJO, 2006). Only in 1990, however, during Carlos Menen’s term as president of the country, did the Argentinean economy open to the international market. Products manufactured in the country started facing direct foreign competition in the national market and companies were not able to simply calculate costs and add a profit margin, in order to determine the market price of their products (ANSALDI, 2002; MIOZZO, 2000). Responding to the new business environment, imposed by the opening of the market to foreign competition, Argentinean companies started adopting lean practices. Otherwise, they would be consigned to stagnation and bankruptcy (KOSACOFF e LÓPEZ, 2000). Burkún and Vitelli (2007) explain that in the 1990’s, Argentina included itself in

the international liquidity movement in a deeper way, but important measures that should be taken by the government to improve the competitiveness of the country's industry were left aside. According to those authors, lack of planning jeopardized the possibilities of technological orientation, not allowing the articulation of the productive system with the centers of technological and scientific development. Discussing the process of economic opening of Argentina to foreign competitors, Minsburg (1999, p. 2) warned: "We live in a world that is being molded by an important and difficult process of transnationalization, submitted to the voracity of financial capital. In most countries a wild sort of capitalism has taken over". On the other hand, the main argument in favor of the neoliberal ideas was the high level of inefficiency of the manufacturing industry in Argentina, which resulted from many decades of protectionism by the State (SCHORR, 2002).

According to Schorr (2002), the productivity rate of the Argentinean industry increased ca. 30% over the 1990's. That happened simultaneously to the reduction of labor-intensive tasks and, therefore, the reduction of the need for workers, which also caused income levels not to increase during the whole decade.

Trade unions were not able to articulate strategies to oppose the new work processes demanded by the new context. Tomadoni and Koessl (2005) discuss the behavior of trade unions in Argentina in face of the adjustments that were required to the new lean systems, introduced in the 1990's. According to them, trade unions were not able to protect the workers' individual interests when opposed to those of the organizations that were empowered by the new scenario. They focused on helping workers to adapt to the circumstances of the new model of industrial production. For Tomadoni and Koessl (2005), the inexistence of trade union leadership renewal was another reason that prevented trade unions from elaborating a strategy that took into account the new production environment, but also the interests of the labor class they represent.

In a study that involved small and mid-size companies in Argentina, Kosacoff and López (2000) state that such organizations find it more difficult than large ones to respond to the new demands of globalization. However, they are extremely important to support and complement large companies, regardless of them being national capital companies or foreign companies playing in the national market.

*Lean production in Romania:* politics, economics and legal structures of Romania were drastically transformed after the incredible revolution of December 1989. According to Ebert *et al.* (1998), an open market replaced centralized control, followed by a privatization wave, also based on a neoliberal approach. Romanian companies had their products directly competing against imported products provided by experienced competitors, in a very similar way to what happened in Brazil and Argentina.

According to Glaser-Segura and Anghel (2003), Romanian manufacturers still struggle to enforce current strict quality requisites imposed by customers that quickly learned to be very demanding. This is still caused by the influence of old values, from the time prior to the revolution, when the communist government dictated the levels of quality, prices, production volumes, logistics programming and other decisions related to the production strategy. A case study carried out by Marinescu and Toma (2008) demonstrated that lean production could be successfully applied to Eastern European countries such as Romania. They report changes in the economy and in the business environment that happened due to the implementation of lean principles in the country: waste rates decreased and productivity consequently significantly increased. According to Marinescu and Toma (2008), training and teamwork were key factors for the success of the introduction of lean philosophy and supply chain management in Romanian manufacturing companies. Differently to the history of highly authoritarian relationships between bosses and workers in Brazil and Argentina, in Romania the good relationship along the hierarchy within organizations facilitates teamwork to develop. Glaser-Segura and Anghel (2003) state that

teamwork may be the good part of the legacy from the pre-revolution period in Romania, as under the socialist system, workers and managers were all considered equal. Workers used to choose their managers, which caused work relationships to be very equalitarian and managers to count with their subordinates' loyalty.

Băleanu's (2002) research shows that Romanian enterprises started to choose their suppliers based on a new set of criteria, in recent years, among which the importance given to the new production philosophy and to just-in-time delivery are very important. Isac and Isac (2002) describe the introduction of Japanese tools such as *poka-yoke*, as ways to ensure the necessary quality standards, required to compete in the new business scenario in Romania. Dima and Ivănu (2002) acknowledge that the just-in-time environment demanded the introduction of new ways of controlling budgets, so that cost centers became responsible for their own accounts, guided by metrics that were each time more demanding.

The transition of the Eastern European countries' manufacturing to an open market also demanded changes in university education, so that operations management teaching met the demands and expectations in the field. Ebert *et al.* (1998) researched 83 Romanian companies and found out that university engineering syllabus needed to change in order to include production and operations management concepts that better fit the new reality of practitioners, increasing the attention given to quality management and just-in-time. Five years later, Glaser-Segura and Anghel (2003) verified that just-in-time in Romania was still a set of incipient practices, usually known to academics and consultants, but strange to industrial plant managers in the field.

## METHODOLOGICAL PROCEDURES

The data collection tool was a structured questionnaire with 117 statements. Respondents had to choose from a set of responses in a 7 point Likert scale, ranging from “strongly disagree” to “strongly agree”. Having an odd number of alternatives, the Likert scale allowed those who did not have an opinion about an issue to choose the alternative in the middle of the scale.

Statements were intended to depict the respondents’ level of awareness or use of the practices, techniques and ideas being discussed, all of which were related (or were a requisite) to the lean philosophy. Six large sets of statements were created, which allowed the researchers to gather data related to a subset of practices concerning: the use of kanban, support from top management, reduction of production batch sizes, total productive maintenance, reduction of setup time, supplier development, communication/contact with other members of the team, process information, statistical process control (SPC), forms of incentive to the workers, adoption of ABC costing, long term relationship with suppliers, communication/contact with customers, use of ERP systems and simplified development of new products. The questionnaire replicated a survey used by Glazer-Segura and Anghel (2003) which was based on the instrument developed by Flynn *et al.* (1999).

When one uses a questionnaire that was originally developed in a different language and for a different culture, some caution is required, in order to ensure that the scales remain valid and equivalent. That is particularly important when one wants to compare results over international boundaries. In order to assure conceptual equivalence and scale validity, when the questionnaire was translated, the authors used a technique of *back translation*, i.e., the questionnaire was translated to the new language and then back to English, in order to check if the resulting statements (after double translation) kept the original meaning. This was done following recommendations provided by Riordan and Vandernburg (1994).

In order to assure the quality of responses, respondents were chosen among people with good knowledge on the issues dealt with in the questionnaire, regarding shop floor practices, relationship with suppliers and customers, incentive policies, among others. Thus, industrial, logistics or purchase managers and directors had priority in the selection of possible respondents.

The companies that participated in the survey were mainly durable goods manufacturers with plants located in Argentina, Brazil or Romania. The reason for having chosen organizations in these countries was the authors' convenience, as they had easy access to manufacturing companies there, due to their consulting and/or teaching connections.

In order to determine the size of the sample, previous studies were analyzed that used the same concepts, methodology and similar theoretical grounds (FLYNN *et al.*, 1995; WAGNER, 1995; GLASER-SECURA and ANGHEL, 2003). Based on those studies, the minimum sample size for each country was set to sixty different responses. However, at the end of data collection, the number of respondents in each country was much higher than that.

#### Data collection procedure

In Brazil, an invitation to participate in the survey was sent early in December 2008, using an email message with a link to the website hosting the questionnaire. The invitation was addressed to qualified professionals in the production or logistics area. Those professionals had been included in a database created by two of the authors of this paper over the last four years for having attended MBAs and extension courses in the Operations Management area at the university where they teach. The return rate was about 25%, which is higher than usual for electronic surveys. Vieira, Viana and Echeveste (1998), Scornavacca Jr., Becker and Andraschko (2001), Cohen (2003) and Graeml and Csillag (2006), just to name a few researchers that also used electronic surveys as data collection tools, achieved much lower return rates. The authors consider that their previous interaction with the respondents as educators may have collaborated



for a higher return rate than usual. From the 121 questionnaires that were returned, 79 were complete and could be used for all the analyses in the study.

In Romania, companies were randomly selected from a list of the largest companies in the country in 2000. While the responses came from all parts of Romania, the majority were from Bucharest-based companies. The survey was printed and applied personally by one of the authors of this paper to 102 production or logistics managers. That happened in October 2006 and June 2007.

In Argentina, the survey was also printed and personally applied by a research assistant, in most cases. Some other responses were obtained via email. Respondents were production, procurement or logistics managers that had close contact with a local university in Cordoba. After completion, surveys were physically collected or sent back via e-mail. Data collection took place between June and October 2007.

#### Data analysis procedure

The data that was gathered was treated and analyzed as follows: first, it was reorganized, converting negative statements into affirmative ones, so that all Likert scales aligned in the same direction. For example, one of the statements presented in the survey was “our plant is disorganized and dirty”. It was converted so results could be compared with those for “our plant emphasizes the importance of putting every tool back in its place after use”.

The next step was a factor analysis procedure used to check if similar statements (as those mentioned above) aligned with similar items. Just as another example, the survey had four questions that referred to kanban practices. Thus, as a matter of consistency, responses to those four questions should present high correlation among themselves. For the sets of related questions, statements that did not align to the constructs that they should represent were

eliminated from the study. In some cases, two constructs were combined in a new one, also as a result of the factor analysis.

After that, the internal reliability of the survey was tested, using Cronbach's alpha, which is a measure of the inter-correlation of a statement with the others that comprise the same construct. The value that was obtained for the set of statements about kanban was 0.897, which indicates that the responses referring to the four statements about it were highly correlated. The minimum acceptable Cronbach's alpha value for this kind of research is  $\alpha = 0.5$ , considering its exploratory nature (NUNNALLY, 1967), although many researchers prefer to work with  $\alpha > 0.7$ . The majority of the scales in the study had  $\alpha > 0.7$ , but there were a few that were just over 0.5.

## ACHIEVED RESULTS

First, we will present and discuss the set of values obtained for the Cronbach's alphas for the fifteen generated scales. After that, we will present and discuss the averages obtained for the variables. We chose to use the ordinal Likert scale as an interval scale, allowing for the calculation of averages. We wish that by doing so, the results gain in description power, providing for a better understanding of the respondents' perception about the practices and cultural issues included in the survey, which help understanding how fit companies are to deploy lean manufacturing. Comparability among countries increases when responses are converted into averages for all different constructs.

*Cronbach's alpha:* Cronbach's alpha was calculated for each of the fifteen generated scales obtained after the data was organized and the factor analysis performed, according to the procedure described in the previous section. Figure 1, below, shows the Cronbach's alpha for the fifteen scales in the study.

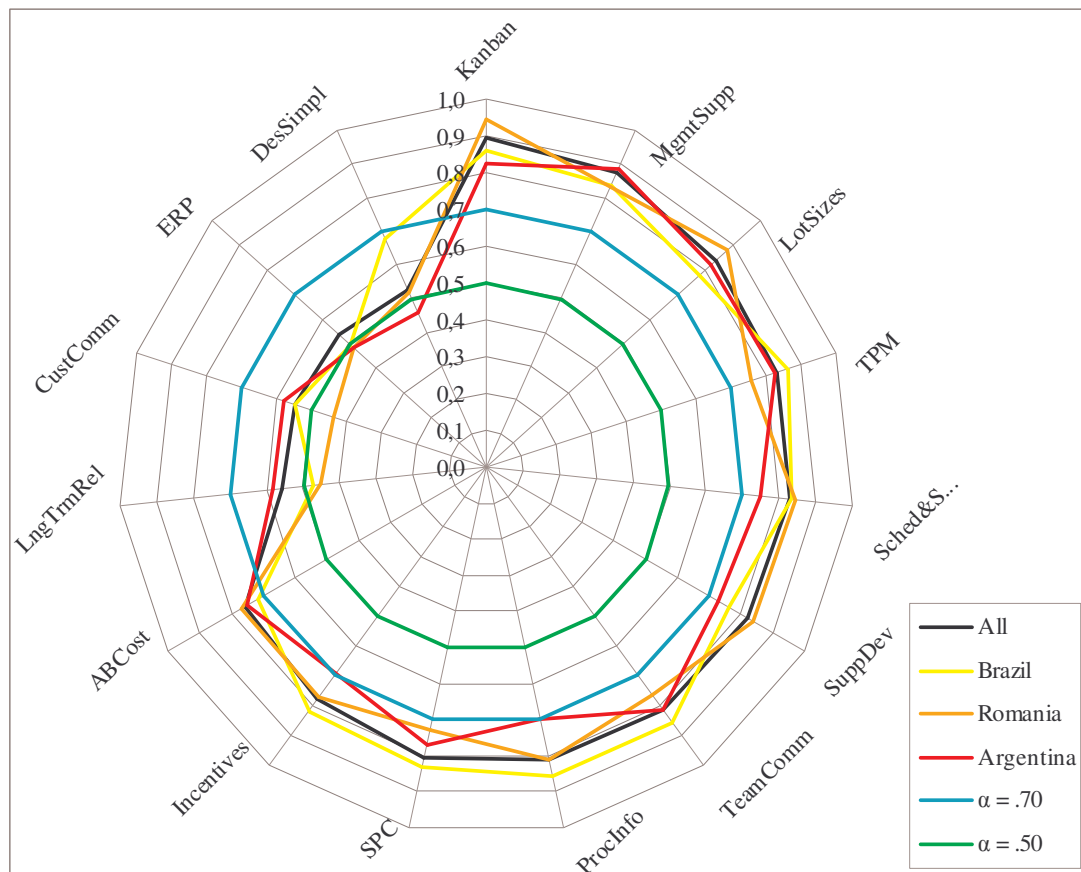


Figure 1 – Cronbach’s alpha for the fifteen constructs in the study.

Source: the authors

As one can see in Figure 1,  $\alpha > 0.70$  for eleven of the fifteen scales in the study: kanban, top management support, batch size reduction, TPM (Total Preventive Maintenance), reduction of setup time and scheduling, supplier development, team communication and contact, process information, SPC, incentives to workers and ABC costing. The remaining four scales: long term relationships, customer communication and contact, ERP and design simplification presented lower values for Cronbach’s alpha ( $\alpha < 0.70$ ), although still over 0.5, considering the observations for the three countries together. Some of those variables were below 0.5 for individual countries. The high values obtained for  $\alpha$  ensure statistical reliability (internal

consistency) of the fifteen constructs that were generated using factor analysis from the 117 original statements in the survey.

High Cronbach's alphas also provide an indication that the practices that are being assessed are adopted in a systematic way or, at least, thoroughly understood by the respondents. For example, even if the four statements about SPC deal with the issue from different perspectives, a respondent that uses the technique should be able to respond to the questions so that they align with the construct. On the other hand, if the respondent did not know SPC well and did not use it, there would be a high chance that s/he would not have the systemic understanding required to answer the four questions consistently.

Another interesting thing was that the reliability factor remained approximately the same, regardless of the country. This can be easily noticed when one looks the curves that relate to each of the three countries, which is an indication that the survey kept its original characteristics even after the translation and application to different contexts.

*Analysis of the average for the constructs:* "1" was the value assigned to "strongly disagree", "2" for "disagree", "3" for "slightly disagree", "4" for "I do not have an opinion about the issue", "5" for "slightly agree", "6" for "agree" and "7" for "strongly agree". Table 1 presents the averages that were calculated for each of the fifteen constructs. Remember that values close to 1 mean "strongly disagree" and close to 7 mean "strongly agree".

Table 1 – Averages obtained for the fifteen constructs in the study

| Construct | TPM (clean work place) | Top management support | Long term relationship | Process information | Reduction of batch size | Team communication | Customer communication | SPC  | Setup time reduction | Design simplification | ABC costing | Supplier development | Incentives to employees | ERP  | Kanban |
|-----------|------------------------|------------------------|------------------------|---------------------|-------------------------|--------------------|------------------------|------|----------------------|-----------------------|-------------|----------------------|-------------------------|------|--------|
| All       | 6.06                   | 5.77                   | 5.73                   | 5.62                | 5.55                    | 5.36               | 5.31                   | 5.04 | 4.76                 | 4.72                  | 4.70        | 4.39                 | 3.89                    | 3.67 | 2.96   |
| Brazil    | 6.06                   | 5.61                   | 5.39                   | 5.51                | 5.51                    | 5.45               | 5.13                   | 5.16 | 4.82                 | 4.70                  | 4.63        | 4.73                 | 3.80                    | 4.23 | 3.48   |
| Romania   | 6.31                   | 6.22                   | 6.14                   | 6.01                | 5.54                    | 5.60               | 5.68                   | 5.32 | 5.05                 | 4.74                  | 5.09        | 4.63                 | 4.39                    | 3.52 | 2.90   |
| Argentina | 5.66                   | 5.26                   | 5.60                   | 5.15                | 5.60                    | 4.87               | 4.96                   | 4.45 | 4.26                 | 4.71                  | 4.20        | 3.63                 | 3.22                    | 3.22 | 2.40   |

Figure 2, below, shows the level of agreement with each of the constructs presented in Table 1.

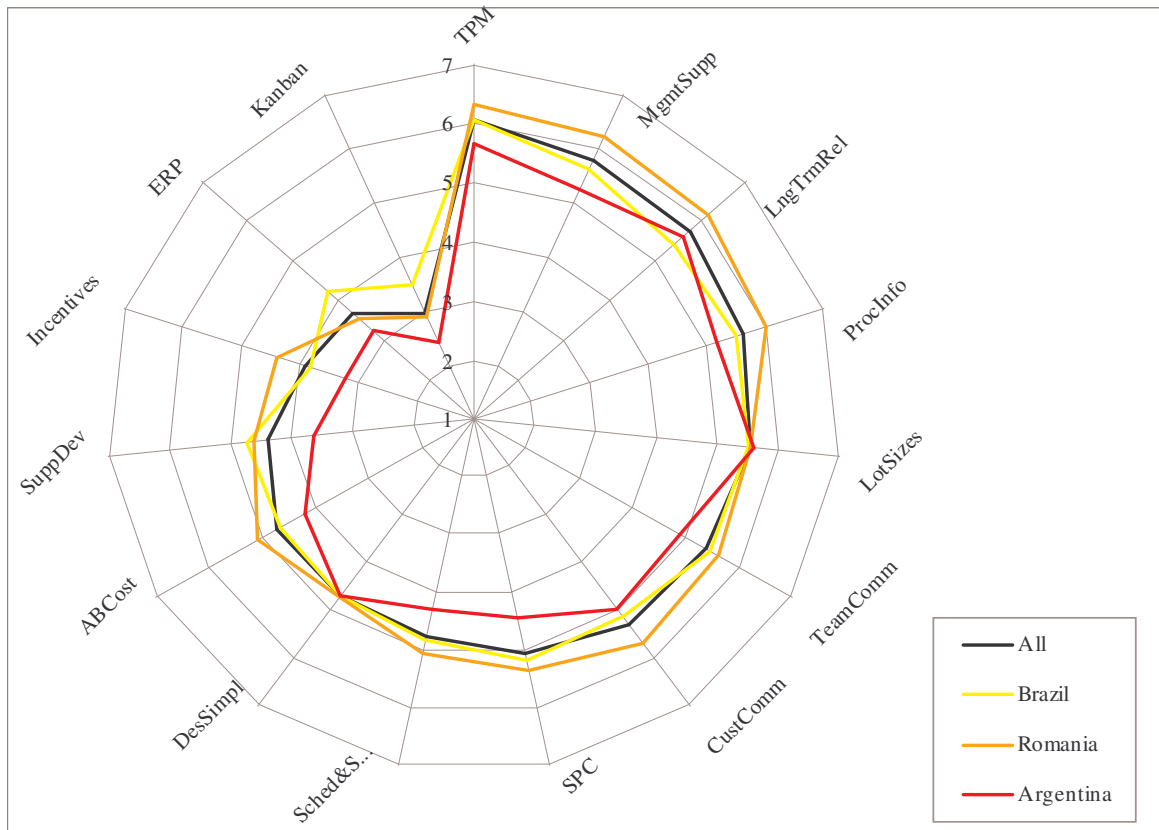


Figure 2 – Averages for the Likert scales regarding each of the fifteen constructs in the study.

Source: the authors.

Again, it is easy to notice that the pattern of responses remained very similar for the three different countries, for most of the fifteen scales. This shows that the three countries have the same overall characteristics concerning the adoption, or at least the understanding, of several factors that are enablers of lean manufacturing. According to the respondents' perception, none of the three countries has all required conditions for lean implementation thoroughly in place. Romanian companies seem to be better suited with respect to cultural and attitude issues (mainly related to collaboration), while Brazilian companies proved to be better equipped in terms of tools and techniques. Argentina presented less favorable results.

Here, the scale called *TPM (Total Preventive Maintenance)* represents a clean and organized work place acknowledged to be the reality of the respondents' organizations. However, as reminded by Santos Neto and Silva (2007), the simple adoption of practices that lead to clean production does not guarantee that production will also be lean. The variable *top management support for improvement actions proposed by the employees*, also perceived as positive, shows that most organizations are aware of the importance of listening to the employees. This assumption is supported by the high score obtained for scales *process information* and *communication with the team*, showing that the companies' problems are processed and informed to the employees. On the other hand, the low score of *incentives given to the employees* is an indication that companies do not usually acknowledge the worker's effort to improve processes. Respondents agree that their companies emphasize *reducing batch sizes*. However, for that to happen, it is important that they put effort into *reducing setup times* (OHNO, 1997), which does not seem to be a major concern.

The results show that the major gap towards achieving a good environment for the use of lean systems in the countries that participated in the survey consists on the use of systems that communicate the actual demand of an item, internally and to the suppliers. The use of ERP's and kanban schemes were the constructs for which the participants acknowledged the lowest levels of

agreement. They actually tended to say that they disagree with the statements that dealt with those constructs.

## CONCLUSIONS

This paper showed that, although lean production has grown in importance in emerging countries, the low level of adoption of practices that enable lean production, as well as some cultural issues, still represent a challenge to the introduction of this production philosophy in countries such as Argentina, Brazil and Romania.

Lean manufacturing is far from being thoroughly implanted in these countries. It was interesting to realize that gaps usually exist for the same constructs, regardless of the country being analyzed, and usually concern the use of ERP systems, which allow internal integration, and kanban, another tool that helps communicating actual demand along the value chain.

In spite of its interesting results, this study has a few limitations that reduce the scope of its conclusions. One such limitation is that, many of the respondents had some sort of bond to the researchers, many times having been their students in MBA or other extension courses. Some respondents may have felt inclined to respond not based on their actual perception of the situation, but on what they thought that the researchers were expecting. Another problem with the samples in the three countries was that respondents did not always have a broad view of the operation in their organizations. Many were production or logistics managers or directors, but there were cases when the respondent was the person in charge of production, logistics or purchasing, but with little knowledge of the other functions covered by the survey.

The next step of this study involves obtaining data from other emerging countries, especially those that are members of the OECD or intend to become members, such as Mexico, India, South

Africa and China. That will be important to find out how they perceive the level of adoption of the constructs that were discussed here.

The discussion that took place in this paper about the adoption of practices that may enable the use of lean manufacturing in emerging countries is relevant not only for its results, but also for stimulating a debate about the extent to which lean manufacturing is actually understood. The issues that were discussed here lead us to think that there is still a lot to be done by those who believe that work is still a central value for our society.

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## Note

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<sup>1</sup> LEI (*Lean Enterprise Institute*) is a non-profit research organization, settled in 1997, which was created to spread the principles of lean thinking to the largest possible number of industrial sectors and companies.