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Enablers and constraints in implementing lean manufacturing: evidence from brazilian SMEs

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Abstract: Lean Manufacturing has revolutionized the global manufacturing environment at an unprecedented rate. In scholarly and managerial literature, many works have reported that Lean Manufacturing is a very efficient approach and a straightforward way towards process improvements, in terms of productivity and value adding activities ratio. However, many studies on Lean Manufacturing have highlighted many problems in its implementation. The analysis carried out within the research project is aimed to the factors enabling or constraining the Lean Transformation of a firm's production system, along with the most relevant tools or practices to be applied. The research methodology used is the so-called "Normative Delphi" with a panel formed by 32 experts coming from 16 Brazilian SMEs. Our results are partially consistent with what has already been discussed in the literature and we found that the most relevant tools/practices are: value stream mapping, 5S methodology, and Kaizen (Gemba walks); the top three enabling factors are: knowledge and sponsorship of senior management, focus on continuous improvement, and employee development fostered by the company; finally, the main critical constraints are: little support from the top management, resistance to change by middle management, and poor or non-qualified Lean training activities.

Keywords: Lean Manufacturing, Implementation, Change Management, SMEs, Delphi

1. Introduction

The organization of industrial production according to the principles of Lean Thinking is a very topical issue. Since the cardinal work of the International Motor Vehicle Program at MIT (Womack *et al*., 1990), several large companies, mainly in the manufacturing sector but not only, have gained superior performances by adopting the Toyota Production System and its evolving variants initially founded in the Automotive Industry. In the dedicated literature, there is a plethora of cases, in depth-analyses and examples which describe successful implementations of Lean Thinking philosophy within real manufacturing systems (Bozdogan *et al*., 2000; Coook and Graser, 2001; Murman *et al*., 2002). When managers first come across case studies of Lean adoption, they may be extremely eager to apply the concept to their own business. However, when the same managers start to research into Lean strategies and methodologies, they can be overwhelmed, even discouraged from committing themselves to developing such a strategy, by the great body of knowledge available (Panizzolo et al., 2014).

The main purpose of this paper is to provide a consistent set of information and knowledge aimed to support those firms expected to undertake a Lean Transformation of production systems (briefly "Lean Transformation") in the near future. More specifically, the paper deal with application of Lean Thinking principles to the Operations Management area which is often called Lean Manufacturing.

The goal is to build an organized outline of prescriptive information and instructions, which organizations have to acquire and critically evaluate, before starting any Lean initiative. Indeed, companies can get advantage from this material, by early identifying the most appropriate areas for intervention and addressing resources and efforts more efficiently.

Among the potential recipients of this work, there are:

- ✓ Small and Medium Enterprises (SMEs), which traditionally have insufficient financial resources to invest in re-organization and Project Management capability;
- ✓ Business organizations which face of the threat of new entrants in their market, due to new technologies or supply globalization;
- ✓ Companies which suffer the effects of the financial crisis and need to regain competitiveness through the redesign of their cost structure;

- ✓ Practitioners, who support organizations in the journey from Lean theory to practices, and scholars, which formalize practices in advancing theory.

The analysis carried out within the research project is aimed to answer to the following questions:

- ✓ Which are the most important tools or practices to apply in a Lean Transformation?
- ✓ Which are the main factors which can facilitate a successful Lean implementation?
- ✓ Which are the most critical factors that can be encountered in a Lean Transformation?

The answers to these questions are based on "opinion-based" information, deducted from experience and on-field direct work. In this perspective, managers which have already introduced and developed Lean projects in many industrial processes or areas have been involved. We have collected the indications coming from these managers through a Normative Delphi method, which is widely accepted as "a qualitative technique of investigation employed in social sciences to predict the future and also to delineate and investigate problems and issues of the present" (Perez and Schuler, 1982).

The paper is structured as follow: the first section gives a literature background of studies relating to the adoption and implementation of Lean transformation strategies. The second section describes the research approach. Then, the empirical results about the most important tools in Lean Transformation for SMEs are reported. Further, discussion of empirical results, pertaining to the enabling and critical factors for Lean Transformation is provided, while conclusions and future developments are drawn at the end.

2. Literature Review

The roots of Lean Manufacturing lie in Toyota Production System (TPS) – the system of organizing production processes in efficient and effective manner which is used in Toyota Motor Corporation. Since the TPS has been discovered and the word "Lean" employed in the bestseller "Machine that changed the world", the idea spread around the world. Initially, this movement started from the automotive industry, and then entered all other industries and sectors (Womack *et al*., 1990).

Lean Thinking has revolutionized the global manufacturing environment at an unprecedented rate. Its focus on producing high quality products in the most efficient and

economical manner possible, while incorporating less human effort, less inventory, less time to develop products, and less space to become highly responsive to customer demands has won the hearts of many organizations.

Despite many firms report large benefits from Lean implementation, a lot of scepticism still remains regarding attainable results and about the real possibility to apply Lean approach outside high volume manufacturing.

In scholarly and managerial literature, many works have reported that Lean Manufacturing is a very efficient approach and a straightforward way towards process improvements, in terms of productivity and value adding activities ratio. However, other studies on Lean Manufacturing phenomena have indicated the difficult and intricate nature of it. The system which is working very well in Toyota might not give similar effective results in other companies. Indeed, many manufacturers have failed in achieving success of Lean Manufacturing implementation.

So, an increasing number of companies and organizations are interested in better understanding Lean Manufacturing system. In particular, there is a need to deepen the knowledge on results achieved in improving different performances, on how to maximize benefits from Lean implementation, and most common difficulties faced by companies implementing Lean Manufacturing.

Over the last decades, a number of studies have been published in this field. Our focus was on articles relating to the adoption and implementation of lean transformation strategies; the analysis was conducted by searching the Scopus Elsevier data base including case reports, classical studies, and comparative studies published. Literature review was conducted using two methods. The first drew on existing literature which describes the practices and tools characterizing a Lean approach in Manufacturing. In addition to the review of this literature, a second targeted analysis was conducted of the international literature on the successful factors and constraints which favour or hinder the diffusion of Lean principles. The ones which are most related to our research work will be presented below, highlighting their scope and objectives. In their study in 2006, Bhasin and Burcher stated about 10 per cent of companies succeeds at implementing Lean Manufacturing practices and only 10 per cent has the philosophy properly instituted...new paradigms and best practices are often taken as a “black box”, which has many dangers inside...if companies use Lean initiatives almost as a fad, most of their effort will fail to produce significant results...finally, there are evidence that no

standard framework for Lean or its implementation exists. A systematic approach needs to be adopted, which optimizes systems as a whole, focusing the right strategies in the correct places (Bhasin and Burcher, 2006).

It is important to note that in their study, the authors point out that only an integrated approach to Lean Manufacturing, which does not focus on individual areas but involves the entire organizational structure, is able to ensure the success of the initiative.

The results from Bhasin and Burcher were not new. In previous years, further studies have already analyzed this topic. A very interesting work by White and Trevor (1983) and White, Pearson and Wilson (1999) investigated Lean Thinking implementation differences between a set of 174 U.S. small manufacturers (with less than 250 employees) and one of 280 U.S. large manufacturers (with more than 1, 000 employees). In that research, the authors tried to understand to what extent Lean Thinking techniques have been implemented, and the relationships between implementation status of 10 specific Lean Thinking management practices and associated changes in performance in the two groups of manufacturers. The results of the study show that the frequencies of the 10 JIT management practices implemented differ between the two groups of manufacturer size, and an association exists between the JIT practices implemented and manufacturer size. Moreover, the changes in performance attributed to JIT implementation vary, depending on implementation status of specific JIT management practices and manufacturer size.

Holland and Light (1999) asserted that in attempting to implement any productivity improvement drive in any organisation, a business should have a clear vision and strategy in forecasting a project's likely costs and duration. Hayes (2000) discussed that successful corporate initiatives like Lean Manufacturing, should be properly planned prior to implementation. Management involvement and commitment are perhaps the most essential prerequisites in aiding any of the desired productivity improvement initiatives (see also works by Antony and Banuelas, 2001; Coronado and Antony, 2002; Eckes, 2000; Henderson and Evans, 2000).

Hines and Taylor (2000) gave a deep overview of Lean paradigm development. The authors said that major part of the companies which are implementing Lean Thinking, are stuck in purely manufacturing process improvement part and forget about the overall philosophy. This might lead to the fail of Lean implementation.

Wu (2003) surveyed a total of 103 American first tier automotive suppliers with more than 100 million $ in annual sales, with the aim to understand whether significant performance/practice differences exist between lean suppliers and non-lean suppliers. In particular, he tries to understand if, even given the same organizational constraints and resources, Lean suppliers gain significant competitive advantages over non-Lean suppliers in production systems, distribution systems, information communications, transport systems, customer-supplier relationships, and on-time staging/delivery performance.

Some authors viewed Lean as a philosophy (Bhasin and Burcher, 2006; Liker, 2004) and performed their analyses, concentrating into the two human aspects of the paradigm, i.e. culture and people development. From the cultural perspective, management systems are difficult to transfer because the environmental context is different from one country to another and from one company to another (Fukuda, 1988; Oberg, 1963; White and Trevor, 1983).

Hilton and Sohal (2012) in their investigation, found that the success factors for Lean implementation are leadership, communication, behaviour and awareness of Six Sigma; policies, culture and organizational support and strategy; education, training and competency of the Six Sigma experts; project improvement teams and project management; and performance evaluations based on quality criteria, information systems, data and measurement.

Irrespective of how it could be perceived, the concept of Lean Manufacturing has unarguably been discussed extensively in the past decades or so. However, there appears to be little empirical evidence in publications on the implementation of Lean Practices and the factors that might influence it in SMEs. Most of these publications tended to focus on the premise of large sized enterprises only.

One interesting exception is the study of Achanga *et al*. (2006), which presented the critical factors that constitute a successful implementation of Lean Thinking within manufacturing SMEs. A combination of comprehensive literature review and visits to 10 SMEs based in the East of the UK were employed in that research. Companies' practices were observed to highlight the degree of Lean Thinking implementation within these organizations. Then, critical factors determining a successful Lean Transformation within SMEs environment, are captured and the authors provide SMEs with indicators and guidelines for a successful implementation of Lean principles. The investigation goes on to highlight four main key factors, that are fundamental or even critical for the implementation of Lean

Manufacturing, i.e. leadership and management, finance, skills and expertise, and organizational culture. In this view, leadership stands for 50%, finance for 30%, organization and culture for 10% and skill and expertise also for 10% of influencing the results of Lean implementation. Achanga *et al*. (2006) suggested that leadership and management commitment are the most critical ones in determining the success of a lean project. Strong leadership and committed management support is the cornerstone to the success of implementing any idea within an organization.

Another study focused on Lean Implementation in SMEs has been co-authored by Portioli *et al*. (2007). In the second part of their work, the authors tried to understand the maturity degree of Lean implementation, the performance level reached, the level of satisfaction and difficulty encountered in adopting Lean concepts, main advantages and barriers encountered, the time needed to gain advantages, which are the most important factors that make this implementation a success. In addition, other understanding items are the Lean organizational structure and the resources involved in the Lean implementation. An interesting result is that main difficulties in implementing the Lean approach are coming from the operators. This can be interpreted as the difficulty in really involving operators in a proactive way. The authors suggested that the main reason may be the need to invest more in education, or the difficulty of top managers to really delegate, increase decision scope of operators, listen to them, and set with them a different relationship. In the final part of this section on literature review, we discuss some specific works regarding Lean Manufacturing implementation in Brazilian firms.

Oprime *et al*. (2011) supply a summary of critical success factors of Lean implementation in the Brazilian context. More specifically, they identify and analyze critical factors in the development of continuous improvement (CI) activities. A conceptual model of relationship between practices and results was tested through a survey conducted in 46 manufacturing companies. Factors such as: problems solving tools training, suggestion incentives, face-to-face communication, visits to the shop floor and adoption of incentive systems, have proved to be critical at reaching success in CI activities. Through factorial analysis, two critical constructs concerning continuous improvement process were identified: 1) promotion of continuous improvement through incentive mechanisms; and 2) High level management support and leadership and management active involvement.

Another interesting study regarding Brazilian firms is that of Moori *et al*. (2013). In the paper the authors examine the relationship among lean manufacturing management, competitive skills and business performance. They conduct a survey of 68 Brazilian companies that use lean manufacturing and analyze data using structural equation modelling. Results suggest that managers lack awareness about the importance of the competitive skills to enhance business performance.

Even the work of Lorenzini *et al.* (2012) is related to the Brazilian industrial sector. The authors aim to assess the lean practices and principles in a small business from the Lean Management System. The key findings show the main difficulties in establishing lean practices in small and medium enterprises (SMEs). Among the highlights of the study there is the emphasis in design of strategic networks with customers, suppliers and internal leadership training.

The work of Ferreira *et al*. (2012) aims to evaluate the use of lean manufacturing practices, according to SAE J4000, in a supply chain of the pharmaceutical industry. The data were collected in four companies: a manufacturer, a distributor and two suppliers. The main section of the SAE J4000 standard is composed of 52 components divided into six elements that assess the degree of implementation of the principles of lean operations in a company. The six elements are: 1) ethics and organization, 2) people and human resources, 3) information system, 4) customer/supplier relationship and organization, 5) product and product management, 6) product and process flow. The results show that companies are aligned only in one of the six elements of the standard, i.e. product and process flow.

Another study that make us of the SAE J4000 standard and is partially focused on the Brazilian context is that of Calarge *et al*. (2012). The article is aimed at analyzing how companies are conducting the Lean production system in the automotive sector of Brazil and Spain. The most impacting elements regarding the Lean Production practices implementation are: Ethics and Organization, Personnel and HR, Customer/Supplier and Organization Rapport, Product and Product Management.

Finally, a latest study to be mentioned in this part of the paper discussing the specific literature on Brazil is that of Valle *et al*. (2011). The paper aims to identify the main Lean Production practices and principles adopted in the auto parts industry of the second largest Brazilian automotive cluster. The results coming from a questionnaire sent to nine companies show that there is a high level of understanding and application of Lean Production especially

with regard to the pull production (Pace Maker), continuous flow, visual control (Andon), autonomation (Jidoka), capacity leveling (Heijunka), multifunctionality, standardized working intructions tools (SWI), OEE (overall equipment effectiveness).

To conclude this section it is important to notice that so far studies in academic literature mostly focus either on very general Lean implementation process or on general organization's characteristics, which should facilitate the process of Lean implementation. Moreover, the different studies above mentioned address different issues showing that there are still many unclear points about Lean Transformation implementations. As well, while UK and USA have some systematic survey, other countries have much less empirical evidences.

3. Research Methodology

A Delphi methodology was chosen for its potential to simultaneously explore similarities and differences of opinions held between different professionals, involved in the process of defining appropriate prescription for an effective Lean Transformation. Delphi method is frequently employed in social science research, as in order to predict the future as to delineate and investigate current problems and critical issues. It is also used to enhance collaboration and provide the most reliable consensus of opinions, minimizing the potential bias that could occur in committee meetings or group discussions. Delphi method favours the "level playing field" concept and encourages honest opinions avoiding the potential conflict inherent in face-to-face meetings and improving the validity of the study results (Perez and Schuler, 1982; Dalkey and Helmer, 1963; Williams and Webb, 1994; Williams *et al*., 1994).

In our project, the so-called "Normative Delphi" has been employed, which allows, according to Buckley (1995) "to identify and test the relative importance of preferences, values or beliefs of a number of experts in relation to a defined matter of inquiry". The Normative Delphi methodology has been used to gather from the experts' different opinions and points of view; in this case, we decided to align with Okoli and Pawloski (2004), which state that experts should be included in a number between 10 and 30. The need to build up a homogeneous panel, which represents different approaches and levels of advancement in Lean Transformation, determined the amplitude of the panel, formed by 32 experts coming from 16 SMEs. The criteria that guided the sample selection are:

- ✓ The firms must belong to the manufacturing sector and have less than 500 heads/ 20 M Euro turnover (Brazilian SME definition) and established in the South-Eastern Brazil;

- ✓ The firms must have at least five years of experience in Lean initiatives (i.e. it has to be excellent in Lean Transformation);
- ✓ The firms have to be willing to share its experience on Lean Transformation critically with other firms.

In addition, it was considered a preferential requirement but not a prerequisite, if the firm had already joined some Lean training program, maybe promoted by leading international institutes, such as Lean Enterprise Institute.

An important issue widely discussed in literature refers to the figure of so-called "expert", selected and involved in a Delphi study. Sackman (1975) investigates "how an expert in a particular field can be defined operationally" and "why the answers provided by experts should be better than that provided by non-experts, as by knowledgeable or informed people". Nevertheless, it should be defined as "expert" anyone who "is able to provide an interesting input" (Pill, 1971). In essence, the definition should help to recruit people on the basis of their knowledge about the studying topic and their interest in the aims of the study (Reid, 1988). Therefore, as regard to people involved, companies were asked to select figures that have:

- ✓ A minimum of two years seniority in their function or four years in the same company;
- ✓ A previous experience of direct involvement in Lean projects or, alternatively a managerial role, which still allows to have a clear view of the various aspects related to Lean initiatives;
- ✓ The personal ability to express their views and to confront within a group experience.

The Delphi model was developed in two stages, the first with an open questionnaire in which experts were asked to identify and classify:

- ✓ Some practices and Lean Transformation tools;
- ✓ Some factors that can facilitate a successful Lean implementation;
- ✓ Some factors that can be encountered in a Lean Transformation.

In the second stage each questionnaire item was synthesized and each participant should classify them by importance and eventually justify his opinion. The scale used was the Likert from 1 to 5. After two rounds the results were discussed in plenary meeting to raise some questions concerning the results obtained.

4. Lean Transformation Process in SMEs: a tool-based analysis

The purpose of this section is to identify key tools for successful implementation of Lean principles in manufacturing. According to Panizzolo (1998) practices/tools that characterize a Lean Manufacturing approach refer to: organization of production processes, synchronization between production programs and market demand; and the relationship with suppliers and customers with respect to quality and timely delivery.

With reference to production processes, in order to work with operational regularity and uniformity of the mix, the following goals have to be performed: reduction of the set-up time using SMED methodology (Shingo, 1985); application of the Spaghetti Chart to clearly detect the flows of materials and, if possible, rearrange them according to the approach of Cellular Manufacturing; a high quality (i.e. compliance) performance of the production process through the Six-Sigma techniques and the use of Poka Yoke (i.e. fail safe error proofing) systems; optimization of the availability and reliability of equipment by implementing the Total Productive Maintenance methodology; sorting and keeping clean working areas by applying all phases of the 5Ss methodology.

Usually, as a mean to understand and streamline work processes the Value Stream Mapping (VSM) methodology is employed (Rother and Shook, 1999). The goal of VSM is to identify, demonstrate and eliminate waste affecting processes. VSM can thus serve as a starting point to help management, engineers, production associates, schedulers, suppliers, and customers recognize waste and identify its sources.

With respect to production planning and control, typical Lean Manufacturing tools are Kanban for pull adjustment of flow, Visual Management for immediate control of the shop floor, the Hejiunka box for levelling and cadencing production.

It is evident that the adoption of these practices in internal operations requires a review of the ways a company relates to suppliers. We refer to issues such as the rationalization of supply network, the construction of closer and lasting relationships, the use of vendor rating programs which evaluate the total cost of ownership, the involvement of suppliers in joint improvement programs, the application of Kanban for regulating the flows of materials from suppliers (Lamming, 1993).

In the first stage of the Delphi model were identified 16 practices that characterize the implementation of the principles of Lean manufacturing. Obviously, the list contains items

well-known in the literature. Some of these practices are at the core of the lean manufacturing approach while others have become known more recently; These practices are listed below:

- ✓ 5Ss;
- ✓ Cell manufacturing;
- ✓ Hejiunka Box;
- ✓ Hoshin Kanri (policy deployment);
- ✓ Ishikawa Diagram;
- ✓ Kaizen (continuous improvement);
- ✓ Kanban with suppliers;
- ✓ Lean Distribution;
- ✓ Poka-Yoke;
- ✓ Set-up time reduction (SMED);
- ✓ Shop-floor Kanban;
- ✓ Six Sigma;
- ✓ Spaghetti Chart;
- ✓ Total Productive Maintenance (TPM);
- ✓ Value Stream Mapping;
- ✓ Visual Control

In the Delphi second round were given scores to rank each tool and the highest value (5.00) was reached by VSM (Table 1), being considered as the main Lean Transformation tool in a SME. The mapping of physical and informational elements of a given production flow through the VSM format, allows to highlight what are the most suitable areas for starting a new Lean project.

At the second place is collocated the 5Ss methodology (4.75), that create the basis of the internal organization and change the paradigm regarding the responsibility of operators and Kaizen (4.75). This last item should not be generically referring to the Kaizen philosophy but rather to the Gemba walks (Womack, 2011). The Gemba walk is an activity that takes management to the front lines in order to look for waste and opportunities to practice Gemba

kaizen, or practical shop-floor improvement. Gemba walks promote the principle of incremental continuous improvement, encourage proposals for change from below, from the employees themselves and not by management, and are a mean to evaluate alternative quick-fix solutions to be normalized later.

Table 1 - The most relevant tools in Lean Manufacturing transformation in SMEs

The most relevant tools in Lean	Score
Value Stream Mapping	4,93
5Ss	4,75
Kaizen (continuous improvement);	4,75
Kanban with suppliers	4,25
Shop-floor Kanban	4,13
Visual Control	4,13
Poka-Yoke	4,05
Set-up time reduction (SMED)	3,98
Total Productive Maintenance (TPM);	3,88
Cell manufacturing;	3,75
Ishikawa Diagram;	3,02
Spaghetti Chart	3,02
Hejiunka Box	2,88
Lean Distribution	2,75
Hoshin Kanri (policy deployment)	2,38
Six Sigma	1,98

On the other hand, Six Sigma gained a low rate (1.98): in opinion of experts, this tool had secondary importance in relation to the success of the adoption of Lean principles in SMEs. Among other practices, the highest scores went to:

- ✓ Kanban with suppliers (4.25) and shop-flow (4.13), to obtain the flow of automatic and dynamic material.
- ✓ Visual control (4.13), critical to increase the efficiency and effectiveness of the production process; the theory behind visual control is that if something is clearly visible or in plain sight, it is easy to remember and keep at the forefront of the mind
- ✓ Poka-Yoke (4.05) and Set-up time reduction (4.00), seen as a main obstacle to reduce lots;
- ✓ TPM (3.88), employed to guarantee the availability of machines and give reliability to the production process in general;

- ✓ Cellular manufacturing model (3.75) which provides flexibility and increase the response speed with the minimum transportation.

5. Enabling and critical factors in LEAN transformation processes

Despite the adoption of Lean principles in manufacturing by many companies in the last 30 years, the data indicate that there are many obstacles and most companies find difficult to implement these principles. Conflicts regarding the results are leading to confusion and frustration, stimulating debate about the causes that lead to this situation. Because of this, besides the identification of best practices for the implementation of Lean principles, others have dedicated their work to identify more appropriate use of these practices. In order to address this topic, during the Delphi's rounds was asked the participants to highlight, on the basis of their experience and expertise, both the factors enabling the launch of Lean Transformation projects and the main constraints that a company may face during the adoption of Lean Manufacturing practices.

5.1. Factors enabling the introduction of Lean Manufacturing practices

Similarly to what has been done previously regarding Lean practices, also in this case it was decided to integrate literature indications with suggestions and comments from managers participating in the workshops. The main factors identified were:

- ✓ Company orientation processes
- ✓ Emergency situation or crisis in the company.
- ✓ Employee development fostered by the company.
- ✓ Experience of managers in Lean practices
- ✓ External support of charismatic consultant
- ✓ Focus on continuous improvement
- ✓ High level of unionization of employees
- ✓ Industry high variety of products and response speed
- ✓ Industry with great competitive focus on reducing operating costs
- ✓ Industry with great spread of Lean practices
- ✓ Knowledge and sponsorship of senior management
- ✓ Previous experience in related events Lean practices

- ✓ Proactive change management

Table 2 shows the score obtained by each item listed. The group recognizes that the main aspect for the success of a Lean implementation is senior management to be aware of the benefits from this initiative (5.00) strengthening the focus given in the publications on the subject in recent decades that highlighted the growth of training courses and models developed from case study and the successful experience. The fact that top management/entrepreneur must be informed of the benefits, in reference to the specific business context, appears as an indispensable prerequisite. This commitment not only reflects and promotes the strategic importance of each Lean Transformation initiative within your organization, but supports and encourages the commitment of resources involved, motivation and focus on the results of the process of change.

The second aspect that was highlighted was the corporate culture oriented to continuous improvement (4.88), showing that together with the awareness of senior management forms the basis for the success of the Lean principles implementation project. The constant drive of process improvement is the key to a successful organization. Many organizations fail to succeed because they place this accountability on leaders instead of people actually doing the work. As a company, we need to build the culture of continuous improvement bottom up, from the most valuable areas of the organization – where the valuable processes are occurring. Empowering all team members within an organization to continuously seek opportunities for improvement is what will lead to strength within a company.

The third factor is "employee development fostered by the company". Regarding the first factor, among the experts there was a strong debate about sustaining Lean improvements. How to maintain the gains from those improvements and build on them was a burning question. Experts highlighted the fact that while Lean coordinators and facilitators and Kaizen teams are invaluable resources for introducing and implementing Lean tools, Kaizen events and Value Stream Mapping projects, it is the role of managers and executives to create an environment and the systems in which employees can and will take responsibility for the practices, behaviors and thinking that achieve, sustain and build on improvements made with Lean. Participants stressed the concept of a supportive management environment for Lean performance and the manager's role in people development and responsibilities in creating a learning environment.

The factor "Company orientation processes" is collocated at the fourth place. Process management is becoming a part of the language and actions of many organizations. It is defined as an approach based on the organization of a company as a whole set of interconnected activities that aim to map, improve, and align organizational processes. Process management is particularly useful to meeting stakeholder expectations and promoting the integration of the different company functions.

Table 2 - Ranking of the main factors enabling the introduction of a Lean Transformation in SMEs

Factors enabling the introduction of Lean	Score
Knowledge and sponsorship of senior management	5,00
Focus on continuous improvement	4,88
Employee development fostered by the company.	4,50
Company orientation processes	4,15
Industry with great competitive focus on reducing operating costs	4,05
Industry with great spread of Lean practices	3,88
Proactive change management	3,63
Emergency situation or crisis in the company.	3,13
Experience of managers in Lean practices	3,13
Previous experience in related events Lean practices	3,13
External support of charismatic consultant	3,03
Industry high variety of products and response speed	2,38
High level of unionization of employees	0,75

In a second level stand the fifth, sixth and seventh positions that are factors that are related to the market where the company operates and previous experience with change management: "industry with great competitive focus on reducing operating costs" (4.05), "industry with great spread of Lean practices" (3.88) and "proactive change management" (3.63). Going down in the scale of importance we found the item “high level of unionization of the workforce” (score 0.75).

5.2. Critical Factors of Lean Implementation in manufacturing firms

The main critical factors adopting Lean Transformation practices coming out from the Delphi group are:

- ✓ Anxiety to achieve tangible results in a short time
- ✓ Conflicts between production and other areas of the company
- ✓ Creation of a Kaizen Promotion Office;
- ✓ Difficulty to assess economic and financial benefits

- ✓ Excellent Lean project Management
- ✓ High cost/investment
- ✓ Inability to identify the right people to support change
- ✓ Lack of involvement of the Supplier Base
- ✓ Lack of appropriate reward systems
- ✓ Lack of flexible working arrangements
- ✓ Lean project adaptation to project management principles
- ✓ Little support from the top management
- ✓ Poor or non-qualified Lean training activities;
- ✓ Presence of an external consultant
- ✓ Production structure distributed in several locations
- ✓ Project Lean become routine before having consolidated the change
- ✓ Resistance to change by middle management

Table 3 shows the scores for each factor. The highest score was "little support from top management" (4.95). Successful Lean implementations have shown that leadership, commitment and participation by top management are the most critical factors in organisations embarking on Lean implementation as they ensure a smooth management and system rollout. Not only is the requirement for setting the vision and developing a solid strategic plan, but it is also for boosting the energy, creativity and involvement of employees to a self-sustaining organisation. Top management support and commitment does not end with initiation and facilitation, but must extend to full implementation of Lean Systems. Intervention from management is necessary for the adequate resources allocation of the project, to take fast and effective decisions, resolve conflicts, remove “anchor-draggers” and bring everybody to the same thinking, to promote company-wide acceptance of the project and to build cooperation among the diverse groups in the organisation.

Resistance to change by middle management (4.75) was considered the second leading cause of difficulty. Experts highlight that the biggest opponents are not those directly involved with the operations, i.e. the workers. In fact the biggest objections come from middle management who should be at the forefront of change. This is problematic on two levels; first,

because these individuals are organizationally positioned to be reinforcing sponsors, and second, because this resistance can cause the infamous "black holes" where changes die and are never seen again. In other words, the most resistance can be expected from those people with the highest vested interest in things remaining the same. In many organizations, those people are middle managers. Remember that middle managers have spent years paying their dues in the organization, with the expectation that their investment will pay-off in a promotion to a senior leadership position. Now the organization is "changing the rules." From the frame of reference of these individuals, there is a personal advantage if the change is not successful.

Table 3 - Ranking of the main critical factors for the introduction of a Lean Transformation in SMEs

Main critical factors for the introduction of Lean	Score
Little support from the top management	4,95
Resistance to change by middle management	4,75
Poor or non-qualified Lean training activities;	4,75
Lack of involvement of the Supplier Base	4,25
Anxiety to achieve tangible results in a short time	4,13
Inability to identify the right people to support change	4,13
Difficulty to assess economic and financial benefits	3,88
Excellent Lean project Management	3,88
Conflicts between production and other areas of the company	3,63
Project Lean become routine before having consolidated the change	3,13
Production structure distributed in several locations	3,03
Lack of appropriate reward systems	2,97
Lack of flexible working arrangements	2,75
Lean project adaptation to project management principles	2,75
High cost/investment	2,50
Presence of an external consultant	1,88
Creation of a Kaizen Promotion Office;	1,38

Poor or non-qualified Lean training activities gains a point of 4.75 and experts stressed that training is a major issue. Some experts point out that some organisations do not pay attention to develop formal training programs and therefore failed to equip their team with the skills and knowledge required of how to address Lean tools and techniques. Obviously, the challenge is to select an appropriate plan for end-user training and education and to do this, organisations need to think about what skills and knowledge these individuals need. It is however important to stress that a successful Lean transformation initiative will likely require the most extensive changes a company will ever have encountered. There will be a significant impact on every employee and every position. Therefore successful transition to Lean will require a deep understanding of its principles and practices, with extensive education and

training at all levels. The focus must be on changing mental models, beliefs, behaviour and attitudes throughout the workforce.

Lack of Involvement of the Supplier Base (4.25) has been ranked at the fifth place. This factor reinforces the idea that the adoption of Lean practices requires higher levels of integration of both information flows and physical flows with suppliers. Both dimensions are considered relevant for the Lean approach: the integration of information flows is a prerequisite to align and streamline processes; the integration of physical flows reduces waste and increases the efficiency of inter-company processes. In this way, companies need to extend the Lean model to the supply side, in order to benefit from supply chain integration alignment with the business strategy. Instead of the usual adversarial style, companies embracing Lean must place their purchasing emphasis on involving a transformation to partnership with suppliers. Among the other factors placed in the upper part of the list we find:

- ✓ Anxiety to achieve tangible results in a short time (score 4.13). One of the complexities associated with Lean implementation is related to the control the anxiety.
- ✓ Inability to identify the right people to support change (score 4.13). To implement Lean successfully, there should be a good implementation team that guides the company during the Lean journey.
- ✓ Difficulty to assess economic and financial benefits (score 3.88). Many experts highlight the relevance of making the connection between continuous improvement initiatives and financial returns by understanding the links to shareholder value and capturing the benefits of performance gains.
- ✓ Excellent Lean project Management (score 3.88). One of the complexities associated with Lean implementation is related to the cross-functional integration nature of the system.

6. Conclusions

The study examined the typical approach of a group of 16 Brazilian SMEs established in the South-Eastern of Brazil in implementing Lean manufacturing principles and practices. The results has been acquired from a group of experts with a deep knowledge of Lean applications. A Delphi methodology was chosen for its potential to simultaneously explore similarities and differences of opinions between these professionals. It was considered that

two rounds would be sufficient to reach adequate stability in opinions. In the first round experts were asked to identify 1) most important Lean Manufacturing tools/practices, 2) the enablers and 3) the constraints in Lean Transformation in SMEs. In the second round, the experts made a ranking of these items. The results are partially consistent with what has already been discussed in the literature. The three top tools/practices are:

- ✓ Value stream mapping
- ✓ 5S methodology
- ✓ Kaizen (Gemba walks)

As regards factors enabling the introduction of Lean Transformation practices, the top three ones are:

- ✓ Knowledge and sponsorship of senior management
- ✓ Focus on continuous improvement
- ✓ Employee development fostered by the company

Giving attention to the critical factors of Lean Implementation, the main ones are:

- ✓ Little support from the top management
- ✓ Resistance to change by middle management
- ✓ Poor or non-qualified Lean training activities

These factors are essential and therefore should be taken into account for achieving the full potential of Lean applications. This study contributes thus, to the practice of Lean implementation and organisational change in SMEs. For managers this study brings up aspects for the management of change. First, realizing that performance effect of such system of management may take time to be realised, and persistence in implementation is crucial for the programme to become a success. Second, the allocation of resources, approach and involvement have considerable influence on the outcome, and must be taken into consideration when such system is designed and performed.

The study has some limitations that restrict the generalisation of the findings. First, it should be noted that the research is limited within the context of Lean implementation in manufacturing environments, and the results may not be applicable to other types of industry. On the other hand, the interviewed experts on Lean are only a small and limited sample based

mostly on their experiences. A larger number of participants from different sectors could lead to more robust conclusions regarding the influence of the context and situational factors in understanding the Lean Transformation process.

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