Towards a model to understand risk factors that affect the lean production implementation

Giuliano Almeida Marodin (gmarodin@producao.ufrgs.br)
Industrial Engineering and Transportation Department (DEPROT)
Federal University of Rio Grande do Sul (UFRGS)

Tarcisio Abreu Saurin
Industrial Engineering and Transportation Department (DEPROT)
Federal University of Rio Grande do Sul (UFRGS)

Abstract
This paper modeled the risks that affect the lean production implementation into three dimensions: Process management, Managerial support and Shop floor involvement. We did a factor analysis with the answers of 57 respondents from Brazilian companies and mini case study. The three categories and some relationships between risks were discussed.

Keywords: lean production, risk analysis, lean implementation

Introduction
Lean Production (LP) has been implemented for several decades in companies all over the world (Hines et al., 2004). Although, there is still a major concern about the difficulties of sustaining gains in a long-term (Bateman and David, 2002). As evidence of those difficulties, studies in English and Australian companies indicated that less than 10% of those who started the implementation process reached maturity in their lean systems (Baker, 2002; Bhasin, 2012). These results could be partly explained by the very nature of the LP implementation, which is complex, time-consuming and require a substantial amount of human resources and effort (Gelidas, 1999; Papadopoulou and Ozbayrak, 2005; Emiliani and Stec, 2005; Lian and Van Landeghem, 2007).

The substantial level of failure in implementing LP indicates the needs for a better understanding of the factors that affect implementing this system (Bayo-Moriones et al., 2008). In this article, the factors that impact on the lean implementation process are re-interpreted and investigated from the perspective of risk management, since this leads to the systematic management of the factors under the PDCA logic (Plan-Do-Check-Act), besides prompting an investigation of the context of LP implementation. A risk is any event or condition of uncertainty that can influence on project performance, represented by the possibility of occurrence of a given event, which, if achieved, results in losses in the project outcome (Aloini et al., 2012). The risk could be explained by the product of the multiplication of the risk exposure and the effect of the loss (Mikkelsen, 1990; Boehm, 1991). Risk management seeks to understand and control the risks that may affect a project with a view to increasing the chances of positive results (Ritchie and Brindley, 2007). Risk management is being used for decades to improve outcomes of processes and projects of similar complexity and scale, such as Enterprise Resource Planning (ERP) implementation (Boehm 1991; Aloini et al., 2012) and Supply Chain Management (Ritchie and Brindley, 2007).

There are already evidences of the presence of risk that affect the LP implementation process, although they are often presented in the literature as difficulties, barriers or success factors. They were mostly investigated in two dominant ways, with empirical evidences of the impact of one risk individually or several risks emerging from an in-depth case study. For example, some studies described the risks that appeared in one case study each, as not encouraging the operators autonomy (Scherrer-Rathje et al., 2009) and lack of commitment of senior management (Crute et al., 2003). Those single company case studies provided few evidences about the possibility that the results could be generalized within a larger number of companies. Boyer (1996) did a survey with 202 plants to suggest that the management support affect the lean implementation process and Angelis et al. (2011) surveyed around 1400 operators in 21 plant sites to suggest that the workforce support impact on lean. Although both of these studies are supported by empirical evidences of the effect of those risks on the lean implementations, they focused only in one risk. We argue that further investigation is needed to collect empirical evidences about the relationship between the risks in implementing LP and their systemic relationship. Modeling the relationship between the risks and project outcome has helped the ERP´s project management field to understand the direct link between risks, their source factors and effect (e.g. Wallace et al., 2004; Aloini et al., 2007)

Thus, the objectives of this paper was to propose a model that explained the categories of risks that impact on the LP implementation and to discuss the motives behind the risk groups. Those objectives were investigated in the context of companies in the South of Brazil, using a survey and a case study as research strategies. It is worth noting the originality of studies on this topic in Brazil, one of the world's major economies. In particular, Brazil is the fifth largest producer of automobiles in the world (Silva, 2011), and the automotive sector is acknowledged as the one that has been adopting LP longest.

Theoretical background - Risks in implementing LP

Since the articles selected presented the risks under different terms (e.g. barriers, difficulties, impact factors), it was necessary to identify those who were consistent with the previous presented definition of risk. For example, the influences of the process type (White and Prybutok, 2001) or plant age (Shah and Ward, 2003) were not considered as risks because they usually cannot be changed, since they are inherent characteristics of the plant or sector (i.e. they are not uncertainties). A large number of risks was recurrent in some papers suggests that some of them are less dependent on context, despite the uniqueness nature of each implementation process (Bhasin, 2012). For example, in a case study in an automotive company, Motwani (2003) identified factors that facilitated LP, such as the commitment of top and middle management, a long-term vision, supervisors' and leaders' technical knowledge of LP and communication between the various hierarchical levels. Scherrer-Rathje et al. (2009) found similar factors in a longitudinal study in a food company.

A list of eighteen risks on implementing LP was made based on the literature review of fourteen studies (Figure 1). This list was subsequently reduced, since there was sometimes overlap between the risks, as the authors used slightly different terms to designate the same subject. After this refinement, it was possible to identify 14 risks, and examples for each of them were established.

Description of the risks / References	1	2	3	4	5	6	7	8	9	10	11	12
R1: People seem demotivated after a few years from the continuous improvement activities begun									X		X	
R2: The people from the areas that support the manufacturing process (Engineering, IT, Logistics, HR, Purchase, Maintenance and others) don´t use or have the sufficient knowledge to help the lean implementation		X		X				X		X		X
R3: Lack of human / financial resources for continuous improvements		X	X		X				X			X
R4: Lack of communication throughout the company about the continuous improvements activities in progress	X			X		X	X		X		X	
R5: Difficulties in seeing the financial benefits of the improvement activities			X		X	X			X			
R6: Middle management not giving enough support to the continuous improvement activities	X	X	X		X	X	X	X	X	X		X
R7: Top management not giving enough support to the continuous improvement activities	X	X	X	X	X	X		X			X	X
R8: Lack of support on the shop floor		X				X	X					
R9: Insecurity of the operators in carrying out new attributions		X		X		X	X	X	X	X	X	
R10: The operators are afraid that there is going to be layoffs because of the manual labor gained by the improvements			X	X			X					
R11: The operators did not feel responsible for using LP practices and solving problems	X	X		X		X	X		X		X	
R12: The top and middle management not having sufficient knowledge or skills to guide the lean implementation process		X	X	X	X	X	X	X		X	X	X
R13: Not sustaining the improvements in the medium and long term				X	X				X		X	
R14: Having difficulties to keep the pace of the ongoing continuous improvement activities			X	X	X		X		X		X	

References: 1) Sriparavastu & Gupta, 1997; 2) Motwani, 2003; 3) Emiliani & Stec, 2005; 4) Papadopoulou & Ozbayrak, 2005; 5) Achanga et al., 2006; 6) Black, 2007; 7) Sim & Rogers, 2009; 8) Pierce & Rich, 2009; 9) Scherrer-Rathje et al., 2009; 10) Farris et al., 2009; 11) Turesky & Connell, 2010; 12) Boyle et al., 2011

Figure 1: Risks on implementing LP and references

Research questions

Using risk management in software development, Barki et al. (1993) suggests that the control and management of individual risks can be unproductive because they frequently have direct relationships between each other and also ambiguities. On the software development projects, the risk treatment strategies have better results if applied into risk categories instead of individual risk, because of the relationships between them (Barki et al., 1993, Bannerman, 2008). Working with risk management in construction projects, Ren (1994) found out that the presence and effect of a certain risk are often not decided by his own features, but by the influence of other risks on the system, so risk mutually affect, impede and promote each other. The complex and varied relationship between risks makes it possible to obtain sub-classifications or factors regarding the risk patterns and relations.

Thus, several authors suggested that the risks have to be analyzed into categories for better results because of the closer relations between risks, as the use of categories also helps to understand the sources of risks, as the classification itself to their source (Aloini et al., 2012). For example, in software development, Bannermann (2008) did multiple interviews to classify the risks into ten categories and Summer (2000) used six case studies to classify the twenty risks into six factors.

The literature that usually presents the risks of the LP implementation process used in-depth case study with little evidences about the relationship between the risks. Also, there were even less efforts to explain the motives behind the sources of those risk and the risks categories. The first and second questions of this research are:

1. Do the risks of implementing LP can be aggregated together into categories?
2. If they can, why do some risks tend to appear together? What is the nature of their relationship?

Research method

Overview of the research method

In this paper, we used a combination of a quantitative and qualitative research strategies. This was necessary because of the stage of development of the phenomenon and the nature of the two research questions. The technical aspects of the LP tools/practices has being studied from many decades and appeared to be well disseminated (Bhasin and Burcher, 2006), although, we argue that there is much to understanding about the LP implementation risks.

The first research question refers to test a hypothesis and the quantitative research strategies are the most recommended on those cases (Yin, 2003). For Malhotra and Grover (1998), the survey-based research could be used on this early stage of the phenomenon development, named as exploratory survey, in order to become more familiar with a topic. It is recommended when the concepts of interest need to be better understood and measured and the resulting data could be used to refine and identify new possibilities and dimensions of interest. Although the survey-based research presented empirical evidences about the risk's relationship, it was not sufficient to understand the nature of the relationship itself. A mini case study, the qualitative part of the research, was the foundation to gather insights about why does some risks tend to present themselves together with other risks. The case-based studies are frequently used as methods for research questions that begin with "How" and "Why" (Yin, 2003). Also, as the quantitative part of the research proposed the risks constructs, the case study was used to refine and build evidences which measures the construct and establish construct validity, as suggested by Eisenhart (1989). The case-based study was used in the sense of understanding the role of context in which the phenomenon occurred and the dynamics of temporal dimensions (Meredith, 1998), such as the relationship between the risks in each construct.

Thus, research method was divided into four stages: (a) a literature review to identify risks on implementing LP, which resulted in a list of risks; (b) designing and applying a questionnaire on a group of companies; (c) analyzing the results from the questionnaire using Exploratory Factor Analysis (EFA) and construct validity; and (d) a mini case study for in-depth understanding of the relationship of the risks identified in the previous stage. Stages (a), (c) and (d) lasted approximately two months each. Stage (b) was longer, and took about four months from drawing up the questionnaire, sending it out and receiving replies

Identifying risks on LP implementation

The literature review began by searching for recent articles (2000-2012) in highly regarded international journals (for example, all had an impact factor and have been published continuously for more than 10 years) in the area of operations management. The studies that dealt with implementing isolated practices (e.g. standardized work) were discarded, since they would probably not reflect the risks of a more complex process of implementing a LP system. In order to enrich the perspectives on the subject, there was a concern to select studies with different research strategies, such as case studies, surveys and literature reviews.

The literature consulted showed only internal risks to the company when implementing LP. However, external risks, such as a natural disaster, strike or a change in legislation, may also impact implementing LP. Given the relatively scanty knowledge about the impact of these risks when implementing LP, and the fact that they have widespread impact on the operations of the company as a whole, the list of risks drawn up was limited to the internal risks.

Design and application of survey questionnaires

Sample characteristics

The criteria for selecting the sample of companies were as follows: (a) to include companies at various stages of using LP, because some risks may appear at specific stages; (b) to include companies located in a specific region of the country, in this case the South of Brazil, so as to reduce the effects of the external environment (e.g. public transport infrastructure, profile and availability of skilled labor), since this would be relatively homogeneous within the sample; and (c) to include companies from different industrial sectors, because LP has been expanding over many kinds of companies in recent years.

With regard to the criteria used to select survey respondents in each company, priority was given to those who had taken part, between 2008 and 2010, in LP courses offered by the institution responsible for this study and for Lean Institute Brasil, an institution that has been working since 1998 on spreading the lean system nationwide. The institution in charge of this study is the only to offer short period courses on LP, which are open to the general public and advertised in major media, in the region. Thus, the sample involved respondents likely to be technically qualified to respond to the survey, a total of 305 people. The non-random choice of companies for surveys and the search for companies that are already known to the researchers is a procedure used in other studies on LP (e.g. Saurin et al., 2010; Boyle et al., 2011).

Risk on implementing LP

The first part of the questionnaire was based on Figure 1. For each risk, the respondent had to indicate its impact and probability. The respondent used a 6-point scale from "0" to "5", where the value "0" represented a non-existent impact or probability and the value "5" corresponded to a very high probability or impact. Since there were fourteen risks, the first part of the questionnaire involved 28 questions. The second part referred to the profile of the respondents and the company, and had a total of nine questions.

Survey data collection

A pre-test with four members of the sample population was conducted and some questions of the questionnaire were redrafted. A pre-test is generally conducted on a small sample and aims to reduce and eliminate problems relating to the content, format and clarity of the questions and alternative answers (Malhotra, 2004). Among the 305 participants initially selected, it was not possible to contact a dozen of them because their e-mail addresses were invalid. Three others said they had not taken part in implementing LP and they did not consider themselves able to answer the questionnaire.

In all, 57 valid responses were obtained of 39 different companies, thus reaching 19% of the valid contacts, a percentage considered to be reasonable compared to other surveys on LP. The percentage achieved by this survey is a little higher than the average rate of survey responses for collecting data by e-mail, which is 15% (Malhotra, 2004).

It is worth noting that the number of respondents was greater than the number of companies. This occurred due to the fact that some companies had respondents from multiple plants. The final answers correspond to an average of the responses from all the employees of a certain plant. The LP implementation process may vary from plant to plant due to many aspects, such as geographic location, product, management team and history (Lewis, 2000).

Analysis of the results of the questionnaire

Exploratory Factor Analysis for risks categories

As there were no previous studies about the risks on the LP implementation into categories and they were not easy to identify, an Exploratory Factor Analysis (EFA) was used to create those constructs, as suggested by Hinkin (1998). The SPSS software, version 20, was used for the EFA and internal validity tests. The sample size to allow an EFA depends on the magnitude of the correlation between population and the number of constructs (Tabachnick, Fidell, 2001). According to the authors, of the correlation is strong and there are few distinct constructs, even a small sample can be considered adequate. Hair et al. (2006) recommend that a FA needs to be based on at least 50 observations. The number of respondents was also above the Rummel (1970) recommendation from 1:4 items to response rate.

The EFA used an extraction by principal components as the method of Varimax orthogonal rotation. The number of groups was determined by considering an eigenvalue greater than 1.0 (Field, 2005), a fact that resulted in defining three groups. The Kaiser-Meyer-Olkin (KMO) test indicated the degree of susceptibility or adjustment of the data to the EFA and the result of 0.778 indicated that the data were suitable (Hair et al., 1998). The study proceeded with internal consistence reliability within the categories using Cronbach's Alpha (Cronbach, 1951). The Alpha´s values were 0.784, 0.723 and 0.816, respectively, indicating a satisfactory grouping of the questions. Values greater than 0.6 indicates an adequate inter-item reliability and is used to validate newly developed scales (Nunnally, 1978).

Mini case study

Case study selection and Data collection

The case study was conducted in a first tier global automotive supplier (Company ABC), which was chosen for the following reasons: (a) it is a Toyota supplier, which is recognized for making efforts to implement its production philosophy throughout its supply chain; (b) it has maintained a structure dedicated to implement LP since 2004; (c) it has corporate guidelines to apply LP in all its plants all over the world. ABC has two plants in Brazil and the plant visited had about 700 employees at the time of the study. The manufacturing processes involve forging, machining and assembling.

The data sources used in the case study were semi-structured interviews, observations made on visits to the factory, official documents (e.g. power point presentations of the continuous improvement activities) and the development of three Value Stream Maps (VSM). The first VSM was done during a workshop for the company's employees in 2009 (coordinated by one of the authors) and the other two were Master degree courses from the author's institution that were held in the plant in 2011 and 2012. During those activities, the data necessary to the use of those tools was collected. The interviewees were chosen by taking in consideration different perspectives of the people involved in the LP implementation. Thus, respondents were a process analyst, whose position in the company was called lean specialist, a production supervisor and a plant manager. Each interview lasted for about two hours. The interviews were conducted with the support of a script with twenty-two questions, divided into two groups: (a) the process of implementing LP (e.g. planning, who were involved, the duration and practices applied); (b) the main risks encountered, how they were managed and whether the respondents had already anticipated the risks before they appeared. The multiple sources of evidences permitted a data triangulation, suggested for stronger the evidences of the results in case-based research (Eisenhart, 1989). The plant observations were made in a walk through the shop floor accompanied by one of the interviewees, when there was the opportunity to illustrate the use of LP practices and principles.

Lean implementation process

ABC's formal LP initiative started in 2004, motivated by the need to reduce costs and improve quality. Regarding quality, a recurring problem was the omission of some steps in the manufacturing process, which generally was only identified in the inspections at the end of the value stream. The functional layout, hitherto existing, contributed to these omissions due to the confusing flow, which induced wrong routings.

Thus, for two years, organizational changes were made and also in the shop-floor layout, with a view to creating manufacturing cells, which are widely recognized as having goals compatible with the lean principle of continuous flow (Saurn et al., 2011). According to the respondents, the team involved in these changes did not have adequate technical support or training, which greatly hindered progress. As a result, those involved confused implementing manufacturing cells with implementing LP throughout the company's business.

In 2006, with the change in the board of directors in Brazil, the support of top management became more assertive. For example, a group of 20 people was trained in some LP practices and some of these people were assigned to implementing them. VSM, quick setups, preventive maintenance, standardized work and poka-yokes are examples of practices applied. In this phase, some of the difficulties encountered were resistance from operators and supervisors to new duties created by LP practices as well as the emphasis on short-term indicators such as payback and ROI of each kaizen event. This emphasis resulted from top management lack of understanding of the LP system, in addition to the company simultaneously using other methods for improvements, such as Six sigma. These methods prioritized actions by their direct financial return, and used complex statistical techniques, thus making it difficult for everyone to understand why certain changes were implemented and others not, in addition to which they hardly ever resulted in operational changes.

A former Toyota executive took up a top management position at the corporate level in 2008 and in the following year, LP acquired greater velocity. This executive coordinated the development of a production system, standardized and defined by the head office, which caused the application of LP practices in the manufacturing and administrative areas to become mandatory. Supervisors and production managers themselves become responsible for implementing and sustaining LP practices and no longer the engineering area, as it had been between 2004 and 2006, or the continuous improvement area, as had been between 2006 and 2008. This change in responsibility was important because of the fact that, previously, implementing LP was seen by supervisors and production managers as a project of the support and engineering areas, i.e. they were tasks that were outside their routine and daily obligations. According to one interviewee, who worked as a process analyst during this period, for most production supervisors, "the lean system was something else to do besides my day-to-day work and not the way to carry out day-to-day activities". When the responsibility for applying LP practices was transferred to supervisors and production managers, these tasks became part of the daily routine of these people. At this stage, great advances were identified in using LP practices, a fact linked to this production system having been formulated and applied at the behest of top management.

Results

Characterization of the sample

The majority of the respondents are analysts and assistants and lower management, such as supervisors and coordinators. Almost 90% of the respondents had direct involvement in implementing LP practices and the respondent's average of experience in LP was 2.8 years.

There were mostly large companies on the sample, what made it irrelevant to test statistical difference regarding company size. As to the production sectors, the sample demonstrates to be scattered over different sectors. The larger group was the auto parts industry with 26%. In fact, the term LP itself originates from studies conducted on the automotive supply chain and it is spreading occurred not only because of studies undertaken at Toyota, but also in other automakers. The average age of a formal LP implementation process in the company was 3 years.

Classification of risks in groups

Table 1 presents the groups resulting from EFA undertaken with Varimax rotation. The results of multiplying the impact and likelihood of each risk were used as the basis for EFA.

*Table 1: Aggregation of the risks when implementing LP**

Risks \ Group (Cronbach's Alpha)	Average	G 1 Process Management (0.784)	G 2 Managerial support (0.816)	G 3 Shop floor involvement (0.723)
R1	3.44	**.604**	.064	.378
R4	3.09	**.719**	.044	.269
R5	3.66	**.624**	.154	-.093
R12	3.19	**.557**	.285	.362
R13	3.89	**.518**	.348	.110
R14	3.35	**.546**	.205	.390
R3	3.30	-.082	**.725**	.396
R6	3.31	.384	**.803**	.022
R7	3.16	.294	**.848**	.167
R8	3.31	.318	.093	**.668**
R9	3.17	.100	.241	**.669**
R10	2.30	-.139	.247	**.728**
R11	3.01	.393	-.111	**.713**
R2 (Excluded)	3.50	.400	.287	.364

Risks R2 was the factor that had the loading value less than 0.5 and also similar relation with two factors. The sample size was not enough to proceed with a Confirmatory Factor Analysis to validate the aggregation and also decide with the inclusion or exclusion of the R2. So, the validations proceeded with the Crombach's Alfa for each factor and the R2 was excluded from the list. The groups' were named based on the nature of its components. In this case, the hierarchical level at which the risks manifest themselves seemed to be the element that distinguished one group from another. The index given in the second column was the result of the square root of the multiplication between the probability and the impact of each risk individually.

Discussions

Risks associated with Process Management (G1)

This group was formed by risks associated with managing the LP implementation process project and presented the highest average index (3,46). The responsibility of planning, execution and sustaining the LP implementation activities are not clear on the literature and some authors prefer to identify as the change agents (e.g. Herron and Hicks 2008). On the case study, those activities were relied to the support areas (e.g. the lean or continuous improvement department) and after 2009 to the production supervisors themselves. The support areas surely play an essential role in training everyone in LP practices (Motwani, 2003), so they need to have technical (Emiliani and Stec, 2005) and managerial competences (Mathaisel, 2005). Although, the active participation of the production managers are also essential of the LP practices implementation (Liker, 2004).

The R13 (not sustaining improvements in the medium and long term) had the highest index (3.89) among the 14 risks. Although hardly mentioned in the academic literature (one example is in the study of Turesky and Connell, 2010), this risk is commonly stressed in practical books (Mann, 2005; Liker and Houseus, 2008). R13 is manifested, of course, some years after the implementation process have initiated and literature shows a greater focus on the early stages of LP (Black, 2007; Pierce and Rich, 2009). The characteristics of the companies surveyed may explain the importance attributed to R13, since the average length of the formal LP processes was 3 years, long enough for the companies to become aware of the difficulty of maintaining the gains obtained in the early stages of implementation.

It is worth noting the presence of R12 (the top and middle management not having sufficient knowledge to guide the lean implementation process) in a category called process management, rather than the managerial support. A possible interpretation of this classification is that R12, in a practical sense, is that this risk features an operational level of the implementation process. It becomes responsibility of the people guiding the implementation process to train all level on the lean principles and practices. The G2 is formed with more strategic aspects of the LP implementation, such as, supporting and guaranteeing the availability of resources of the transformations occur. Table 3 shows that the loading factor of this risk for G1 (0.557) was greater than twice the loading factor for G2 (0.285).

There were some relations in G1 that could be identified on the empirical study. For example, the evidence of presence of R12, especially between 2004 and 2006. Director's and manager's lack of knowledge had led to unclear and vague objectives regarding performance indicators related to LP as well as it was not clear what principles and practices should be used. In addition, managers were unable to identify the technical and management training needs of the staff in charge of LP. Due to this absence of goals to guide the process (role of top management), those in charge (members of the support areas) felt insecure in carrying out the necessary improvements or in applying LP practices. Since 2006, investment in training the support areas and supervisors, although this has had little impact on R12, since managers and directors were not trained in an equivalent manner. Moreover, managers' and directors' lack of knowledge (R12) contributed to the difficulties of seeing the financial returns on the actions taken (R5). As a result of R5, targeting and prioritizing actions emphasized short-term financial indicators, and/ or were linked to mass production, for example, the volume of production and efficiency of equipment.

As a result of this context, on some occasions, middle managers demanded for actions contrary to LP principles. For example, a production supervisor reported that "more than once, management asked for increasing stocks and hiring temporary workers to meet a forecast of future demand (actions that generated wastes from over-production, inventory and transportation), instead of seeking to reduce the setup time, improve stability and productivity". These facts also had an impact on R14 (having difficulties to keep the pace of the ongoing continuous improvement activities), because projects with objectives linked to LP (e.g. increasing productivity, reducing stocks and improving the level of service) were often neglected in favor of other projects aimed at short-term goals.

The R13 was present in the case of ABC, especially between 2004 and 2008. For example, in that period, kaizens events to implement and improve practices like visual management and standardized work were conducted in the same cells over and over again, because workers and supervisors did not manage to maintain those practices. After 2008, this risk was reduced considerably when the company's production system had been standardized. The formal production system clearly defined the lean practices that should be applied in the cells, the performance measures, the role of every hierarchical level on problem solution and audit procedures. The top manager executive that put the system in place personally visited the plants to make sure that the production system was being implement properly. The development and implementation of the standardized production system reduced the effects of the risks on G1.

Risks associated with Managerial support (G2)

This category had an average of 3,25, slightly less than the G1. The support of top and middle management is commonly identified as crucial in implementing LP (Emiliani and Stec, 2005), although these levels generally fail to communicate, support and guide the process (Sim and Rogers, 2008). In the case of ABC, R6 (middle management not giving enough support to the continuous improvement activities) had a strong relationship, especially during 2004 to 2008. The top management indicated interest in implementing LP as a way to gain competitiveness in the market. However, it did not control or aid the process, nor did it link LP to business goals. The board did not charge middle management with getting involved in LP, so they did not need to monitor, prioritize actions or assist in the process.

However, R6 and R7 had no impact on R3 (lack of human resources for continuous improvements) in the ABC Company, because the process was always supported with financial and human resources. The availability of resources can be explained by the fact that ABC is a large multinational company and it is part of the automotive industry, in which there is a natural encouragement to adopt LP. However, the impact of both R6 and R7 on R3 should always be considered as a real possibility, since lack of support from top and middle managers can, for example, restrict investments in training and they may not allocate the time necessary for employees to take part in the process.

Risks associated with Shop floor involvement (G 3)

The risks related to the shop floor support had the lesser average (2,96). R10 (the operators are afraid that there is going to be layoffs because of the manual labor gained by the improvements) had the smallest impact and probability values. The low value of the impact of R10 suggests that most respondents have not experienced the outcome of such risk. This risk has often a high negative impact on the LP implementation and violates the fundamental lean principle of respect to the people (Sim and Rogers, 2008; Emiliani and Stec, 2005).

In the ABC Company, the dismissal of operators (R10) had a strong negative impact on LP and had a direct relationship with other risks. The impact of R10 on R8 (lack of support on the shop floor) was verifiable early in the process, from 2004 to 2006. From the beginning, operators were fearful of the changes that LP would bring in their work and this worsened because of a related event. In 2005, there was a layout change because of a process for creating a manufacturing cell and re-casting jobs. At that time, the area decreased from five to three people due to the reduction in walking times, transport, and fitting into the client's expected rhythm, the takt time. The two people who were surplus were transferred to another sector, from which, about a month later, they were dismissed. After this, R8 became evident because the operators did not want to take part in kaizen events, to discuss day-to-day problems or to suggest improvements. The company acknowledged the error and took a few years to regain the operator's support.

In 2006, with the change of company's board of directors in Brazil, the relationship between R11 (the operators do not feel responsible for using LP practices) and R9 (insecurity of operators in undertaking new duties) was evidenced. Improvements were made by the members of the continuous improvement sector and, at times, changes in procedures and layout were made without the operators participating in or being consulted. The lack of involvement of operators in applying LP practices (e.g. in creating standardized work) led to their not understanding the reason for using these practices and often to not feeling comfortable with the changes generated. These two risks, R9 and R11, besides being related to each other, also caused an impact on R8, because the operators' lack of knowledge, training and involvement in applying LP practices had an even more adverse effect on their support.

In fact, during the period from 2006 to 2008, the operators did not incorporate LP into their routine and sometimes only regarded LP practices as bureaucratic procedures. For example, at times, there was no concern about completing the production analysis board (see Narusawa and Shook, 2009, p. 110) and thus the main problems were not being correctly measured and recorded as evidence. The solutions ended up having a great chance of not being effective or not being maintained due to the lack of information for prioritizing them and the lack of the operators' involvement, these are essential aspects for continuous improvement (Liker, 2004).

The proposed model

Each category suggests one major area of concern when implementing LP. The first one, the process management category, had the higher average score on the survey and also the higher number of risks. On the case study, this category had an important negative influence on the LP implementation. Thus, there were evidences that the success of the implementation process depends upon a series of responsibilities to assure the low (or none) impact of those risks. Those responsibilities could be summarized as planning, communication, linking to financial performance measures, employees training, follow-up of the improvements plan and sustaining the improvements in a long term. As such, as the knowledge of LP evolved, it became essential to understand the effects of strategy that are used to implement (e.g. how the tools/practices are going to be implemented) rather than the set of tools/practices that needs to be applied. This second one seems to be already extensively studied in the literature. Thus, the risk management approach has demonstrated potential to improve the understanding of the risks that emerges from the implementation process.

The literature had already pointed out the managerial support and the shop floor involvement as important roles of LP implementation. Although, this research presents some additional findings that must be highlighted. The results showed evidences that the top and middle management, although highly correlated, represent two different features of the same category. In other words, this indicates what previous researches on management support fail to achieve (e.g. Boyer, 1996), that there is more than one level of managerial support and the top and middle management can be in misalignment with each other. It is also responsibility of the managerial support to guarantee the availability of financial and human resources to carry on the improvement activities.

The shop floor involvement is also critical to the LP implementation, but needs to be understood in its broader sense. The results suggested that it is not simple condition that represent if the shop floor to be supportive or not to the implementation. This category embraces some risks that could be direct related to how the company involves the shop floor in the implementation. For example, the category suggests that the involvement requires: a job security guarantee for the employees; shop floor employees to be trained to perform their tasks according to the LP practices; to give the shop floor the formal responsibilities to perform those new attributions. Than, the shop floor support could be achieved.

Conclusions

This paper had the objective of proposing a model to better explain the risks categories that impact on the LP implementation process and help to understand the relation between those risks. The research method had two distinctive characteristics: (a) the use of three different research strategies (i.e. literature review, case study and survey); (b) the use of the risk management perspective to support data collection and analysis. Concerning the literature review, the risk management perspective made it easier to identify, within a substantial body of knowledge on factors that have an impact on the LP implementation process, which factors could be regarded as risks (i.e. factors that were sources of uncertainty) and which factors should be interpreted simply as constraints, since they were very difficult to be changed, at least in the short-term, within the context of a specific sector (e.g. type of machinery). Thus, fourteen risks were identified based on the literature review.

The survey was conducted to analyze the probability and impact of each risk, based on questionnaires answered by 57 respondents representing 39 companies from Southern Brazil – one of these companies was the same in which the case study was carried out. The results of the questionnaire pointed out that the risks could be classified in three categories, which were referred to as risks associated with process management, managerial support and shop floor involvement. The case study worked into two different ways. First, as an opportunity to gain deeper insights on the risks pointed out by the literature review, in a company that has been formally committed with LP for more than eight years. That provided detailed examples of the fourteen risks. Second, to provide relevant insights about the relationship between risks and the importance of each category on the LP implementation process. The case study proved to be very useful for supporting the analysis of the results of the survey. For example, while the groups of risks detected by the survey indicated that the risks within each group had strong relationships, the survey, by itself, did not provide any insight on the nature of these relationships. The case study acted as a counter-measure for this drawback, since the investigation of the risks in a real context provided real and meaningful examples of interactions among risks. Thus, this possibility may be stressed as strength of the proposed method.

The drawbacks of the method should also be emphasized. Firstly, it does not deal with two major risk management stages: risk response and risk monitoring. Nevertheless, the results of this study establish a background for dealing with these stages. The identification of possible responses to risks should start with a literature review on the major theoretical and practical issues underlying each of the fourteen selected risks. For example, the literature on lean accounting (Maskell and Baggaley, 2004) is likely to be insightful for responding to R5 (difficulties in seeing the financial benefits of the improvement activities). Risk monitoring is probably more straightforward than risk response, since it may start by designing metrics related to each risk. For example, on an individual company level, surveys could be undertaken on a regular basis to identify the extent to which the staff is supporting LP implementation, as well as the extent to which they are satisfied with this process.

Secondly, the prioritization of risks obtained from the survey may not be consistent with the real priorities in a specific company. Indeed, depending on the unique characteristics of LP implementation in each company, prioritization may be different than the one obtained in this study. Thus, the highest priority obtained by the risks related to the process management be interpreted only as a tendency within the sample of companies investigated.

The study also has some limitations due to the nature of the sample used in the survey. The fact that the respondents are mostly from companies located in the South of Brazil suggests that their answers are linked to regional issues, where the spread of LP may have come under local influences. In addition, it is worth pointing out that, as with any risk management process, it is impossible to identify all risks. Another limitation is that the research focuses only in internal risks, as not considering the consequences of external ones that could also have a negative influence in LP implementation.

The results of this pioneering research in using concepts of risk management on implementing LP open up room for future research merging the two themes. As regarding the proposed model, this research was devoted to theory building of finding causal relationships among variables and proposing how and why the variables should be related (Malhotra and Grover, 1998). The next step on the development of the proposed model is to subject it to theory testing and provide empirical evidences of the existing relations. In a particular, there is also a need to in-depth knowledge on the role of each of the categories on the LP implementation. Based on a clear definition of the role of the hierarchical levels in the LP implementation process, the tacit skills and knowledge of each one could be investigated and, thereafter, the methods of training and development investigated that are related to such skills. Another opportunity for future studies is the development of methods for managing risks when implementing LP, which take into account all risk management stages. Of course, such methods should be integrated with broader methods for implementing LP in the whole business.

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