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Abstract: Lean Production has been documented in the last decades as a management methodology that brings many benefits. Nevertheless, many companies faced difficulties in implementing it and in having success. This happens due to the existence of some barriers to its implementation. This fact also occurs in the multinational company studied in this paper. Applying a case study methodology, research on the potential barriers for Lean and pull system implementation in a company that adopted Lean around two decades ago was made. To collect data for the case study, 17 interviews at different hierarchical levels in the organization were performed. The results of interviews analysis show that Lean and pull requires an integrated implementation of several dimensions.

Keywords: Lean Production, Pull System, Lean implementation, Barriers.

1. Introduction

The Toyota Production System (TPS) is supported by two main technical pillars: Just-In-Time (JIT) and Jidoka [1]. JIT production allowed to achieve the Japanese market requirements such as high variety and low volumes [1]. TPS has an effective process to assure quantity, quality and also respect for humanity, by simultaneously increasing customer satisfaction and productivity, and reducing costs by eliminating wastes [1]. Due to the system's successful results several companies have implemented Lean tools. However, despite having several advantages and well-known results [2,3], Lean Production remains difficult to fully implement [4-6]. This difficulty was felt by the company on the case study presented.

This paper presents the analyses of the interviews results undertaken in the case study research conducted in a multinational supplier company of an automotive industry. The research has been developed to understand the barriers faced by pull implementation as the production control system. Since the company has been implementing Lean Production for approximately two decades, and adopting principles aligned with it and tools to operationalize them, it is important to identify the barriers for pull system failures which have consequences for the production control performance and for product delivery. This demanded a research approach that adopted an integrated perspective of the difficulties concerning Lean Production and pull system implementation, as these difficulties could have unknown root causes, or could be not perceived as having consequences for the implementation of the system, or could be far away from the point where they were felt. Many authors [7-9] have been developing research related to barriers and critical factors referring to Lean implementation as a whole. But some issues related to the pull system are still not satisfactorily addressed. For instance, should a company

that implements Lean implement the pull system too? For a specific company, even if it is implementing Lean, is pull the most appropriate production control system? The implications of these connections and related difficulties are still not clearly stated on the literature. This research addresses these gaps, and its novelty stems from the understanding of the main barriers determining the successful implementation of the pull system in a Lean environment. The case study methodology that was adopted allows to have a deep and integrated perspective of the current situation and to achieve that understanding.

This paper is organized in five main sections: first one is the introduction, the next one outlines a brief literature review about the barriers of Lean and Pull implementation. In the third section, the research methodology is presented. In the fourth, the interview results are presented and discussed. The fifth section presents the main conclusions and the last statements of this paper.

2. Lean and Pull system implementation barriers

Kim [10] stated that JIT has the purpose to produce or stock "only the necessary items in necessary quantities at the necessary time". Due to that, JIT is a Pull system in relation to material and information flow [11]. Pull production is one of the most important pillars of TPS and it is the base for JIT production [1]. In the interpretation of TPS, Womack and Jones [12] considered it as the fourth principle according to the Lean Thinking principles.

In general, pull production means: the upstream process only produces when the downstream process requires. The production is triggered taking into account the customer demand and the signal to produce is given by the downstream to the upstream process. Production quantity covers the replenishment stock between processes [13]. It also means that pull systems is a method to control the workload in the systems [14]. Sundar et al. [16] refer that the success of pull is related to the small batches approaching one piece flow, following the takt time to respect customer demand, using kanban to signal the replenishment and level the products in quantity and time.

This technical description of pull system explains fourth Lean Thinking principle. To start production, companies must know what the value means for the client, i.e, the value is what he/she is willing to pay for (the first principle). The second principle is the "Value Stream" referring all value-added and non-value-added activities to produce the product. The third principle is to create "Flow", i.e. eliminating all non-value -added activities that provoke bottlenecks and Work In Process (WIP), in order to deliver the required products as quickly as possible (fourth principle), and finally looking for perfection by continuous improvement [12]. These interlinked and apparently simple principles demand a company focused in value streams, with all stakeholders aligned to the same purpose: satisfying the client. But companies have to deal with many customers. This generally means people management in a functional and hierarchical organization, each functioning in their own silo which diversifies efforts [16]. Among other reasons, this is frequently pointed out as a barrier to Lean successful implementation and, consequently, to pull production.

Important factors such as management commitment and leaders actively supporting continuous improvement, the creation of a Lean culture inside the organization that might require an organizational change management, knowledge and training, the correct application of Lean tools, the employees involvement on the Lean culture are some facilitators and successful factors for Lean implementation [7-9,17,18]. Attending to the research perspective, these factors were organized in five categories described in the following sections: (1) Leadership and management commitment, (2) Training and continuous improvement, (3) Organizational culture, (4) People involvement, (5) Technical knowledge.

2.1. Leadership and management commitment

Leadership is commonly referred as an important and crucial factor driving a Lean implementation process. According to Achanga et al. [9] there are critical factors on the success of Lean implementation such as leadership. So, the management level involvement on continuous improvement activities should start by a clear strategy definition [9,18]. There is a consensus in other research studies about management commitment and involvement that is fundamental to implement and maintain continuous improvement [7,17]. For a successful implementation, company administrators must believe in Lean

fundamentals and support teams on the implementation [6,8,9,19,20].

2.2. Training and continuous improvement

Cowger [19] mentions that Lean is a philosophy of continuous improvement, it does not stop in any point of time. Lean is about creating a continuous improvement mind-set, people-focused leaders and increase Lean knowledge [20]. Talking about continuous improvement is about process improvements focus on workers involvement, from the shop floor to management levels [17]. Companies should look for contradictions as a way of growing and never being satisfied with *status quo* because this mind-set fosters continuous improvement and creativity. As such, developing problem solving methods is needed in order that employees look for contradictions as a challenge and deal with them systematically. For that, the correct application of Lean tools and methods is fundamental. Different research states the importance of knowledge and training to lead and perform Lean activities. Education and training works as a Lean enabler to select the right tools and practices and also to make decisions [6-8]. Such training and knowledge is also important at management level to support and manage Lean initiatives [8,9].

2.3. Organizational culture

Some studies [8,9,21] refer that organizational culture is a determinant factor and it is also mentioned as a failure cause of Lean implementation. A change management will be needed for Lean implementation and that means resources availability, get workers involved and having people with enough empowerment to implement and sustain the implementation [8]. This is in line with Yadav et al. [22] research that mentions Lean implementation as a transformational process that involves organizational culture changes from a social-technical systems perspective.

Related to organizational structure, Womack & Jones [23] argue that a functional organizational structure may create some misalignment between function goals and organizational goals. Value adding activities require a new organizational model: *Lean Enterprise*, which means a group's mission is to work on value adding creation inside of a value stream [23]. Mascitelli [24] presents *Value-Stream Organization* as an alternative to fully project-based and purely functional organizations. It is important having a person dedicated to continuous improvement who coordinates and leads the activities, manages required resources and has a role of coaching to support teams [7].

2.4. People involvement

Concerning people involvement, there are some factors such as knowledge, involvement of workers and availability for continuous improvement that influence a successful implementation.

According to Lodgaard *et al.* [8], clear roles and responsibilities in a lean implementation process should be defined, otherwise it becomes a barrier. Authors also reported that many workers thought that "lean was not part of their job" [8] because that kind of tasks are commonly seen as extra effort. Workers must be involved in the process, so they feel as being part of the implementation process and thus contribute with their ideas. Lack of motivation is also mentioned as a barrier in other studies because involvement of workers on continuous improvement is a key factor for its sustainability [7,8].

Furthermore, employees should have freedom to contradict ideas, give their opinions and managers should listen them actively in an open environment [25]. In this process it should be included several types of improvements that encourage workers and motivate them to participate in continuous improvements, and also big improvements that are visible into financial indicators [7,18].

2.5. Technical Knowledge

Garcia-Sabater & Marin-Garcia [7] referred that to get the maximum potential of Lean production it requires application of continuous improvement tools, not only Lean tools application and some managers confuse that. For instance, related to waste elimination, Liker [26] refers that it is not possible to eliminate waste (Mura) on the manufacturing system without working in other elements such as: *Muri* (machines and equipment overburden) and *Mura* (unevenness). Lack of understanding that tools, practices and the need to implement them as whole leads some practitioners to say that Lean does not

work [26]. According to Takeuchi et al. [25] it is not possible to copy any practice directly from one company to another. Each company should find a way to create its own culture and adapt the practices. So, human and organizational aspects should be also included and emphasized when spreading Lean principles and they should not be isolated from the other Lean tools and practices [8,27]. Nonaka [28] mention that tacit knowledge is very important and personal. Teams may learn from each other, using its own knowledge and sharing its experience. The author refers redundancy as an important element to create knowledge because it promotes discussion between members [28]. Knowledge can be also accessed by using a benchmark approach, for instance, and also external consultants or internal resources in cases of high maturity companies [27].

3. Research methodology

The purpose of this research is to understand and analyse the barriers to Lean and pull implementation in a specific company. This research has some characteristics of an exploratory study, but it has also explanatory characteristics, since some causal relationship between variables are considered.

The research presented in this paper draws upon the findings of a case study conducted in collaboration with a multinational supplier company of automotive industry (first tier) that implemented Lean principles for several years. The company has about 3500 employees and produces mainly multimedia products. In order to increase data reliability, a protocol was developed. Several field procedures were used in the case study but this paper focus on the data collected through interviews.

Semi-structured interviews were conducted with 17 employees from different hierarchical levels, ranging from operational employees to mid-level and top-level managers. The researcher performed the interviews during eight weeks in the company facilities. Each interview took on average one and half hours and were audio-recorded. The research data was analysed to identify the main barriers to Pull implementation, the main reasons of continuous improvement process failures, as well as the impact of the organizational structure and employees' involvement on the process. The interviews were transcribed and analysed using qualitative analysis procedures with support of webQDA software.

4. Results and discussion

The interviews analysis indicated some barriers that hinder the implementation of Lean principles and the Pull system. In the next sections all findings related to Lean, continuous improvement process and pull implementation barriers are presented in detail. Barriers were rated by relevance level in each topic.

4.1. Lean Production

Concerning difficulties and challenges of Lean production implementation, results were categorized into leadership, people, organizational, technical issues and project creation (table 1). Table 1 also shows a value obtained from the most mentioned difficulties (the highest values) by the interviewees to the less mentioned ones (the lowest values), denominated as the Relevance Index (RI).

Table 1. Main difficulties and RI of Lean Production implementation per category.

Leadership	RI	People	RI	Organizational	RI	Technical Issues	RI	Project Creation	RI
Strategy definition	7	Understand the lean meaning	4	Missing culture	6	Instable processes	2	Continuous improvement projects creation	1
		Missing knowledge	2	Departmental structure	5			Missing cause-effect relation	1
				Theory *vs* real	3				

On the leadership category, strategy definition was the main and most relevant difficulty referred. The main problem was the absence of a clear and defined strategy which can then be followed by every department. Forty-one percent of the interviewees in this study said there was no clear strategy defined by the top management, one of the critical success factors [9]. Each department tries to achieve its own objectives independently of a global company strategy.

One of the difficulties pointed out was related with Lean production definition and its real meaning.

In fact, some authors [19,20] mentioned there is no clear and concise definition of Lean and that might lead to a lack of communication and to different goals because of misunderstanding among practitioners. Additionally, on the people category, it was mentioned that there was a lack of knowledge about Lean. Existent research shows the importance of knowledge of managers and practitioners on successful lean implementation [8,9,27].

Many interviewees referred that they miss a Lean culture. According to the literature, everyone in the company should live that culture and improve continuously. However, only some of interviewees acknowledge that understanding and try to push these topics. As Dorval et al. [29] and Schonberger [20] mentioned, Lean culture "remains very superficial" on the literature review and there is still some ambiguity. Also related with organizational aspects is the departmental structure as a barrier to implement Lean. Each department works individually without an integrated perspective and due to that some tools and procedures become difficult to implement. Sometimes these departments are working for contradictory goals and the difficulty increases. Another difficulty is related with difficulty of implementing theoretical concepts on the company conditions. Companies should adapt tools and methods to their specific circumstances [25], otherwise, it may result in process dysfunctionalities.

It was also mentioned as a difficulty of Lean implementation, the processes and equipment instability that impacts negatively on production control. There are some difficulties on the development and implementation of continuous improvement projects. Furthermore, cause-effect relations in project creation are not clear because sometimes results do not bring benefits or, at least, the expected ones.

4.2. Continuous improvement process

Reasons for continuous improvement projects having a lower level of implementation, according to the interviewees' answers, are presented in table 2. They are organized in four categories: leadership, people, organizational and project creation. For each reason, the Relevance Index RI, as defined previously, is presented.

Table 2. Main reasons and RI for continuous improvement process fail per category.

Leadership	RI	People	RI	Organizational	RI	Project Creation	RI
Missing project tracking	3	People do not have time/ are not allocated	6	Missing planning Strategies	2	Project creation without criteria	6
Missing focus	2	Resources are not enough	4	Missing resources management per Value Stream	1	Many projects	5
Missing time for coaching	2	The way how project is assigned to owner	4	Dependency between departments	1		

On the leadership category it was mentioned that there are gaps in project tracking, monitoring and team support from managers' side. In this was included missing focus from managers on the project conclusion. Another reason was the missing time for project team coaching in order to support and motivate them to understand project scope and conclude it with success. Managers commitment for continuous improvement is a fundamental process enabler [7,17].

People allocated to the projects do not have enough availability to develop it because their workload does not include that kind of projects. That reason was the most relevant one. Another problem is related with criteria of project assignment to the project owner because, sometimes, people involved are not the right one. Continuous improvement activities should be part of workers' roles and they should have know-how to develop these kind of tasks [7,8] but, due to those failures in know-how, people do not understand very well the project purpose and, consequently, people demotivate. Another reason is also connected with the previous one, the resources with knowledge are not enough to develop such projects.

On the organizational category, three main reasons were pointed out, including lack of planning strategies, which means that there is a tendency to spend less time on the planning phase than on execution, and it should be the opposite. The planning strategies also include project team selection and resources management. The second organizational problem was the lack of resources management,

because value stream managers responsible for continuous improvement projects do not have authority to manage resources working on their projects due to their hierarchical position and company functional structure. A third problem mentioned by the interviewees was the dependency between departments when a project depends on different ones. It is more difficult to conclude projects whose project team belongs to different departments because it has different objectives.

Interviewees mentioned that some continuous improvement projects were created without robust criteria because objectives and improvement indicators were not well defined, so there is a lack of cause effect relation as already mentioned in the section 4.1. This reason was one of the most cited reason for continuous improvement process failure. Another reason pointed out was related to the amount of projects that were created and the capacity to develop them all.

4.3. Pull system implementation

One of the main interview subjects was related with production control system focus on pull principle implementation. Pull systems implementation has been one of the company objectives in the last years. However, the company has been facing some difficulties in this process, and the main ones are reported in table 3 followed by the respective Relevance Index RI.

Table 3. Main difficulties and RI of Pull System implementation per category.

Leadership	RI	People	RI	Organizational	RI	Technical Issues	RI	External factors	RI
Different strategies	6	Missing knowledge	10	Departmental structure	2	IT tools	9	Customer fluctuations	7
Missing alignment between departments	5	Missing enough knowledge to understand benefits	3	Production lines must not stop	2	Line layouts/ flows	8		
				Change paradigm	1	Process complexity	4		

On leadership, it was mentioned again problems related with strategy. Different strategies are reflected in lack of alignment between departments, each one is working individually and not for a common goal. So, the existence of different objectives between departments, most of them contradictory, is a very problematic point because pull system involves a team composed of people from different areas. Additionally, it was mentioned that administration involvement and commitment is fundamental for pull implementation.

Concerning people, lack of knowledge to apply the concept was a unanimous and the most relevant reason for the interviewees. People do not understand the real benefits of pull implementation because they have not enough knowledge about it. Since pull system is one Lean principle, this finding was already referred in section 2.2 as a barrier to implement Lean, so it is a common difficulty.

Departmental structure was also mentioned as a barrier for the implementation because it interferes in several departments with different objectives and focus. Pull system implementation depends on an integrated perspective and it cannot be compared with other tools that may be implemented at individual level such as 5S. So, there is a need to change the paradigm related to productivity, planning methods and people mind set. And concerning paradigms, or, at least, the visible and operational parts of the paradigm, there is one present in the company that implies: “production lines must not stop”. With a pull system approach, production lines will only produce the quantity and products needed, and that means machines may even stop. Such an approach is still not well accepted due to equipment cost and operators’ productivity.

Related to technical topics, the system lacks an integrated production control IT tool that supports implementation because, with a huge quantity of product references (more than 1900), it is almost impossible to manage all processes manually. Another barrier is the company physical structure: plant layout is not oriented to the flow, there are many production pools and pre-assemblies that do not favour Lean approach because they create intermediate stocks that are a barrier for one-piece flow. Additionally, many complex and instable processes limit the implementation because they are not

flexible enough to react easily to customer fluctuations, the only external factor found out. Interviewees mentioned some customers have a lot of fluctuations and instable orders, and the company is dependent on the Original Equipment Manufacturer (OEM) orders. So, it becomes difficult to have levelled production plans. Having levelled production plans allows for one-piece flow production, the third Lean principle that is closely related with low work-in-process levels and flexibility [20]. Schonberger [20] presented problems related with the absence of synchronism between upstream processes and high variability of demand that might cause, on the one hand, back orders, and on the other hand, leftovers.

5. Conclusions

Lean Production implementation has many advantages for manufacturing and other sectors. However, it is far from being a straightforward process, and there are many challenges that companies must overtake in order to be successful on their implementation efforts.

This case study undertaken in a multinational company with a relatively strong commitment to Lean demonstrates some weaknesses concerning organizational culture. Many barriers of different dimensions such as leadership, organization, people, technical issues, external factors and continuous improvement projects related were found out. In each category was presented different reasons rated by relevance level. Having a functional structure seems to be a very important barrier for the pull system implementation, because its implementation involves several areas of the organization that must be strongly articulated between themselves. Missing of a clear strategy deployed in different levels of the hierarchy may be the cause of several communication problems and misalignment related to plant strategy. Leadership commitment is one of the most important factors for the implementation and for the Lean culture spreading over the organization. Furthermore, the findings suggest that implementing lean tools individually, one by one, in a piecewise manner, and only looking at the technical point of view, may not be enough to achieve an effective implementation. Additionally, individual and organizational knowledge represents a determinant factor for the successful implementation. In this case study, knowledge gap represents a huge relevance on pull system implementation.

Results are considered indicative and may contribute to new knowledge by pointing out specific issues that can be considered determinant factors in similar situations. Although the findings cannot be generalized, they are in line with literature and additionally, present an integrated perspective of the main implementation barriers of both concepts: Lean and pull. One of the issues that was raised by this research is whether the pull system is an adequate system for all circumstances. As future research, the authors will try to realize under what conditions the pull system is the right planning and production control system that fits customer demands.

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