What Can be Learned from More Than 100 Case Studies of Lean in Services?

DIANA ISABEL PINTO PEREIRA, PAULO S. A. SOUSA, MARIA R. A. MOREIRA
Faculty of Economics,
University of Porto,
R. Dr. Roberto Frias, s/n, 4200-464 - Porto,
PORTUGAL

Abstract:- This research investigates the implementation of lean practices in services in order to identify those that have a greater influence on company performance. Regression analysis with data from a systematic literature review was the basis to study the relationship between lean and performance. For this purpose, a total of 104 case studies were considered. A main finding was that some lean practices, such as "voice of the customer" and "cross-functional teams" have a significant positive influence on performance. Also, the results suggest that the more engaged managers are and the more they invest in training, the better company performance will be. Finally, one may also conclude that knowledge about the determinants of lean management will allow managers to be aware of what is decisive to improve company performance.

Key-Words: - Lean management, Systematic literature review, Regression analysis, Service industry, Case studies

Received: April 8, 2023. Revised: July 13, 2023. Accepted: July 21, 2023. Published: August 4, 2023.

1 Introduction

In today's global economy, companies face increasing pressure to reduce costs and respond rapidly to worldwide competition, [1]. Customers are more demanding [1], and customized products are becoming the big trend of the XXI century, turning mass production into a huge challenge, [2]. From this need to adapt to ever-changing customer demands, lean management has arisen. Originating in Japan and the Toyota Production System, lean is a management philosophy rooted in producing at a minimal cost and the pace of customers' demand, therefore reducing any kind of waste, [2].

Lean management can be successfully implemented in any industry, [3]. However, it cannot be equally applied by all companies, given the differences among industries or even among regions, [4].

Despite being first introduced in manufacturing, lean management is becoming increasingly popular in services, [5]. So, although the use of this philosophy is by now well settled in the manufacturing sector, [6], it is relatively new for service companies, [7].

Nevertheless, the application of this philosophy can be seen in many services such as healthcare, banks and financial institutions, education, call centers, and IT, among others, [7].

As the number of studies analyzing the impact of lean on services is increasing, it becomes relevant to further investigate this topic. Thus, the main purpose of this research is to identify the factors that have a greater influence on the lean performance of service companies.

To achieve this, a systematic literature review of case studies on lean management in the service industry was carried out. The data collected was then used as a basis to study the relationship between lean and performance, by means of a regression model.

We could find several literature reviews and bibliometrics of lean management in specific services, mainly by healthcare companies, [8], [9], [10], [11]. We could also find a meta-review paper analyzing the state of the art on lean management in services, [5], essentially focusing on the applicability of lean principles. So, to our best knowledge, ours is the first study that assesses lean practices by different types of services and does so by converting the identified case studies into observations to go on doing regression analysis. Therefore, it fills the gap in the literature concerning the identification of the elements that explain a higher or lower influence of lean on company performance. Furthermore, we believe this study can be of extreme help to managers operating in the

service industry that want to be aware of what is important or decisive to implement this philosophy.
This paper is organized as follows: next section presents a literature review concerning lean thinking (fundamental concepts, practices, tools and techniques, benefits, implementation issues, and critical success factors), and the research framework; then the methodology used is described and, afterward, the main results, conclusions, and practical and theoretical impacts are discussed.

2 Literature Review

Mass production established at the beginning of the 20th century, allowed consumers to get low prices (costs), but, on the other hand, restricted access to product variety, [12]. However, after the II World War, the context of the Japanese market for automobiles was characterized by scarcity of resources and intense domestic competition, [13]. To survive in this context, Japanese car manufacturers concluded that mass production was no longer a viable option. Hence, in the 1950s, the engineers Taiichi Ohno and Shigeo Shingo developed the Toyota Production System, [2], which later became known as "lean production", a term coined by John Krafcki in 1988, [12]. This denomination was then popularized through the book "The machine that changed the world", where it was introduced as a dynamic process that emphasizes the elimination of waste and continuous improvement combined with employees' empowerment, [12].

Nevertheless, for many, the concept of lean production is not clear, [13], and several authors have tried to better define it (e.g., [14], [15], [16], [17]). Such definitions have different emphases: elimination of waste, value, employee engagement, customers, continuous improvement, increasing quality and efficiency, and lower cost. Even so, they can be understood as complementary, in the sense that, the elimination of waste and continuous improvement can be achieved by identifying value, reducing non-value-adding activities, creating better working conditions, easing flows within supply chains, and engaging all employees, all of which will lead to increased quality and efficiency and to lower costs that, subsequently, will increase both company's and end customer's value.

Hence, the main goals of lean are to eliminate waste, [12], and to increase value for customers, [13]. Moreover, in accordance with [12], lean thinking is guided by five principles: (1) value, (2) value stream, (3) flow, (4) pull, and finally, (5) perfection. Once created and analyzed the value stream, a lean company must identify and eliminate non-value-adding activities, improve flows, produce based on demand-pull systems, and continuously strive for improvements without disregarding the importance of a strong involvement of employees, [18]. From this, one may highlight two main concepts, basic to lean production: waste and value.

[12], claimed that what does not create value is a waste ("muda") and must be eliminated, minimized, or converted into value. Taiichi Ohno (1988) has identified seven categories of waste: i) transportation; ii) inventory; iii) motion; iv) waiting; v) overproduction; vi) processing, and vii) defects, [19].

Although lean was first introduced in manufacturing, it is becoming increasingly popular in services, [5]. Thus, [20], adapted these seven types of waste to services, identifying the following categories: delay, duplication, unnecessary movement, unclear communication, incorrect inventory, opportunity loss, and errors. Furthermore, the authors also supported that it should be added a further type of waste for both manufacturing and services: "not using the mind of employees".

Regarding value, [13], claimed that the perception of value was usually and wrongly seen as a reduction of costs. Instead, the value should be seen from a customer perspective, and, if so, it can be increased either by removing wasteful activities or adding product/service features that customer value. Indeed, customer value can be increased by reducing costs, but also by improving customer satisfaction from, for example, the reduction of waiting times and defects, [21]. Several practices, tools, and techniques are mostly used to optimize processes by eliminating waste, [21].

2.1 Lean Management: Tools and Implementation Issues

The lean strategy's umbrella encompasses plenty of methods that intend to improve the performance of organizations, [22]. Having a set of reliable tools and techniques is crucial to decrease waste and provide value to customers, [23]. However, the implementation of lean is not straightforward for all organizations, as it requires adaptation to the different processes, markets, and supply chain characteristics, which means that, depending on the environment, some practices could be suitable to an organization and some could not, [18].

[24], categorize inter-related practices into four bundles: Just-in-time (JIT), Total Quality Management (TQM), Total Preventive Management (TPM), and Human Resource Management (HRM). JIT is a program whose main purpose is to

continuously reduce all forms of waste, [25]. Therefore, JIT production is based on producing or ordering exactly the quantity that is needed at the moment that is needed, [26]. TPM is designed to maximize equipment effectiveness while the goal of TQM is the continuous improvement as well as the sustainability of products and processes quality, [25]. HRM is viewed as a program that supports all the other three, since, for these programs to succeed, it is crucial to have, for instance, cross-functional training, and employee involvement, [25].

This research follows the following structure to analyze some of the lean tools for each bundle. For JIT we considered the tools: Piece flow, Small-lot production, Standardization of work, Pull system, Cellular production, Line balancing; Heijunka, Kanban, Visual control, and Jidoka; for TQM we included: Value stream mapping (VSM), Kaizen, 5 Whys, Cause and effect diagrams, Pareto analysis, PDCA (Plan-Do-Check-Act), and Supply quality management; for TPM we considered: OEE (Overall Equipment Effectiveness), SMED (Single-Minute Exchange of Die), 5S (Sort, Set in order, Shine, Standardize, Sustain), Preventive maintenance and Breakdown maintenance; finally for HRM we included: Flexible teams, Cross-functional Teams, and Self-directed work teams.

[25], stated that JIT, TQM, and TPM form a comprehensive and consistent set of practices that aim to improve performance through waste reduction and continuous improvement.

Additionally, lean is frequently combined with another approach used to process improvement – Six-Sigma. Six-Sigma is a program centered on the customer that uses problem-solving methodologies and highlights data-based decision-making, [27]. A commonly used problem-solving methodology is DMAIC, which stands for Define, Measure, Analyze, Improve, and Control (De Koning et al., 2008). In the define phase, the SIPOC diagram (Suppliers-Inputs-Processes-Outputs-Customers) and VOC analysis (Voice of Customer) are frequently used to identify all the important elements for process improvement and to make sure that they are in line with customer requirements, [28].

Several benefits of lean implementation, both qualitative and quantitative, have been pointed out by various authors. Quantitative benefits include improvement in production lead time, processing time, cycle time, set-up time, inventory, defects, and equipment effectiveness, while qualitative gains comprehend, among others, improved employee morale, effective communication, standardized housekeeping, and team decision-making, [2].

Reviewing several studies, [29], found that lean benefits can also be found in different types of services. In healthcare, lean helps to reduce waiting time, improved the quality of care, improved productivity and efficiency, capacity expansion without additional facilities, and increased the utilization of operating theatres. In software service companies, lean leads to lower variability in performance, fewer defects, and rework, improved operational performance, and improved quality. In education, lean allows improved quality, the relevance of course materials, reduction in delivery time of knowledge, and delivery of higher value. And finally, in the public sector, delivering a high-quality service that meets customer requirements with efficient resource utilization is one of the benefits of lean, [30].

Notwithstanding providing plenty of benefits, lean implementation is not always effective and sustainable, [2]. Thus, [2], identified some critical issues and categorized them into pre-implementation issues, implementation issues, and post-implementation issues. The first category includes issues such as misconceptions about the objectives of lean management and lack of communication, top management commitment, training, and education programs. One possible implementation issue is the non-effective supplier relationship. And finally, post-implementation issues include, for instance, a lack of proper post-implementation planning: an organization should review the entire process and create opportunities for continuous improvement.

Some factors that are fundamental to a successful implementation of lean were pointed out by, [31]. They constitute the critical success factors of lean: i) Leadership and management commitment: strong leadership would allow a flexible organization structure, as well as knowledge enrichment of the workforce, [31], and will also promote the removal of barriers, [2], ii) Financial capability: lean implementation requires some financial capabilities like, for instance, hiring consultants and training of people; iii) Skills and expertise: it is important that employees are open to the idea of skill enhancement and, in this era of fierce competition, the capability of innovation and differentiation of the employees can also be critical; and iv) Organizational culture: the culture of the organization must be supportive to lean implementation, and communication and employee involvement to achieve improvements are key.

Despite all the above, we should keep in mind that lean is not the best choice for all companies: lean must be compatible with the company's

products, processes, and customers and lean practices should be adapted for each business environment, [1].

2.2 Services: Characteristics and Categorization

According to [32], the service sector contributes to more than 50% of the GPD (Gross Domestic Product) of top economies, becoming thus globally vital [29].

Service is an activity that usually includes interaction with the customer with the purpose of providing a solution to its problem, [29], [33]. Therefore, the service industry is very different from manufacturing given its characteristics: intangibility, heterogeneity, and inseparability, [34]. Other characteristics such as perishability are also associated with services, [37], [29].

Regarding the type of service, [35], developed a service process matrix that highlights two key elements: first, the labor intensity of the service, and second, customer interaction and service customization, [36]. This two-by-two matrix presents four types of services: Service factory, Service shop, mass Services, and Professional Services.

A service factory requires low labor intensity and a low degree of interaction with customers and customization. According to [36], this type of service offers limited variety but has advantages in terms of price, speed, and personal touch. It includes services such as airlines, trucking, hotels, and resorts, [35]. The service shop takes place when the degree of interaction with customers and customization is increased. Unlike service factories, these organizations offer a high variety of services which supports their competitive advantage but makes them somewhat difficult to control, [36]. Examples of service shops are hospitals, auto repair shops, and other repair services, [36]. Mass service businesses are characterized by high labor intensity and low degrees of interaction with customers and customization. Having a limited-service mix, these organizations have a chance to compete in price, [36]. In this category, one can find services such as retail, wholesaling, education, laundry, cleaning, and many routine computer software and data-processing functions, [35]. When the degrees of interaction with customers and customization increase, we are talking about professional services. This kind of service includes doctors, lawyers, accountants, architects, investment bankers, and other organizations which depend on the professional skills of, usually, few individuals, [35], [36].

Nonetheless, there are other proposals to categorize services. For instance, taking into consideration the service process perspective, [37], as well as, [38], have proposed a taxonomy of services: people-processing services – the presence of the customer is essential –, possession-processing services – customers' presence is not necessary since the service is performed on a product from the customer and therefore, its presence is not necessary – and information-processing services – it does not require the presence of the customer at all, [5].

Regarding performance in services, it is important to have in mind three perspectives: the service provider – does the company accomplish its objectives? –, interest groups – does the network meet the shared objectives? – and the customers – does the service meet the customers' expectations? Yet, the principal focus of service must be to provide value to the customer, [39].

According to the study of [39], the first perspective includes measures such as efficiency (e.g.: costs, value-added, equipment utilization rate), quality (e.g.: customer satisfaction), personnel (e.g.: well-being at work), and profitability (e.g.: gross margin). With regard to the network, some examples of measures are the efficiency of cooperation and the success of shared planning. Finally, a service company must always consider the customer's perceived value to measure its performance.

As the purpose of this research is to study the impact of lean on performance, it also makes sense to identify measures that indicate the success of lean. Performance measures include costs (e.g. costs with unnecessary resources, saving for doing it right at the first time), quality (e.g., customer satisfaction, percentage of complaints), flexibility (e.g., number of customized solutions), and productivity (e.g., number of customers served per hour). Also, time-related measures (lead time, processing time, etc.) were found to be quite significant to the evaluation of the usefulness of lean on performance. Finally, as explained in previous sections, the primary goals of lean are to eliminate waste, [12], and, as in services, to increase value for customers, [13]. Therefore, the elimination of waste and customer satisfaction should also be measured to evaluate the performance of the lean implementation.

2.3 Research Framework and 'Theoretical' Model

The main aim of this research is to investigate lean implementation within services. We want to study which lean factors mostly affect performance in service companies. Also, we want to deeper analyze

which practices are more used and which of them have a greater impact.

In this way, in our model, the independent variables are the practices included in each bundle, as from the literature review (JIT, TQM, TPM, and HRM) and the practices related to Six-Sigma; the number of practices used; the type of service; the company size and the degree of management commitment, employee involvement, and training. To study performance, we chose as a dependent variable the number of performance measures that show improvement, but also: the performance measures quality/defects, customer satisfaction, productivity/efficiency, cost savings, elimination of waste, and time. Figure 1, below, depicts our research framework.

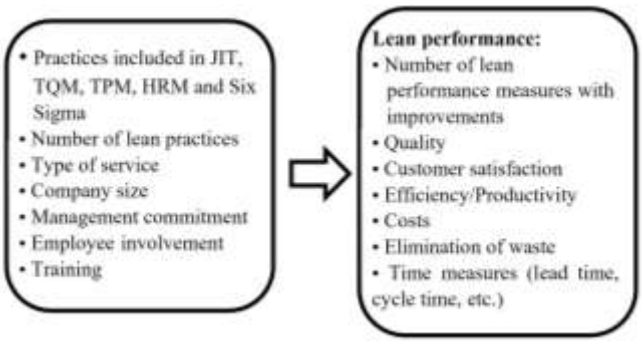

Fig. 1: A research framework

Our 'theoretical' model was designed to identify the factors (their importance and expected signal) that have a greater influence on the lean performance of companies.

From the different theoretical approaches discussed in the previous sections, seven elements may have a greater or lesser impact on companies' performance. Accordingly, those are (1) the Number of practices adopted, (2) Usage of JIT, TQM, TPM, HRM, and Six-Sigma practices, (3) Management commitment, (4) Employee involvement, (5) Training, (6) Type of service and (7) Size of the company.

The number of practices adopted is an exploratory variable; however, as lean is guided by five principles (Womack & Jones, 1996), we expect that all are addressed in order to successfully implement it, and, for that reason, a higher number of practices adopted should drive to a higher impact of lean on performance.

Regarding the use of JIT, TQM, TPM, HRM, and Six-Sigma practices, [25], [26], [27], these bundles have different goals: JIT intends to reduce all forms of waste, TQM is focused on continuous improvement and sustainability, TPM relies on equipment effectiveness, and HRM works as a support for all these three, [25]. Furthermore, Six Sigma is highly related to problem-solving methodologies, [27]. Therefore, it is expected that all the practices included in these bundles contribute to better performance: for instance, the use of value stream mapping through its focus on eliminating waste and efficiency, and kaizen by being cantered in continuous improvement, [26]. The JIT bundle includes several practices: cellular production; kanban, heijunka, visual control, one-piece flow, standardization, line balancing, and pull system. As a fundamental principle in JIT, the elimination of waste will also be considered as its practice. The TQM bundle contains the following practices: value stream mapping, Kaizen, PDCA, Cause and effect diagrams, Pareto analysis, five whys, and some supportive charts such as run chart and control chart. TPM also includes 5S, as the other TPM practices are more related to manufacturing. The HRM bundle includes self-directed work teams and flexible cross-functional teams, and Six Sigma comprises DMAIC, SIPOC, and VOC. The use of Six Sigma will also be considered as a practice.

The third element, management commitment is one of the critical success factors of lean, it is anticipated that the greater the management commitment, the greater the impact on lean performance. Concerning employee involvement, it is expected to have a higher impact on performance when there is stronger employee involvement. Regarding the fifth element, training, we can say that more investment in training should lead to a higher impact on performance. The existing heterogeneity between the different kinds of services makes it difficult to treat them as if they were the same. Finally, the element size of the company: if, on one hand, large companies have financial capabilities that allow them to invest in training programs and innovation, which can be crucial to lean performance, on the other hand, they usually have a more complex structure that does not support flexibility. Thus, the expected signal can be either positive or negative.

This relation depicts the theoretical model:

$$Performance = f\begin{pmatrix}\text{Number of practices adopted;}\\ \text{Use of the practices in i;}\\ \text{Management commitment;}\\ \text{Training}\\ \text{Employee involvement;}\\ \text{Type of service;}\\ \text{Size of company}\end{pmatrix}$$

Being:

Performance: the several performance measures: Number of performance measures that show

improvement, Quality/defects, Customer satisfaction, Productivity/efficiency, Cost savings, Elimination of waste, Time;
i: the bundles' JIT, TQM, TPM, HRM, and Six-Sig.
Figure 2 synthetizes the determinants considered in the theoretical model and their expected impact on lean performance.

Group	Variables	Expected signal
Number of practices adopted	Nr Lean Practices Adopted	*
Use of JIT practices	Cellular Production; *Kanban*; *Heijunka*; Visual Control; One Piece Flow; Elimination Waste; Standardization; Line Balancing; Pull System	+
Use of TQM practices	VSM; *Kaizen*; PDCA; Cause Effect Diagrams; Pareto Analysis; Five Whys; Supportive Charts	+
Use of TPM practices	Five S	+
Use of HRM practices	Self-Directed Work Teams; Flexible Cross Functional Teams	+
Use of Six sigma practices	Six Sigma; DMAIC; SIPOC; VOC	+
Management commitment	Management Commitment_Leadership	+
Training	Training	+
Employee involvement	Culture/Employee Involvement	+
Type of service	Type Of Service	*
Size of company	Company Size	+/-

*Exploratory variable

Fig. 2: Determinants of the theoretical model

3 Materials and Methods

For the systematic literature review, we followed the structure proposed by, [40]: planning, conducting, and reporting. The first phase consisted in identifying the objectives for this review and developing a protocol to decide the inclusion criteria. To be as accurate as possible in addressing the research questions, the inclusion criteria should be decided carefully. Firstly, only case studies must be used as a source of data collection. Therefore, literature reviews and surveys were excluded. Secondly, the articles selected must only analyze the implementation of lean in services as this is the purpose of this study. Finally, the articles to include must analyze the relationship between lean implementation and the performance of the companies. For that reason, studies that do not report performance results after lean implementation were excluded.

The process of selecting articles began with a literature search on the bibliographic database Scopus, B-On, and Web of Knowledge. The search was made with the aim of finding papers that have performed literature review studies about the topic under study: the relationship between lean practices and lean performance, in the case of services. The keywords searched in different fields (abstract, article title, and subject) were "review", "lean", "service", and "literature analysis". This process returned four articles, [5], [29], [7], [41]. The articles that were analyzed by these authors were included in this research as much as possible.

In order to complement the case studies (articles) found in these four literature review papers, another search in Scopus, B-On, and Web of Knowledge was made, using the terms "lean service" and "case study" in a different field (abstract, article title, and subject).

This process is illustrated in Figure 3.

In the final, 80 articles were listed in [5], 122 in [29], more than 70 in [7], and 172 in [41]. Searching the online databases, 426 articles were found. As it was expected, some of these articles were common.

After excluding the articles that were not adequate according to the above-mentioned inclusion criteria, 72 articles were considered suitable for our analysis (Appendix 1). As some of these articles had multiple and statistically independent case studies, a total of 104 case studies were considered for this analysis.

The database containing all the information collected from the 72 studies is available upon request to the authors.

Then, all data regarding the type of service, size of companies, country, number of (and which) lean practices that were adopted, and the results obtained in terms of performance were registered. Moreover, the existence of critical success factors studied in the literature review was also evaluated.

The practices were coded "1" if used and "0" if not used.

The type of service was classified into the following groups: healthcare, hotel industry, housing services, telecommunications, call centers, banking, financial and insurance services, software and IT industries, distribution, logistics and retail industries, education, public sector, and engineering, in line with the division done by Hadid and Mansouri (2014). In the case of companies from the public sector, an effort was made to classify them as thinly as possible, as there are plenty of services provided by the public sector. For instance, local authorities or governments were classified as public administration.

Company size, if the information was available, was divided into large, medium, or small, on the basis of information provided, and/or the number of employees and turnover.

In each case, performance measures and critical success factors (management commitment/

leadership, training/education programs, and organizational culture/employee involvement) were classified on a 1 to 5 Likert Scale. 1 – The performance measure had noticeably worsened/ The critical success factor was quite insufficient; 5 – The performance measure had noticeably improved/ The critical success factor was excellent. Scales 2, 3, and 4 are in the middle: 2 are insufficient; 3 – Indifferent/ Non-significant; 4 – The performance measure had improved/ The critical success factor was good.

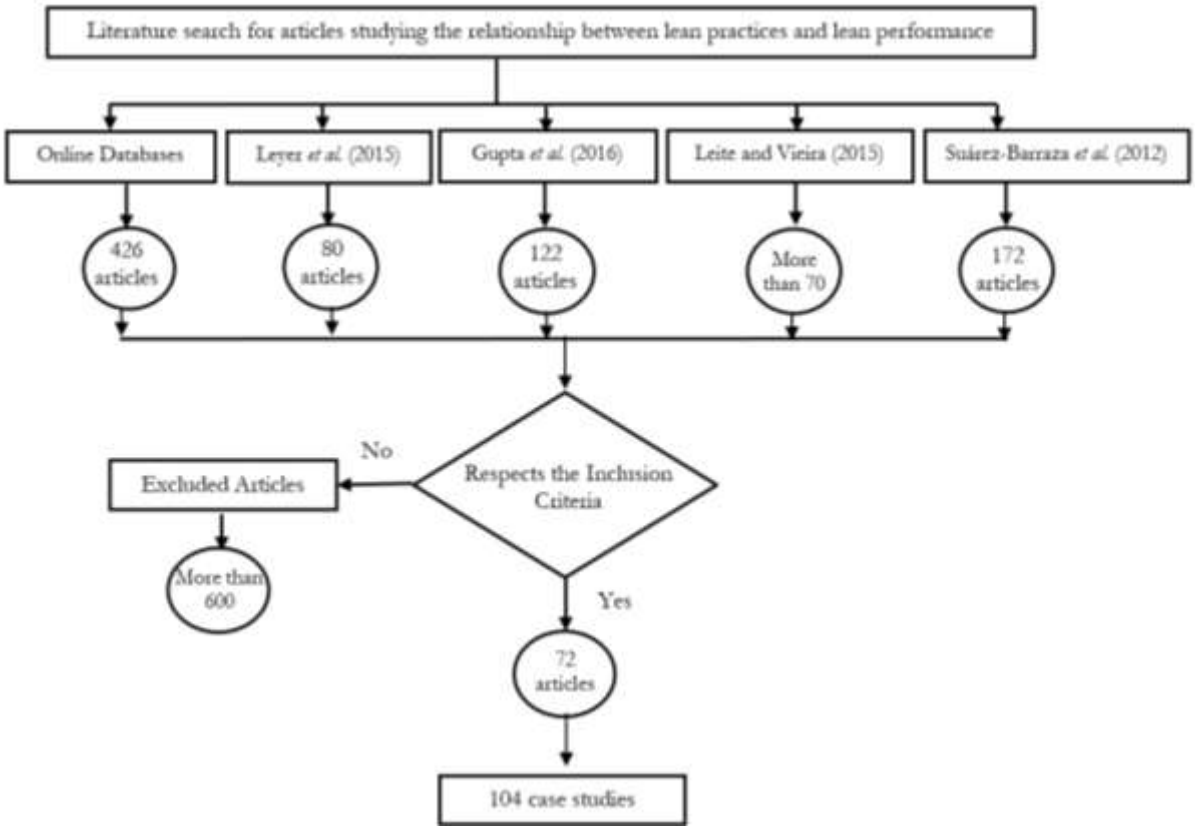

Fig. 3: Process of articles selection

Regarding the final step, the description and analysis of the created database are presented in the next Section. This database was also used to perform a regression analysis, as the case studies were converted into observations.

4 Main Results

4.1 Descriptive Analysis

As highlighted before, it was possible to obtain 104 valid case studies of as many companies, to analyze the implementation of lean management.

The timeframe of the study was divided into the following periods: 2002-2005, 2006-2009, 2010-2013, and 2014-2018. The period 2006-2009 is that comprising more case studies (41), followed by 2010-2013 (34). Regarding company size, big companies stood out: 50 companies out of the 104 studied. It was not possible to determine the size of 22 companies due to a lack of information. The sample includes companies from several countries such as Australia, Canada, China, Denmark, India, Italy, Mexico, Netherlands, Portugal, Scotland, Korea, Sweden, Spain, Thailand, and Taiwan. The two most represented countries are the UK (24% of the total number of firms) and the USA (10%), all of which led us to conclude that lean has been and still is implemented worldwide.

Regarding the type of service, the selected companies are from very different sectors: engineering; education; banking, financial, and insurance; healthcare; hotels, distribution, retail, and logistics; public administration; IT and software; telecommunications, etc. It should be noted that healthcare is the most frequent service we came across, representing approximately 32% of the total number of companies.

Several lean practices were found to be used and/or in use by the selected companies: SMED, Kanban, one-piece flow, cause, and effect diagrams, Pareto analysis, 5 Why's, and pull system. Value stream mapping and kaizen were undoubtedly the most utilized – these two practices were used by 72% of the companies. Nevertheless, standardization, elimination of waste, 5S, cellular production, visual control, line balancing, self-directed work teams, and flexible, cross-functional teams can also be highlighted. Moreover, a significant number of these companies combined lean and six-sigma, using methodologies such as DMAIC, SIPOC, and VOC. Practices such as preventive maintenance and breakdown maintenance were not found to be used as they are more usual in manufacturing.

Disregarding value stream mapping and kaizen, the most used practices were slightly different depending on the type of service. For instance, for healthcare, the most common was the elimination of waste, self-directed work teams, and visual control, while for banking, financial and insurance companies, the most used were standardization and line balancing. Furthermore, call centers invested more in practices such as cellular production, the voice of customers and flexible, cross-functional teams, and, for example, companies related to construction/ engineering focused on the elimination of waste.

In the analyzed case studies, one can find some performance measures: time, productivity /efficiency, quality/defects, revenues/cost savings, and customer satisfaction, for example. In general, lean proved to be helpful in improving performance in the before mentioned aspects, which is consistent with the benefits presented by [29].

Finally, the existence of critical success factors was also analyzed, and the ones mentioned are management commitment, training/educational programs, and organizational culture/employee involvement. Companies lacking these factors showed worse performance than the others. This is in line with [2], which defends that the lack of critical factors puts at risk the effectiveness of lean implementation.

4.2 Correlations between Variables

The correlation matrix showing the most significant correlations between variables is presented in Figure 4. The dependent variable is the number of performance measures classified with 4 or 5 (Nperf>4). We also analyzed, as dependent variables, the following performance measures: Time, Elimination of waste, Productivity/efficiency, Quality/defects, Costs savings, and Customer satisfaction.

It should be highlighted that Pareto analysis, the voice of the customer, cross-functional teams, and training, have a significant and positive correlation with at least 4 of the lean performance measures.

Moreover, the voice of the customer was revealed to be the practice with more positive, significant, and strong correlations (rho>0,3) at a level of significance of 1%: the number of lean performance measures that were improved (performance measures classified with 4 or 5), quality and customer satisfaction. Increasing value for the customers is one of the main goals of lean management (Hines et al., 2004); therefore the use of the voice of the customer becomes essential to ensure that all elements are in line with its requirements (Antony et al., 2012).

On the other hand, 5 Whys, 5S, kaizen, heijunka, visual control, standardization, and employee involvement do not have a significant correlation with any lean performance measure.

With regard to performance measures, cost savings is the one that is significantly and strongly correlated with more lean practices.

Going deeper into the analysis, one can confirm a significant correlation between the first dependent variable – the number of improved performance measures – and 10 variables. Four of them with a level of significance of 1% - number of practices adopted, the voice of the customer, Pareto analysis and flexible, cross-functional teams, and six with a level of significance of 5% - VSM, PDCA, supportive charts, cellular production, DMAIC, and Training. From there, the variables with a stronger correlation with performance (rho>0,3) are the number of lean practices adopted, the voice of customers, and cross-functional teams. According to this bivariate analysis perspective, companies that use these practices tend to have better performance. The same happens in companies that invest in training and use as many lean practices as possible. The number of adopted practices turned out to be important since lean is guided by five principles, [12] and it can be inferred that it requires different practices to address each of these principles. However, the use of PDCA (with a negative sign),

does not grant the same benefits. The variable time has a significant correlation with 1 variable at a level of significance of 1% - cellular production, and 2 variables at a level of significance of 5% – line balancing and flexible, cross-functional teams – which means that the use of these practices is associated to a better time performance.

The variable elimination of waste has a positive and significant correlation with the elimination of waste (practice) at a level of significance of 1% and with cellular production and cross-functional teams at a level of significance of 5%. Therefore, the use of these practices and the investment in training tend to lead to higher performance concerning the elimination of waste.

Regarding productivity and efficiency, there are 2 variables with a significant correlation at a level of significance of 5% - PDCA and line balancing –, and 2 at a level of 1% - pull system and flexible, cross-functional teams. With a positive sign, line balancing, pull system, and flexibility, cross-functional teams tend to contribute to better productivity and efficiency, while PDCA does not seem to have the same benefit.

Concerning quality, the voice of the customer, training, and the number of lean practices adopted have a significant correlation with it, at a level of significance of 1%, and VSM, one-piece flow, flexible, cross-functional teams, and management commitment at a level of 5%. Hence, the use of these practices, the existence of management commitment, and investment in training lead to higher quality; the very same happens if companies use as many practices as possible.

	Nperf>4	Time	Elimination of waste	Productivity	Quality	Costs savings	Customer satisfaction
Nr of lean practices adopted	0,376** (0,000)	0,068 (0,494)	0,102 (0,301)	0,157 (0,112)	0,275** (0,005)	0,289** (0,003)	0,159 (0,107)
VSM	0,197* (0,045)	-0,019 (0,844)	-0,071 (0,474)	-0,053 (0,592)	0,207* (0,035)	0,261** (0,007)	0,103 (0,297)
PDCA	-0,214* (0,029)	-0,071 (0,471)	-0,114 (0,248)	-0,212* (0,031)	-0,045 (0,651)	-0,149 (0,131)	0,109 (0,272)
Cause and effect diagrams	0,177 (0,072)	0,040 (0,690)	0,111 (0,261)	0,006 (0,953)	0,039 (0,693)	0,325** (0,001)	0,047 (0,633)
Pareto analysis	0,260** (0,008)	0,118 (0,235)	0,011 (0,912)	0,191 (0,052)	0,172 (0,081)	0,256** (0,009)	0,017 (0,864)
Supportive charts	0,241* (0,014)	0,120 (0,224)	0,129 (0,193)	0,116 (0,243)	0,012 (0,902)	0,265** (0,007)	0,090 (0,364)
Cellular production	0,207* (0,035)	0,254** (0,009)	0,208* (0,034)	0,150 (0,129)	0,060 (0,547)	-0,025 (0,803)	0,135 (0,171)
One piece flow	0,143 (0,147)	0,036 (0,719)	0,022 (0,823)	0,161 (0,103)	0,200* (0,041)	-0,081 (0,416)	-0,058 (0,559)
Elimination of waste	0,069 (0,486)	-0,019 (0,851)	0,253** (0,009)	0,016 (0,871)	0,077 (0,438)	-0,007 (0,941)	0,023 (0,816)
Line balancing	0,011 (0,909)	0,202* (0,040)	-0,162 (0,101)	0,232* (0,018)	0,061 (0,536)	-0,153 (0,121)	-0,198* (0,043)
Pull system	0,177 (0,073)	0,164 (0,095)	0,029 (0,771)	0,264** (0,007)	-0,033 (0,737)	-0,023 (0,815)	0,097 (0,327)
Six sigma	0,119 (0,227)	0,002 (0,981)	-0,079 (0,425)	-0,149 (0,131)	0,095 (0,339)	0,433** (0,000)	0,107 (0,278)
DMAIC	0,241* (0,014)	0,009 (0,930)	0,018 (0,856)	0,116 (0,243)	0,058 (0,556)	0,438** (0,000)	0,074 (0,453)
SIPOC	0,102 (0,304)	0,041 (0,677)	-0,052 (0,599)	0,019 (0,845)	0,044 (0,659)	0,314** (0,001)	-0,119 (0,229)
VOC	0,369** (0,000)	0,069 (0,485)	0,123 (0,212)	0,075 (0,452)	0,327** (0,001)	0,212* (0,030)	0,420** (0,000)
Self-directed work teams	-0,112 (0,257)	0,070 (0,479)	-0,073 (0,462)	0,061 (0,538)	-0,151 (0,127)	-0,237* (0,016)	0,024 (0,808)
Flexible, cross-functional teams	0,355** (0,000)	0,195* (0,047)	0,203* (0,039)	0,284** (0,004)	0,203* (0,039)	0,045 (0,653)	0,145 (0,141)
Management Commitment	0,124 (0,210)	0,052 (0,600)	-0,025 (0,803)	-0,124 (0,211)	0,210* (0,032)	0,030 (0,766)	0,114 (0,247)
Training	0,240* (0,014)	0,018 (0,853)	0,176 (0,075)	0,062 (0,534)	0,292** (0,003)	-0,077 (0,439)	0,171 (0,083)

The level of significance is in brackets.
** significant at 0,01 (highlighted with grey cells)
* significant at 0,05.

Fig. 4: Spearman correlation matrix

Concerning quality, the voice of the customer, training, and the number of lean practices adopted have a significant correlation with it, at a level of significance of 1%, and VSM, one-piece flow, flexible, cross-functional teams, and management commitment at a level of 5%. Hence, the use of these practices, the existence of management commitment, and investment in training lead to higher quality; the very same happens if companies use as many practices as possible.

With respect to cost savings, six-sigma, DMAIC, SIPOC, Pareto analysis, and cause and effect diagrams were found to have a significant correlation at a level of significance of 1%. This can be explained by the problem-solving character of these tools, [42], [27]. The same happens with the number of lean practices adopted, VSM, and supportive charts. Additionally, it was found a significant correlation between the voice of customers and self-directed work teams at a level of 5%. With a negative sign, self-directed work teams do not tend to have the same positive influence as the remaining mentioned practices regarding cost savings.

Finally, customer satisfaction has a significant correlation with the voice of customers at a level of significance of 1% and with line balancing at a level of significance of 5%. Therefore, given the positive sign, the use of the voice of the customer tends to improve customer satisfaction.

4.3 Results of Multivariate Analysis and Discussion of Results

Two linear regression models were estimated to explain lean performance: one considering as dependent variable the number of performance measures that improved due to lean implementation (classified with 4 or 5), including cost, quality, time, productivity/efficiency, customer satisfaction, and elimination of waste – model 1 –, and another one considering only one performance measure as dependent variable: quality – model 2 –, as this is one of the most relevant measures linked to the emergence of lean management.

Model 1:

$$Nperf \geq 4 = f\begin{pmatrix} \text{Use of the practice } i \\ \text{Magement commitment} \\ \text{Training} \\ \text{Employee involvement} \end{pmatrix}$$

Being:

Nperf ≥ *4*: the number of performance measures classified with 4 or 5;

i: the practices VSM, Kaizen, PDCA, Cause and Effect Diagrams, Pareto Analysis, 5 Whys, Supportive charts, 5S, Cellular production, Kanban, Heijunka, Visual control, One-piece flow, Elimination of waste, Standardization, Line Balancing, Pull system, Six-sigma, DMAIC, SIPOC, VOC, Self-Directed Work teams, Flexible cross-functional teams.

Model 2:

$$Quality = f\begin{pmatrix} \text{Type of service} \\ \text{Company size} \\ \text{Use of the practice } i \\ \text{Magement commitment} \\ \text{Training} \\ \text{Employee involvement} \end{pmatrix}$$

Being:

Quality: the quality performance measure;

i: the practices VSM, Kaizen, 5S, Cellular production, Visual Control, Elimination of waste, Standardization, Line Balancing, Six-Sigma, Voice of the customer, and Self-directed work.

4.3.1 Results of Model 1

We ensured that the model met all linear model assumptions using the 'gvlma' package, [43], in R version 3.5.0. This package implements the testing procedure developed in [43]. The Shapiro test was also used to test the normality of residuals.

Initially, this model also included the type of service, company size, and the number of practices used, but these variables had to be discarded because, despite a good adjustment, they did not fulfill the normality condition resulting from the application of the Shapiro-Wilk test to the residuals.

The results (detailed in Figure 5) obtained show that eleven factors explain the impact of lean on performance. Of these eleven factors, nine have a positive sign: Pareto analysis, 5 Whys, supportive charts, heijunka, pull system, the voice of customer, flexible, cross-functional teams, management commitment, and training, which means that the use of these practices, the commitment of the management team and the training of employees tend to contribute to higher performance.

As expected, the use of tools from JIT (pull system and heijunka), TQM (Pareto analysis, 5 Whys, supportive charts), HRM (Flexible cross-functional teams), and Six-Sigma (Voice of Customer) leads to higher performance, [25], [26], [27]. Still, the use of TPM did not prove to significantly help to improve performance.

Furthermore, the positive and statistically significant sign of management commitment and training points out that the higher degree of management commitment and training, the better performance. Indeed, these two are considered

critical success factors for the implementation of lean, [31], [2], and, for that reason, this result was expected. On the other hand, it was expected that organizational culture/employee involvement was another critical success factor, [31], which was also highlighted by this sample under analysis.

Conversely, the other two factors – Kaizen and Visual Control – that explain the dependent variable have a negative sign. It was expected to be a positive sign, given the possibility of highlighting mistakes and defects provided by visual control, [1], and the continuous improvement character of Kaizen, [26]. In the case of kaizen, it should be taken into consideration that it works based on gradual and incremental changes, and its effects may not be readily perceived in a short period of time, [22]. Another possible explanation for these results may be some implementation problems with these lean practices and thus they were not fully and effectively implemented, [22]. Or, if these practices were implemented at the first stages of the lean, they may have had a significant improvement at that time and not at the time the case was analyzed.

	Determinants	Estimate	Std. Error	t value	Pr(>|t|)
Practices	VSM	0,113	0,299	0,379	0,705
	Kaizen	-0,717	0,271	-1,900	0,061*
	PDCA	-0,717	0,605	-1,186	0,239
	Cause and Effect Diagrams	0,180	0,474	0,380	0,705
	Pareto Analysis	1,255	0,482	2,718	0,008***
	5 Whys	0,982	0,538	1,832	0,071*
	Supportive charts	0,903	0,379	2,384	0,020**
	5S	-0,147	0,327	-1,062	0,292
	Cellular production	0,143	0,283	0,504	0,815
	Kanban	-0,340	0,873	-0,506	0,814
	Heijunka	1,356	0,788	1,788	0,081*
	Visual control	-0,761	0,332	-2,294	0,025**
	One-piece flow	-0,068	0,548	-0,124	0,901
	Elimination of waste	0,173	0,253	0,884	0,498
	Standardization	0,293	0,297	0,988	0,327
	Line Balancing	0,313	0,341	0,918	0,361
	Pull system	0,898	0,409	2,194	0,031**
	Six sigma	-0,432	0,415	-1,042	0,300
	DMAIC	-0,074	0,638	-0,121	0,904
	SIPOC	-0,023	0,504	-0,045	0,964
	VOC	0,886	0,298	2,304	0,024**
	Self-Directed Work teams	-0,018	0,295	-0,033	0,958
	Flexible cross-functional teams	0,564	0,317	1,778	0,079*
Critical success factors	Management commitment	0,122	0,076	1,621	0,110*
	Training	1,171	0,071	2,410	0,018**
	Employee involvement	-0,048	0,064	-0,754	0,453

Significant codes: *0,1 **0,05 ***0,01 (all the variables with *, ** and ***, highlighted with grey cells)

Regression statistics:

Residual standard error: 1,057 on 77 degrees of freedom

Multiple R-Squared: 0,5051 Adjusted R-Squared: 0,338

F-Statistic: 3,023 on 28 and 77 DF p-value: 0,00009278

Shapiro-Wilk normality test of the residuals: W: 0,9882 p-value: 0,494

Assessment of the linear model assumptions ('gvlma' package results):

	Value	p-value	Decision
Global Stat	8,229449	0,08353	Assumptions acceptable
Skewness	2,279978	0,13103	Assumptions acceptable
Kurtosis	0,003097	0,95542	Assumptions acceptable
Link Function	3,207442	0,07330	Assumptions acceptable
Heteroscedasticity	2,738952	0,09793	Assumptions acceptable

Fig. 5: Results of the 1st. model

4.3.2 Results of Model 2

Regarding the second model, we ensured it fulfilled all linear model assumptions via the 'gvlma' package. The Shapiro test was also used to test the normality of residuals.

In this model, it was possible to include the type of service, the company size, and the number of lean practices used.

The results of this model (listed in Figure 6) show that nine factors explain performance in terms of quality, five of which with a positive sign: service Software and IT, number of practices used, line balancing, management commitment, and training.

The type of service was an exploratory variable and the statistically significant and positive sign of Software and IT means that being a company in this sector is a determinant of better quality performance. Thus, software and IT appears to be predisposed to be a service to adopt lean management.

	Determinants	Estimate	Std. Error	t value	Pr(>|t|)
Type of service	Banking, financial and insurance	-0,106	1,276	-0,083	0,933
	Call Centre	2,666	1,600	1,667	0,100
	Distribution, retail and Logistics	-0,570	1,458	-0,391	0,697
	Education	1,825	1,713	1,065	0,290
	Engineering	-1,537	1,450	-1,060	0,293
	Healthcare	-0,617	1,259	-0,490	0,626
	Hotel industry	-3,488	2,434	-1,433	0,156
	Housing services	2,830	2,422	1,169	0,247
	Human Resources	-0376	2,595	-0,145	0,885
	Legal sector	0,506	1,844	0,275	0,785
	Police sector	-1,451	2,192	-0,662	0,510
	Public administration	-0,067	1,410	-0,048	0,961
	Public sector (not specified)	-3,138	2,453	-1,280	0,205
	Software and IT	2,418	1,442	1,676	0,098*
	Telecommunication	0,060	1,647	0,036	0,971
Company size	Big	0,319	1,552	0,206	0,838
	Medium	-1,477	0,655	-2,257	0,027**
	Small	-0,330	0,674	-0,490	0,626
	Not specified	0,261	0,683	0,383	0,703
Practices	Number of practices used	0,566	0,201	2,815	0,006***
	VSM	-0,557	0,610	-0,912	0,365
	Kaizen	-1,916	0,556	-3,447	0,001***
	5S	-0,068	0,675	-0,100	0,921
	Cellular production	-0473	0,592	-0,799	0,427
	Visual Control	-2,152	0,721	-2,984	0,003***
	Elimination of waste	0,130	0,515	0,252	0,802
	Standardization	-0,319	0,546	-0584	0,560
	Line Balancing	1,474	0,665	2,217	0,030**
	Six Sigma	-1,332	0,820	-1,625	0,108
	Voice of customer	-0,455	0,642	-0,710	0,480
	Self-directed work teams	-1,169	0,592	-1,977	0,052*
	Flexible cross-functional teams	-1,089	0,737	-1,479	0,143
Critical success factors	Management commitment	0,486	0,146	3,321	0,001***
	Training	0,328	0,131	2,482	0,016**
	Employee involvement	-0,070	0,121	-0,577	0,566

Significant codes: *0,1 **0,05 ***0,01 (all the variables with *, ** and ***, highlighted with grey cells)

Regression statistics:

Residual standard error: 1,767 on 68 degrees of freedom

Multiple R-Squared: 0,5753 Adjusted R-Squared: 0,3567

F-Statistic: 2,632 on 35 and 68 DF p-value: 0,0003179

Shapiro-Wilk normality test of the residuals: W: 0,98598 p-value: 0,3455

Assessment of the linear model assumptions ('gvlma' package results):

	Value	p-value	Decision
Global Stat	1,01346	0,9077	Assumptions acceptable
Skewness	0,36576	0,5453	Assumptions acceptable
Kurtosis	0,17257	0,6778	Assumptions acceptable
Link Function	0,02492	0,8746	Assumptions acceptable
Heteroscedasticity	0,45022	0,5022	Assumptions acceptable

Fig. 6: Results of the 2nd. model

Another exploratory variable analyzed in this model is the number of practices used. Again, the positive and statistically significant sign for this variable means that the more practices are used, the higher the quality is achieved. This is in accordance with what was expected since lean is guided by five principles, [12], and all should be addressed to successfully implement it.

In this model, the use of line balancing proved to be a factor that contributes to higher performance. This was also expected given the presented motivations of JIT. Moreover, according to [22], JIT has the highest impact on performance which concerns quality.

In conformity with the first model, management commitment and training are also factors that determine and influence positively the quality of the service. The more committed managers are and the more they invest in employee training, the greater the quality that the company achieves.

Again, in accordance to model 1, kaizen and visual control present a negative and statistically significant sign. In this second model, the same happened in the case of the variable self-directed work teams.

Finally, the sign for the company size, in terms of impact on performance, was expected to be either positive or negative since the larger the company the more financial resources it has, but it also has concomitantly less flexibility, [44]. Our results show it is possible to conclude that the implementation of lean in medium-sized companies is not likely to be linked to higher quality.

4.4 Implications

This study has theoretical and practical implications, enriching the literature and providing some valuable managerial insights.

Firstly, the analyzed case studies were converted into observations in order to allow regression analysis, and, to our knowledge, this is the first time such an approach is followed to study lean-in services.

Practically, this study can be extremely helpful for managers that want to be aware of lean implementation in services and its value, to know which are the most used practices, and which are the factors that have a greater influence on performance. In this way, engineering managers should direct their efforts when implementing lean management, by showing all their commitment and investing in educational programs to prepare the most important assets of any company – the employees.

Individually, this analysis can provide some insights for engineering managers that are considering the implementation of lean or how to achieve better results with it.

As lean practices "cross-functional teams", "management commitment" and "training" proved to have a positive influence on performance, the more engaged engineering managers are and the more they invest in the training of employees, the better performance companies will achieve.

5 Conclusion

For many years now, companies have been facing plenty of challenges with more and more demanding customers and high pressure to reduce costs. In this context, lean management emerges as an attractive option to develop improvement actions and to be ahead of the competition. Given the importance of the service sector in the economy and the growing use of this philosophy in these areas, this study had the main goal to identify the chief factors that influence lean performance in service companies.

The results showed that value stream mapping and kaizen are undoubtedly the more adopted practices. Nevertheless, six-sigma practices, standardization, elimination of waste, 5S, cellular production, visual control, line balancing, self-directed work teams, and flexible, cross-functional teams can also be highlighted. Furthermore, lean proved to be useful in improving different performance measures such as time, productivity, quality, costs, and customer satisfaction.

It should not be anticipated that all lean practices contribute to improving all performance measures. The voice of the customer, Pareto analysis, and cross-functional teams should be highlighted as the practices that positively influence more performance measures, with a level of significance at 1%.

Given the results obtained with two developed and tested models, several factors have a positive influence on lean performance in a global way: the use of Pareto analysis, 5 Whys, supportive charts, heijunka, pull system, the voice of the customer, and flexible, cross-functional teams. Specifically, regarding quality, line balancing can also be relevant. Thus, diverse lean practices proved to have a positive influence on performance.

On the other hand, and contrary to expectations, there are very well-known practices (e.g. kaizen and visual control) that have been shown to have a negative impact on lean-on performance.

Finally, it would be insightful to further investigate this topic, as this research suggests a

need for further empirical evidence regarding lean practices and their relationship with performance. Future research should focus on how to implement lean management in services; for instance, it would be important to find out which practices should be implemented simultaneously or if they should be implemented sequentially.

References:

[1] Russel, R.S. & Taylor, B.W. (2011). *Operations Management: Creating Value Along The Supply Chain*, Hoboken, NJ John Wiley & Sons, 7th edition.

[2] Bhamu, J., & Sangwan, K.S. (2014). Lean manufacturing: literature review and research issues. *International Journal of Operations & Production Management*, 34(7), 876-940.

[3] Rose, A.N., Deros, B.M., & Rahman, M.N. (2009). A review on lean manufacturing practices in small and medium enterprises. *Proceedings of Seminar - AMReG 09*, 29 Julai 2009, Kajang, Selangor, Malaysia.

[4] Lucato, C.W., Calarge, A.F., Junior, M.L., & Calado, R.D. (2014). Performance evaluation of lean manufacturing implementation in Brazil. *International Journal of Productivity and Performance Management*, 63(5), 529-549.

[5] Leyer, M., Vogel, L., & Moormann, J. (2015). Twenty years research on lean management in services: results from a meta-review. *International Journal of Services and Operations Management*, 21(4), 389-419.

[6] Yadav, O.P., Nepal, B.P., Rahaman, M.M., & Lal, V. (2017). Lean implementation and organizational transformation: A literature review. *Engineering Management Journal*, 29(1), 2-16.

[7] Leite, H.D., & Vieira, G.E. (2015). Lean philosophy and its applications in the service industry: a review of the current knowledge. *Production*, 25(3), 529-541.

[8] Filser, L.D., da Silva, F.F., & de Oliveira, O.J. (2017). State of research and future research tendencies in lean healthcare: a bibliometric analysis. *Scientometrics*, 112(2), 799-816.

[9] Moraros, J., Lemstra, M., & Nwankwo, C. (2016). Lean interventions in healthcare: do they actually work? A systematic literature review. *International Journal for Quality in Health Care*, 28(2), 150-165.

[10] Daultani, Y., Chaudhuri, A., & Kumar, S. (2015). A decade of lean in healthcare: Current state and future directions. *Global Business Review*, 16(6), 1082-1099.

[11] Poksinska, B. (2010). The current state of Lean implementation in health care: literature review. *Quality Management in Healthcare*, 19(4), 319-329.

[12] Womack, J. P., Jones, D. T., & Roos, D. (1990). *The Machine that Changed the World*. Simon and Schuster.

[13] Hines, P., Holweg, M., & Rich, N. (2004). Learning to evolve: a review of contemporary lean thinking. *International Journal of Operations & Production Management*, 24(10), 994-1011.

[14] Radnor, Z., Holweg, M., & Waring, J. (2012). Lean in healthcare: the unfilled promise*?*. *Social Science & Medicine*, 74(3), 364-371.

[15] Hallgren, M., & Olhager, J. (2009). Lean and agile manufacturing: external and internal drivers and performance outcomes. *International Journal of Operations & Production Management*. 29(10), 976-999.

[16] Shah, R., & Ward, P. T. (2007). Defining and developing measures of lean production. *Journal of Operations Management*, 25(4), 785-805.

[17] Liker, J.K. and Wu, Y.C., (2000), Japanese automakers, US suppliers and supply-chain superiority, *Sloan Management Review*, 42, 81-93.

[18] Panwar, A., Nepal, B.P., Jain, R., & Rathore, A.P. (2015). On the adoption of lean manufacturing principles in process industries. *Production Planning & Control*, 26(7), 564-587.

[19] Swink, M., Melnyk, S.A., Cooper, M.B., & Hartley, J.L. (2014). *Managing Operations across the Supply Chain*. New York, NY: McGraw-Hill/Irwin.

[20] Radnor, Z., Walley, P., Stephens, A., & Bucci, G. (2006). Evaluation of the lean approach to business management and its use in the public sector. *Scottish Executive Social Research*, Blackwell's Bookshop, Edinburgh.

[21] Titov, S., Nikulchev, E., Bubnov, G., & Biryukov, A. (2016). Impact of lean production initiatives on quality: Theoretical analysis and empirical research. *Calitatea*, 17(150), 57-60.

[22] Belekoukias, I., Garza-Reyes, J.A., & Kumar, V. (2014). The impact of lean methods and tools on the operational performance of manufacturing organisations. *International Journal of Production Research*, 52(18), 5346-5366.

[23] Manzouri, M., Ab-Rahman, M.N., Zain, C.R., & Jamsari, E.A. (2014). Increasing production and eliminating waste through lean tools and techniques for halal food companies. *Sustainability*, 6(12), 9179-9204.

[24] Shah, R., & Ward, P. T. (2003). Lean manufacturing: context, practice bundles, and performance. *Journal of Operations Management*, 21(2), 129-149.

[25] Cua, K.O., McKone, K.E., & Schroeder, R.G. (2001). Relationships between implementation of TQM, JIT, and TPM and manufacturing performance. *Journal of Operations Management*, 19(6), 675-694.

[26] Abdulmalek, F.A., Rajgopal, J., & Needy, K.L. (2006). A classification scheme for the process industry to guide the implementation of lean. *Engineering Management Journal*, 18(2), 15-25.

[27] De Koning, H., Does, R.J., & Bisgaard, S. (2008). Lean Six-Sigma in financial services. *International Journal of Six-Sigma and Competitive Advantage*, 4(1), 1-17.

[28] Antony, J., Bhuller, A.S., Kumar, M., Mendibil, K., & Montgomery, D.C. (2012). Application of six-sigma DMAIC methodology in a transactional environment. *International Journal of Quality & Reliability Management*, 29(1), 31-53.

[29] Gupta, S., Sharma, M., & Sunder, M.V. (2016). Lean services: a systematic review. International *Journal of Productivity and Performance Management*, 65(8), 1025-1056.

[30] Tsironis, L. K., & Psychogios, A. G. (2016). Road towards Lean Six-Sigma in service industry: a multi-factor integrated framework. *Business Process Management Journal*, 22(4), 812-834.

[31] Achanga, P., Shehab, E., Roy, R., & Nelder, G. (2006). Critical success factors for lean implementation within SMEs. *Journal of Manufacturing Technology Management*, 17(4), 460-471.

[32] Laureani, A., Brady, M., & Antony, J. (2013). Applications of lean six-sigma in an Irish hospital. *Leadership in Health Services*, 26(4), 322-337.

[33] Gronroos, C. (1990). Relationship approach to marketing in service contexts: The marketing and organizational behavior interface. *Journal of business research*, 20(1), 3-11.

[34] Parasuraman, A., Zeithaml, V.A. & Berry, L.L. (1985), A conceptual model of service quality and its implications for future Research, *Journal of Marketing*, 49(4), 41-50.

[35] Schmenner, R. W. (1986). How can service businesses survive and prosper. *Sloan Management Review*, 27(3), 21-32.

[36] Siha, S. (1999). A classified model for applying the theory of constraints to service organizations. *Managing Service Quality: An International Journal*, 9(4), 255-264.

[37] Lovelock, C. H., & Yip, G. S. (1996). Developing global strategies for service businesses. *California management review*, 38(2), 64-86.

[38] Leyer, M., & Moormann, J. (2014). How lean are financial service companies really? Empirical evidence from a large scale study in Germany. *International Journal of Operations & Production Management*, 34(11), 1366-1388.

[39] Laihonen, H., Jääskeläinen, A., & Pekkola, S. (2014). Measuring performance of a service system–from organizations to customer-perceived performance. *Measuring Business Excellence*, 18(3), 73-86.

[40] Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a methodology for developing evidence- informed management knowledge by means of systematic review. *British Journal of Management*, 14(3), 207-222.

[41] Suárez-Barraza, M.F., Smith, T., & Dahlgaard-Park, S.M. (2012). Lean service: A literature analysis and classification. *Total Quality Management & Business Excellence*, 23(3-4), 359-380.

[42] Furterer, S., & Elshennawy, A.K. (2005). Implementation of TQM and lean Six-Sigma tools in local government: a framework and a case study. *Total Quality Management & Business Excellence*, 16(10), 1179-1191.

[43] Peña, E.A., & Slate, E.H. (2006). GVLMA: Global validation of linear model assumptions. R Package version 1.0.0.2 https://CRAN.R-project.org/package=gvlma. Global validation of linear model assumptions. *Journal of the American Statistical Association*, 101(473), 341-354.

[44] Hadid, W., & Mansouri, S.A. (2014). The lean-performance relationship in services: a theoretical model. *International Journal of Operations & Production Management*, 34(6), 750-785.

Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

The authors equally contributed in the present research, at all stages from the formulation of the problem to the final findings and solution.

Sources of Funding for Research Presented in a Scientific Article or Scientific Article Itself

No funding was received for conducting this study.

Conflict of Interest

The authors have no conflict of interest to declare that is relevant to the content of this article.

Appendix 1

List of studies included in the cases analysis (by year)

Author(s)	Journal
Allway and Corbett (2002)	Journal of Organizational Excellence
Cuatrecasas-Arbós (2002)	International journal of production economics
Swank (2003)	Harvard business review
Brown *et al.* (2004)	Interfaces
Farrar (2004)	Lean Construction Journal
Emiliani (2004)	Quality Assurance in Education
Cuatrecasas-Arbós (2004)	International Journal of Services Technology and Management
Furterer and Elshennawy (2005)	Total Quality Management & Business Excelence
Emiliani (2005)	Quality Assurance in Education
Lummus *et al.* (2006)	Total Quality Management & Business Excelence
Agbulos *et al.* (2006)	Journal of construction engineering and management
Su *et al.* (2006)	International Journal of Six Sigma and Competitive Advantage
Al-Aomar (2006)	International Journal of Product Development
Al-Sudairi (2007)	Construction Innovation
Fillingham (2007)	Leadership in Health Services
Ben-Tovim *et al.* (2007)	Australian Health Review
Lee *et al.* (2007)	Service Industries Journal
Change and Su (2007)	International Journal of Six Sigma and Competitive Advantage
Lodge and Bamford (2008)	Public Money & Management
Papadopoulos and Merali (2008)	Public Money & Management
Kress (2008)	Journal of Access Services
Mcquade (2008)	Public Money & Management
De Koning *et al.* (2008)	International Journal of Six Sigma and Competitive Advantage
Radnor and Walley (2008)	Public money and management
Hines *et al.* (2008)	Public money and management
Waterbury and Bonilla (2008)	International Journal of Six Sigma and Competitive Advantage
Jin *et al.* (2008)	International Journal of Six Sigma and Competitive Advantage
Kung *et al.* (2008)	Canadian Journal of Civil Engineering
Julien and Tjahjono (2009)	Business Process Management Journal
Barraza *et al.* (2009)	The TQM Journal
Song *et al.* (2009)	Int. J. Services and Standards
Piercy and Rich (2009)	International journal of operations & production management
Castle and Harvey (2009)	International Journal of Productivity and Performance Management
Fischman (2010)	Quality Management in Health Care
Wang and Chen (2010)	Total Quality Management & Business Excelence
Delgado *et al.* (2010)	Journal of Manufacturing Technology Management
Laureani *et al.* (2010)	International Journal of Productivity and Performance Management
Van Leeuwen and Does (2010)	Quality Engineering
Radnor (2010)	Journal of Manufacturing Technology Management
Laureani and Antony (2010)	International Journal of Productivity and Performance Management

Suárez-Barraza and Ramis-Pujol (2010)	Journal of Manufacturing Technology Management
Grove *et al.* (2010)	Leadership in Health Services
LaGanga (2011)	Journal of Operations Management
Larsson *et al.* (2011)	Production, Planning & Control
Karstoft and Tarp (2011)	Insights into imaging
Bonaccorsi (2011)	Journal of Service Science and management
Doman (2011)	Quality Assurance in Education
De Souza and Pidd (2011)	Public Money & Management
Staats *et al.* (2011)	Journal of Operations Management
Malladi *et al*. (2011)	International Journal of Business Information Systems
Nepal *et al.* (2011)	Engineering Management Journal
Mazzocato *et al.* (2012)	BMC health services research
Cheng and Chang (2012)	Total Quality Management & Business Excelence
Jaca *et al.* (2012)	Total Quality Management & Business Excelence
Bortolotti and Romano (2012)	Production Planning & Control
Psychogios *et al.* (2012)	International Journal of Quality & Reliability Management
Chadha *et al.* (2012)	Clinical Governance: An International Journal
Mazur *et al.* (2012)	Engineering Management Journal
Kumar *et al.* (2013)	International Journal of Productivity and Performance Management
Di Pietro *et al.* (2013)	Total Quality Management & Business Excelence
Chiarini (2013)	Leadership in Health Services
Balazin and Stefanic (2013)	International Journal of Services and Operations Management
Radnor and Johnston (2013)	Production Planning & Control
Bhat *et al.* (2014)	International Journal of Productivity and Performance Management
Drotz and Poksinska (2014)	Journal of Health, Organisation and Management
Mazzocato *et al.* (2014)	Journal of Health, Organisation and Management
Gutierrez-Gutierrez *et al.* (2016)	International Journal of Lean Six Sigma
Haddad *et al.* (2016)	Engineering Management Journal
Salam and Khan (2016)	International Journal of Services and Operations Management
Ratnayake and Chaudry (2017)	International Journal of Lean Six Sigma
Antony *et al.* (2017)	Total Quality Management and Business Excellence
Antony *et al.* (2018)	International Journal of Productivity and Performance