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What can be learnt from 100 case studies of lean in services?

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WHAT CAN BE LEARNT FROM 100 CASE STUDIES OF LEAN IN SERVICES?

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Biographical Note

Diana Isabel Pinto Pereira was born on 28th May, 1995, in Porto. Diana is the first child of Arnaldo Donato Alves Pereira and Maria Alexandrina Gomes Pinto.

In 2013, she started her academic path at Faculdade de Economia da Universidade do Porto (FEP), finishing her bachelor's degree in Economics in 2016. In the same year, she decided to join the Master in Management in the same institution, which allowed her to get important knowledge in several areas such as operations and supply chain management and quality management.

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Abstract

Purpose – Lean thinking is a philosophy that has kept a lot of interest in the literature and is becoming increasingly popular for service companies. Therefore, the main objective of this research is to investigate the implementation of lean practices in services. It aims to identify the lean implementation factors that have a greater influence on the performance of companies.

Design/methodology/approach – In this research, a systematic literature review on implementation of lean in services was used as a basis to create a regression model. A total of 104 case studies were considered in this research.

Findings – We found that some lean practices such as voice of customer and cross-functional teams have a positive and significant influence on performance. On the other hand, there are practices (e.g. *kaizen* and visual control) that have a negative coefficient in the regression explaining the lean performance. Also, the results of this study suggest that the more engaged managers are and the more they invest in the training of employees, the greater performance will be.

Originality/value – According to our best knowledge, this is the first known study that assesses lean practices on the major sectors of services, by converting case studies into observations to do a regression analysis. It fills a gap in literature concerning the identification of the elements of lean implementation that explain the higher or lower performance.

Practical implications – By knowing the determinants of lean performance, managers will be aware of what would be important or decisive to implement lean. This research also contributes to the body of knowledge of lean in services. Moreover, any kind of improvement in the service sector (healthcare, education, banks and finance, etc.) that lean may allow will possibly constitute a benefit to society in general.

JEL-codes: L80, M11

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1. Introduction

Nowadays, companies face an intense pressure for a quicker response and for reducing costs, given the era of globalization in which we live (Russel *et al.*, 2011). Customers are becoming more demanding (Russel *et al.*, 2011), and customized products are developing into the big trend of this century, turning mass production into a huge challenge (Bhamu and Sangwan, 2014). From the need of being able to adapt to ever changing customer demands, lean management has arisen. Originated in Japan and used to describe Toyota Production System, lean is a philosophy whose objective is to produce at the minimal cost and at the pace that customers demand, therefore reducing any kind of waste (Bhamu and Sangwan, 2014).

This system can be successfully implemented in any industry (Rose, 2009). But, on the other hand, it cannot be equally applied in all companies given the existing differences among industries or even regions (Lucato *et al.*, 2014).

In spite of being introduced in manufacturing, lean management is becoming increasingly popular for service companies (Leyer *et al.,* 2015). So, although the use of this philosophy is well settled in the manufacturing sector, it is relatively new for service companies (Leite and Vieira, 2015).

Nevertheless, the application of this philosophy can be seen in plenty of services such as healthcare (Poksinska *et al.*, 2017; Jorma *et al.*, 2016; Henrique *et al.*, 2016; Hicks *et al.*, 2015; Farrokhi *et al.,* 2015; Sanders *et al.*, 2015 Cheng *et al.,* 2015; Bath *et al.,* 2014; Mazzocato *et al.,* 2014; Laureani *et al.,* 2013; Aguilar-Escobar *et al.*, 2013; Radnor *et al.,* 2012), banks and financial institutions (Li *et al.*, 2017; Lameijer *et al.*, 2016; Leyer *et al.*, 2014; Delgado *et al.*, 2010; de Koning *et al.*, 2008; Apte and Goh, 2004), education (Srichai *et al.*, 2015; Emiliani, 2004), call centers (Laureani *et al.,* 2010; Piercy and Rich, 2009) and IT (Wang *et al.,* 2012; Staats *et al.*, 2011; Malladi *et al.*, 2011), among others.

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 in the lean performance of service companies.

In order to achieve this, a systematic literature review was carried out. This systematic literature review will be further used to do a regression analysis.

There are several literature reviews and bibliometries of lean on specific services, mainly healthcare (Filser *et al.*, 2017; Moraros *et al.*, 2016; Daultani *et al.*, 2015; Poksinska, 2010). Also, there is a meta-review that analyses the state of the art on lean management in services (Leyer *et al.,* 2015), focused essentially on the applicability of lean principles. So, according to our best knowledge, this is the first known study that assesses lean practices on the major sectors of services, by converting case studies into observations in order to do a regression analysis. It fills the gap in literature concerning the identification of the elements that explain the higher or lower influence of lean on its performance. Furthermore, this study can be of extreme help for managers operating in the services sector that want to be aware of what would be important or decisive to implement this philosophy.

This work is organized as follows. Besides this chapter, in Chapter 2, it is presented a literature review concerning lean thinking that approaches the fundamental concepts, practices, tools and techniques as well as the benefits, implementation issues and critical success factors. A description of services, similar studies and the research framework are also presented in that chapter. In Chapter 3, the methodology is described. Finally, Chapter 4 comprises the main results of this research, and Chapter 5 its conclusions.

2. Literature Review

In this chapter, it is presented the fundamental concepts of lean management. First, the concept of lean thinking is introduced, being described its origin, definitions, principles, practices, techniques and tools. Furthermore, the main benefits, implementation issues and critical success factors are also reviewed. In Section 2.2, it is made a description of services, encompassing its characteristics, its categorization and how to measure its performance. Finally, in sections 2.3 and 2.4 similar studies and the research framework are discussed.

2.1. Lean Management

2.1.1. Definition and Origin of Lean

Mass production – standardized products at a very high volume –, developed on the beginning of 20th century, allowed to the consumers to get low costs, but on the other hand, without access to variety (Womack *et al.*, 1990). However, after the II World War, the context for the Japanese market for automobiles was characterized by scarcity of resources and intense domestic competition (Hines *et al.*, 2004). In order to survive in this context, mass production was not a viable option anymore. Therefore, in 1950, the engineers Taiichi Ohno and Shigeo Shingo developed the Toyota Production System (Bhamu and Sangwan, 2014), later known by lean production, a term coined by John Krafcki in 1988 (Womack *et al.*, 1990).

This term was then popularized through the book "The machine that changed the world" that described lean as using "less of the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product in half the time. (…) less than half the needed inventory on site, results in many fewer defects, and produces a greater and ever growing variety of products" (Womack *et al.*, 1990, p. 13). Hence, this dynamic process emphasizes the elimination of waste and continuous improvement combined with employees' empowerment (Womack *et al.*, 1990).

However, for many, its concept is not clear (Hines *et al.*, 2004) and several authors have tried to define it. Some definitions are illustrated on Table 1.

Authors	Definitions
Liker and Wu (2000)	"A philosophy of manufacturing that focuses on delivering the highest quality product at the lowest cost on time."
Shah and Ward (2007)	"An integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability."
Hallgren and Olhager (2009)	"A program aimed mainly at increasing the efficiency of operations."
Radnor *et al.* (2010)	"A management practice based on the philosophy of continuously improving processes by either increasing customer value or reducing non-value adding activities (Muda), process variation (Mura), and poor work conditions (Muri)."
Alves *et al.* (2012)	"A model where the persons assume a role of thinkers and their involvement promotes the continuous improvement and gives companies the agility they need to face the market demands and environment changes of today and tomorrow."

Table 1: Definitions of Lean in literature (Sources: Bhamu and Sangwan (2014), p.4 and Gupta *et al.* (2016), p.3)

These definitions have several focuses: elimination of waste, value, employees' engagement, the customers, continuous improvement, increasing quality and efficiency and lower cost. Even so, they can be seen 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 which will lead to an increased quality and efficiency and to a lower cost that, consequently, will increase both company's and end costumer's value.

Shah and Ward (2007) stated that lean is viewed from two perspectives: philosophical and practical. The first perspective is related to its goals and guiding principles, and the second to its range of management practices, tools and techniques.

The main goals of lean are to eliminate waste (Womack *et al.,* 1990) and to increase value for customers (Hines *et al.,* 2004). Moreover, in accordance with Womack *et al.* (1996), lean thinking is guided by five principles: (1) value, (2) value stream, (3) flow, (4) pull, and finally, (5) perfection. More specifically, once created and analysed the value stream, a lean company must identify and eliminate non-value adding activities, create flow, produce based on the demand-pull system, and continuously strive for improvements without disregarding the importance of a strong involvement of employees (Panwar *et al.*, 2015).

In this way, it is possible to highlight two main concepts: waste and value.

Womack and Jones (1996) 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 the seven categories of waste which are described as follows: i) transportation (units being unnecessarily moved); ii) inventory (units waiting to be processed or delivered); iii) motion (unnecessary resource activity); iv) waiting (resources wasted waiting for work); v) overproduction (processing more units than are necessary); vi) processing (excessive or unnecessary operations), and vii) defects (waste due to unnecessary scrap, rework, or correction) (Swink *et al.*, 2014).

However, despite the fact that lean was first introduced in manufacturing, it is becoming increasingly popular in services (Leyer *et al.,* 2015). Thus, Radnor *et al.* (2006) adapted these seven wastes to services, identifying: delay, duplication, unnecessary movement, unclear communication, incorrect inventory, opportunity lost and errors. They also defend that it should be added a waste both for manufacturing and services: "not using the mind of employees".

Regarding value, Hines *et al.* (2004) claimed that the perception of value was usually and wrongly seen as reduction of costs. Instead, value should be seen in a customer perspective, and it can be increased either by removing wasteful activities or adding product/service features that customers value. Indeed, the customer value can be increased by reducing costs but also by improving customer satisfaction with, for example, reduction of waiting time and defects (Titov *et al.*, 2016).

The practices, tools and techniques are used mostly to optimize processes by eliminating waste (Titov *et al.*, 2016). This is addressed in the next section.

2.1.2. Lean Management: Practices, Tools and Techniques

The lean strategy's umbrella encompasses plenty of methods that intend to improve the organizational performance of organizations (Bhasin, 2012, cited in Belekoukias *et al.,* 2014). Having a set of reliable tools and techniques is crucial to decrease waste and provide value to customers (Manzouri *et* al., 2014). However, the implementation of lean is not straightforward for all organizations, 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 (Panwar *et al.,* 2015).

Shah and Ward (2003) categorize inter-related practices into four bundles: Just-in-time (JIT), Total Quality Management (TQM), Total Preventive Management (TPM), and Human Resource Management (HRM). This research will follow this structure to analyse some examples of lean tools for each bundle (Table 2).

Cua *et al.* (2001) stated that JIT, TQM and TPM form a comprehensive and consistent set of practices whose objective is to improve performance through waste reduction and continuous improvement.

JIT is a program whose main purpose is to continuously reduce all forms of waste (Cua *et al.*, 2001). Therefore, JIT production is based on producing or ordering exactly the quantity that it is needed in the moment that is needed (Abdulmalek *et al.*, 2006). 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 (Cua *et al.,* 2001). HRM is viewed as a program that supports all the three already described, since, in order to these programs succeed, it is crucial to have, for instance, cross-functional training, and employee involvement (Cua *et al.,* 2001).

Methods	Tools	Description
JIT	One piece flow	A process that consists in moving one piece at a time (Li *et al.*, 2009)
	Small-lot production	The use of small lot production requires less space, less investment and simplifies transportation, reducing lead time (Russel *et al.*,2011)
	Standardization of work	The purpose of standardize is to ensure that each task is organized in a way that maximizes consistency and efficiency (Abdulmalek *et al.,* 2006).
	Pull system	Production system in which workers only look for the parts and materials needed on the previous station when needed and if it can be processed immediately. It relies on customer's requests (Russel *et al.*,2011)
	Cellular production	It consists in reorganizing the process and the workspace as efficiently as possible (De Koning *et al.*, 2008)
	Line balancing	To avoid over and under capacity, the processing capacity for each job needs to be balanced. (De Koning *et al.*, 2008)
	Heijunka	A process that keeps the production level as constant as possible (Abdulmalek *et al.,* 2006)
	Kanban	A visual signal to support flow that indicates when an activity can start (Melton, 2005)
	Visual control	Procedures that highlights problems, making them visible (Russel *et al.*,2011)
	Jidoka	Its objective is the reduction of quality defects. It includes tools such as mistake proofing devices (poka-yokes) and visual control systems (andons) (Belekoukias *et al.*, 2014)
	OEE	A measure of the performance of an equipment in order to know if it is

		doing what it is supposed to (Williamson, 2006, cited in Muchiri *et al.* 2008)
TPM	SMED	A process that aims to reduce setup time (Abdulmalek *et al.,* 2006)
	5S	A process that consists on sorting, straightening, sweeping and cleaning, systematizing, and standardizing in order to reduce waste (Abdulmalek *et al.,* 2006). It allows a well-organized workspace. (De Koning et al.,2008)
	Preventive maintenance	A system of periodic maintenance to reduce the probability of machines' breakdown (Russel *et al.*,2011)
	Breakdown maintenance	An activity that involves repairing a failed machine (Russel *et al.*,2011)
TQM	Value stream mapping (VSM)	A method to identify and measure value and non-value added activities in order to eliminate waste and inefficiencies. (Abdulmalek *et al.,* 2006).
	Kaizen	An approach that aims gradual and continuous improvement. (Abdulmalek *et al.,* 2006). It includes tools such as: data check sheet, run chart, gantt chart, etc. (Belekoukias *et al.,* 2014).
	5 Whys	Trough asking the five whys, companies can find out the fundamental causes of the problems. (Cheng and Chang, 2012)
	Cause and effect diagrams	They are used to identify the root causes of the different problems. (Furterer and Elshennawy, 2005)
	Pareto analysis	Pareto charts are useful to understand patterns and identify gaps. (Furterer and Elshennawy, 2005)
	PDCA	Plan-do-study-act cycles begin based on improvement opportunities stemming from the mapping process (Ben-Tovim *et al.*, 2007)
	Supply quality management	Quality is the number one criteria for choosing suppliers and its involvement is emphasized to ensure the quality of products and processes. (Cua *et al.,* 2001)
HRM	Flexible, Cross-functional Teams	It is expected that employees perform multiple tasks. (Cua *et al.*, 2001). It includes practices such as: job-rotation program, job design, and formal, cross-functional training (Shah *et al.*, 2003)
	Self-directed work teams	Employees work in teams and are involved in problem solving groups. (Shah *et al.,* 2003)

Table 2: Description of lean methods and tools (Source: Own elaboration)

Additionally, lean is frequently combined with another approach used to process improvement – Six Sigma. Six Sigma is a programme centred in the customer that uses problem solving methodologies and highlights data-based decision-making (De Koning *et al.*, 2008). A commonly used problem solving methodology is DMAIC that stands for Define, Measure, Analyse, Improve and Control (De Koning *et al.*, 2008). In the define phase, SIPOC diagram (Suppliers-Inputs-Processes-Outputs-Customers) and VOC analysis (Voice of Customer) are frequently used to identify all the important elements for the process improvement and to make sure that they are in line with the customer requirements (Anthony *et al.*, 2012).

As Total Quality Management, Six Sigma is based on the pursuit of continuous improvement (Cheng and Chang, 2012)

2.1.3. Benefits and Implementation Issues

Several benefits of lean implementation have been pointed out by various authors, both qualitative and quantitative. The quantitative benefits include improvement in production lead time, processing time, cycle time, set up time, inventory, defects and equipment effectiveness while the qualitative ones comprehend improved employee morale, effective communication, standardized housekeeping, team decision making, among others (Bhamu and Sangwan, 2014).

By reviewing several studies, Gupta *et al.* (2016) came to a conclusion regarding lean benefits in different types of services. In healthcare, lean helps to have reduced waiting time, improved quality of care, improved productivity and efficiency, capacity expansion without additional facility, and increased utilization of operating theatres. In software service companies, lean leads to lower variability in performance, fewer defects and rework, improved operational performance and quality. In education, lean allows improved quality, relevance of course materials, reduction in delivery time of knowledge, and delivery of higher value. And finally, in public sector, delivering a high-quality service that meets customer requirements with efficient resource utilization is one of the benefits of lean.

In spite of providing plenty of benefits, not always lean implementation is effective and sustainable (Bhamu and Sangwan, 2014). Thus, Bhamu and Sangwan (2014) identified some critical issues and categorized them in pre-implementation issues, implementation issues and post-implementation issues. The first includes issues such as misconception about the objectives of lean management and lack of communication, top management commitment, training and education programs. One possible issue on implementation is the non-effective supplier relationship. And finally, post-implementation issues addresses for instance lack of proper post-implementation planning: an organization should review the entire process and create opportunities to continuous improvement.

Moreover, we should keep in mind that lean is not the best choice for all companies: lean has to be compatible with the company's products, processes and customers and lean practices should be adapted for each business environment (Russel *et al.,* 2011).

2.1.4. Critical success factors for lean implementation

According to Achanga *et al.* (2006), there are some factors that are fundamental to a successful implementation of lean:

- Leadership and management commitment: Strong leadership would allow a flexible organization structure as well as knowledge enrichment in the workforce (Achanga *et al.*, 2006). It will also permit the removal of barriers (Bhamu and Sangwan, 2014).
- Financial capability: Lean implementation requires some financial capabilities due to for instance hiring of consultants and training of people.
- Skills and expertise: It is important that employees are open to the idea of skill enhancement. Besides, in this era of fierce competition, the capability of innovation and differentiation of the employees can also be critical.
- Organizational culture: The culture of the organization must be supportive to this implementation. Communication and employee involvement to achieve improvements are the key.

As explained in the previous section, lack of communication, management commitment, and training and education programs can put at risk the effectiveness of lean implementation.

2.2. Services

2.2.1. Characteristics and categorization of services

Anon (2013) stated that the service sector contributes to more than 50% of the GPD of top economies, becoming then globally vital (Gupta *et al.*, 2016).

Grönroos (1990) defined service as an activity that usually includes an interaction with the customer with the purpose of providing a solution to its problem (Gupta *et al.*, 2016). Therefore, the service industry is way different from manufacturing given its particular characteristics: intangibility, heterogeneity and inseparability (Parasuraman *et al.,* 1985). Their description is presented in Table 3.

Characteristic	Description
Intangibility	Services are performances: they cannot be counted or measured
Heterogeneity	The performance varies from producer to producer and from consumer to consumer
Inseparability	Often, production and consumption are inseparable

Table 3: Characteristics of services (Source: Parasuraman *et al.*, 1985)

Other characteristics such as perishability are also associated to services (Lovelock and Gummesson, 2004, cited by Gupta *et al.*, 2016). Moreover, Osborne *et al.* (2013) claimed that the user is the co-producer in services (Gupta *et al.*, 2016).

Regarding the type of service, Schmenner (1986) developed a service process matrix that highlights two key elements: first, the labour intensity of the service, and second, the customer interaction and service customization (Siha, 1999). This two-by-two matrix can be seen in Table 4.

		Degree of Interaction and Customization	
		Low	High
Degree of labour intensity	Low	**Service Factory** - Air and land transports - Hotels and resorts	**Service Shop** - Hospitals - Auto repair shops and other repair services
	High	**Mass service** - Retail - Wholesaling - Education	**Professional Service** - Doctors - Lawyers - Accountants - Architects

Table 4: Service process matrix (Source: Schmenner (1986))

Going through this table, we realize that service factory requires low labour intensity and low degree of interaction and customization. According to Siha (1999), this type of services offers limited varieties but has advantages in terms of price, speed and personal touch. It includes services such as airlines, trucking, hotels, resorts (Schmenner, 1986).

The service shop takes place when increasing the degree of interaction and customization. Unlike service factories, these organizations offer high variety of services which encompasses their competitive advantage, but makes them however difficult to control (Siha, 1999). Examples of service shops are hospitals, auto repair shops and other repairs services (Siha, 1999).

"Mass service" businesses are characterized by a high degree of labour intensity and a low degree of interaction and customization. Having a limited service mix, these organizations have a chance to compete in price (Siha, 1999). In this category, it can be found services such as retail, wholesaling, education, laundry, cleaning and many routine computer software and data-processing functions (Schmenner, 1986).

When the degree of interaction with the customer as well as of customization increases, we start talking about professional service. This kind of service counts with doctors, lawyers, accountants, architects, investment bankers and other organizations dependent of the professional skills of few individuals (Schmenner, 1986 and Siha, 1999).

Nevertheless, there are other proposals to categorize services. For instance, in which regards to the process perspective of the service, Lovelock and Yip (1996) as well as Leyer and Moormann (2012) have proposed a method that divides services in: people-processing services – the presence of the customer is essential –, possession-processing services – its presence is not absolutely necessary since the service is performed on a product given by the customer and therefore, its presence is not absolutely necessary – and information-processing services – it does not require the presence of the customer (Leyer *et al.*, 2015).

2.2.2. Services performance measures

In which regards to 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 a service is to provide value to the customer (Laihonen *et al.*, 2014).

According to the study of Laihonen *et al.* (2014), 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.: sales margin). In which regards to the network, some examples of measures are efficiency of cooperation and success of shared planning. Finally, a company must take into account the customer perceived value in order to measure its performance.

As the purpose of this dissertation is to study the impact of lean on performance, it also makes sense to identify the measures that indicate the success of lean. Performance measures include cost, quality, flexibility and productivity. Also, time-related measures (lead

time, processing time, etc.) were found to be quite significant to the evaluation of the effectiveness of lean on performance (Karim and Arif-Uz-Zaman, 2013). Finally, as explained in previous sections, the primary goals of lean are to eliminate waste (Womack *et al.,* 1990) and, as for services, to increase value for customers (Hines *et al.,* 2004). Therefore, elimination of waste and customer satisfaction should also be measured to evaluate the performance of lean implementation.

2.3. Similar Studies

In this section, it is presented the results and conclusions of similar studies related to lean thinking in services.

Leyer *et al.* (2015) intended to show if and how lean management can be applied in services but the main focus of this study was the applicability of lean principles. Services were categorized in a process point of view and the results showed that overall, lean has a positive impact in services, however, smaller than in manufacturing. In this way, in every type of service, benefits such as cost reduction and improved customer service are achieved. Moreover, value stream and the pull approach are the principles more used. Finally, according to the authors, more research should be done regarding how lean can be applied in services as well as its causes and effects.

Gupta *et al.* (2016) summarized the importance of Lean as well as its evolution in services through a systematic literature review. The results showed that although lean principles can be applicable in services, its transfer from manufacturing presents some limitations due to its particular characteristics. Also, the authors conclude that employees' involvement is crucial to successfully implement lean in services.

Leite and Vieira (2015) studied the creation and evolution of Lean philosophy in services, also through a systematic literature review. Moreover, they intended to analyse the principles and practices more oriented to these sectors. In this way, the authors concluded that there is no single model of tools or standards to be applied but a mix of them that must be used according to the specific needs of the company, generating not only large economic and financial results but also higher employees' engagement.

Suárez-Barraza *et al.* (2012) reviewed and categorized the literature concerning the theme "lean service". They found out that the literature can go from the concept of lean to the

creation of new definitions, going through its applications and definition of theoretical models.

A synthesis of the mentioned studies is presented below in Table 5.

Authors	Theme	Type of service	Search method	Nr of reviewed studies	Main findings/conclusions
Leyer *et al.* (2015)	Lean principles in services	All	Databases such as Emerald Management and ScienceDirect	80	Lean principles have a positive impact in services, however lower than in manufacturing. There is a need to adapt lean from company to company.
Gupta *et al.* (2016)	Importance and evolution of lean in services	All	Databases such as Google Scholar, Emerald and Science Direct	122	Lean is applicable to services, having its implementation however some limitations due to its particular characteristics. Employees' engagement is crucial.
Leite and Vieira (2015)	Creation and evolution of lean philosophy in services	All	-	More than 70	Lean philosophy has large economic and financial benefits for service companies. The implementation of lean tools must be done in step with the specific situation of a company.
Suárez-Barraza et al. (2012)	Literature in lean services	All	Databases such as Proquest, Business Source Elite, Business Source Premier, Emerald, Science Direct and Google Scholar.	172	The more analysed subjects in literature regarding lean service are: concept, applications, theoretical models and creation of new definitions

Table 5: Similar studies

2.4. Research Framework

The main aim of this research is to investigate lean implementation within services. We want to study which lean factors most affect performance in service companies. Also, we want to deeper analyse which practices are more used and which of them have a greater impact.

In this way, as independent variables, we will consider the practices included on each bundle of the literature review – Just-in-time, Total Quality Management, Total Productive Maintenance and Human Resource Management, practices related to Six Sigma, the number of used practices, type of service, company size and the degree of management commitment, employee involvement and training. To study performance, the dependent variables include: quality, customer satisfaction, efficiency/productivity, costs, elimination of waste and time measures.

The research framework is presented in Figure 1.

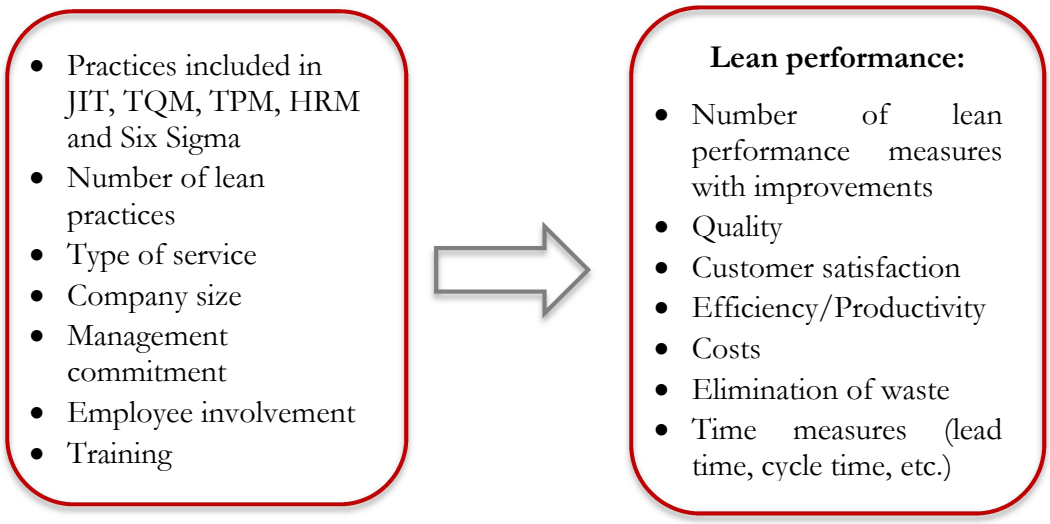

Figure 1: Research framework

To sum up, this study aims to answer to the following research questions:

- ❖ What are the determinants of effectiveness of lean on performance?
- ❖ Which practices have a greater impact on the performance?

To do that, we propose a theoretical model. This model proposes to identify the factors (its importance and expected signal) that have a greater influence in the lean performance of companies.

According to the different theoretical approaches discussed in the previous sections, there are seven elements that may have a greater or lesser impact on performance of companies. Accordingly, they are:

(1) Number of practices adopted

This is an exploratory variable. However, as lean is guided by five principles (Womack *et al.*, 1996), we expect that all should be addressed in order to successfully implement it and, for that reason, a higher number of used practices drives to a higher lean performance.

(2) Use of JIT, TQM, TPM, HRM and Six Sigma practices (Cua *et al.*, 2001, Abdulmalek *et al.*, 2006, De Koning *et al*,, 2008).

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 (Cua *et al.,* 2001). Furthermore, Six Sigma is highly related to problem solving methodologies (De Koning *et al.*, 2008). Therefore, it is expected that all the practices included in these bundles contribute to a greater performance: for instance, the use of value stream mapping through its focus on eliminating waste and efficiencies and *kaizen* by being centred in the continuous improvement (Abdulmalek *et al.*, 2006).

There will be considered the following practices for each bundle:

JIT: Cellular production; *kanban*, *heijunka*, visual control, one piece flow, standardization, line balancing and pull system. As a fundamental principle in JIT, elimination of waste will also be considered as practice.

TQM: Value stream mapping, *Kaizen*, PDCA (Plan-Do-Check-Act), Cause and effect diagrams, Pareto analysis, five whys and some supportive charts as run chart and control chart.

TPM: Only 5S will be considered, as the other TPM practices are more linked to manufacturing.

HRM: Self-directed work teams and flexible cross-functional teams.

Six Sigma: DMAIC, SIPOC and VOC. The use of Six Sigma will also be considered as a practice.

(3) Management commitment (Achanga *et al.*, 2006; Bhamu and Sangwan, 2014).

As one of the critical success factors of lean, it is anticipated that the greater the management commitment, the greater the impact on lean performance.

(4) Employee involvement (Achanga *et al.*, 2006).

It is expected a higher impact on performance when there is a higher employee involvement.

(5) Training (Bhamu and Sangwan, 2014).

More investment in training should lead to a higher impact on performance.

(6) Type of service

The existing heterogeneity between the different kinds of services makes it difficult to treat them as they were the same (Hadid and Mansouri, 2014). This variable is exploratory.

(7) Size of the company (Hadid and Mansouri, 2014)

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 have a more complex structure that does not support flexibility (Hadid and Mansouri, 2014). Thus, the expected signal can be either positive or negative.

The following equation depicts the theoretical model:

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

$$i = JIT, TQM, TPM, HRM, SixSigma.$$

Table 6 synthetize the determinants considered in the theoretical model and its expected impact in lean performance.

Group	Variables	Expected signal
Number of practices adopted	NrLeanPracticesAdopted	*
Use of JIT practices	CellularProduction; *Kanban*; *Heijunka*; VisualControl; OnePieceFlow; EliminationWaste; Standardization; LineBalancing; PullSystem	+
Use of TQM practices	VSM; *Kaizen*; PDCA; CauseEffectDiagrams; ParetoAnalysis; FiveWhys; SupportiveCharts	+
Use of TPM practices	FiveS	+
Use of HRM practices	SelfDirectedWorkTeams; FlexibleCrossFunctionalTeams	+
Use of Six sigma practices	SixSigma; DMAIC; SIPOC; VOC	+
Management commitment	ManagementCommitment_Leadership	+
Training	Training	+
Employee involvement	Culture/EmployeeInvolvement	+
Type of service	TypeOfService	*
Size of company	CompanySize	+/-

*exploratory variable

Table 6: Determinants of the theoretical model

3. Methodological Considerations

In this Chapter, it is presented the methodological tool that is used on this dissertation: a systematic literature review that will further be used as a basis for a regression analysis. In Section 3.1, it is done some considerations about the concept of this methodology. The focus of Section 3.2 is the description of the required steps. Finally, in Section 3.3, it will be explained the article selection process.

3.1. Systematic Literature review

According to Tranfield *et al.* (2003), systematic literature reviews differ from the traditional since they allow an audit trail of the procedures and conclusions of the reviewers, through a transparent, systematic and scientific process.

We followed the structure proposed by Tranfield *et al.* (2003):

Steps	
1st step	Planning
2nd step	Conducting
3rd step	Reporting

Table 7: Steps of a systematic literature review

3.2 Planning, conducting and reporting

The first phase consisted in identifying the objectives for this review and developing a protocol to decide the inclusion criteria.

In order to be as accurate as possible addressing the research questions, the inclusion criteria should be decided carefully.

First, only case studies must be used as source of data collection. Therefore, literature reviews and surveys were excluded.

Second, these articles must only analyse the implementation of lean in services as this is the purpose of this study.

Finally, the articles must analyse 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.

Inclusion criteria	
1st	Data type: case study
2nd	The study has to analyse: Lean in services
3rd	The study has to analyse: Relationship between lean implementation and company performance

Table 8: Inclusion criteria

Four specific articles were included as sources: Leyer *et al.* (2015), Gupta *et al.* (2016), Leite and Vieira (2015) and Suárez-Barraza *et al.* (2012). The articles that were analysed by these authors were included in this research as much as possible.

To complement these articles, using the terms "lean service" and "case study", a literature search for articles was performed. The source of those articles was mainly databases such as SCOPUS and Google Scholar.

Under the second phase of this process, all the articles that according to these criteria were not adequate were excluded. Then, all data regarding the type of service, size of companies, country, number of (and which) lean practices that were used and the results obtained in terms of performance were recorded. Moreover, the existence of the critical success factors studied in the literature review was also evaluated.

The practices were classified with "1" if used and "0" if not used.

The type of service was classified into the following groups: healthcare, hotel industry, housing services, telecommunication, 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 case of being a company of the public sector, this was classified as more specific as possible as several services can be a part of this category. For instance, local authorities or governments were classified as public administration.

The size of company, if the information is available, will be classified into large, medium or small, based on the information provided, and/or the number of employees and turnover.

For each case, the performance measures and the critical success factors (management commitment/leadership, training/education programs and organizational culture/employee involvement) were classified in a scale of 1 to 5 – Likert Scale:

1 – The performance measure had noticeably worsened/the critical success factor was quite insufficient;

2 – The performance measure had worsened/the critical success factor was insufficient;

3 – Indifferent/ Non-significant;

4 – The performance measure had improved/the critical success factor was good;

5 – The performance measure had noticeable improved/the critical success factor was excellent.

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

3.3. Articles selection process

The process of articles selection is described in Figure 2.

As previously mentioned, this process started with a literature search. Four specific articles were considered as a source: 80 articles were listed from Leyer *et al.* (2015), 122 from Gupta *et al.* (2016), more than 70 from Leite and Vieira (2015) and 172 from Suarez-Barraza *et al.* (2012). From the online database, 426 articles were found. Some of these articles were common.

After excluding the articles that were not adequate according to the inclusion criteria, 72 articles were considered as suitable to our analysis (Appendix 1). As some of these articles were 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 to be used is available upon request to the author.

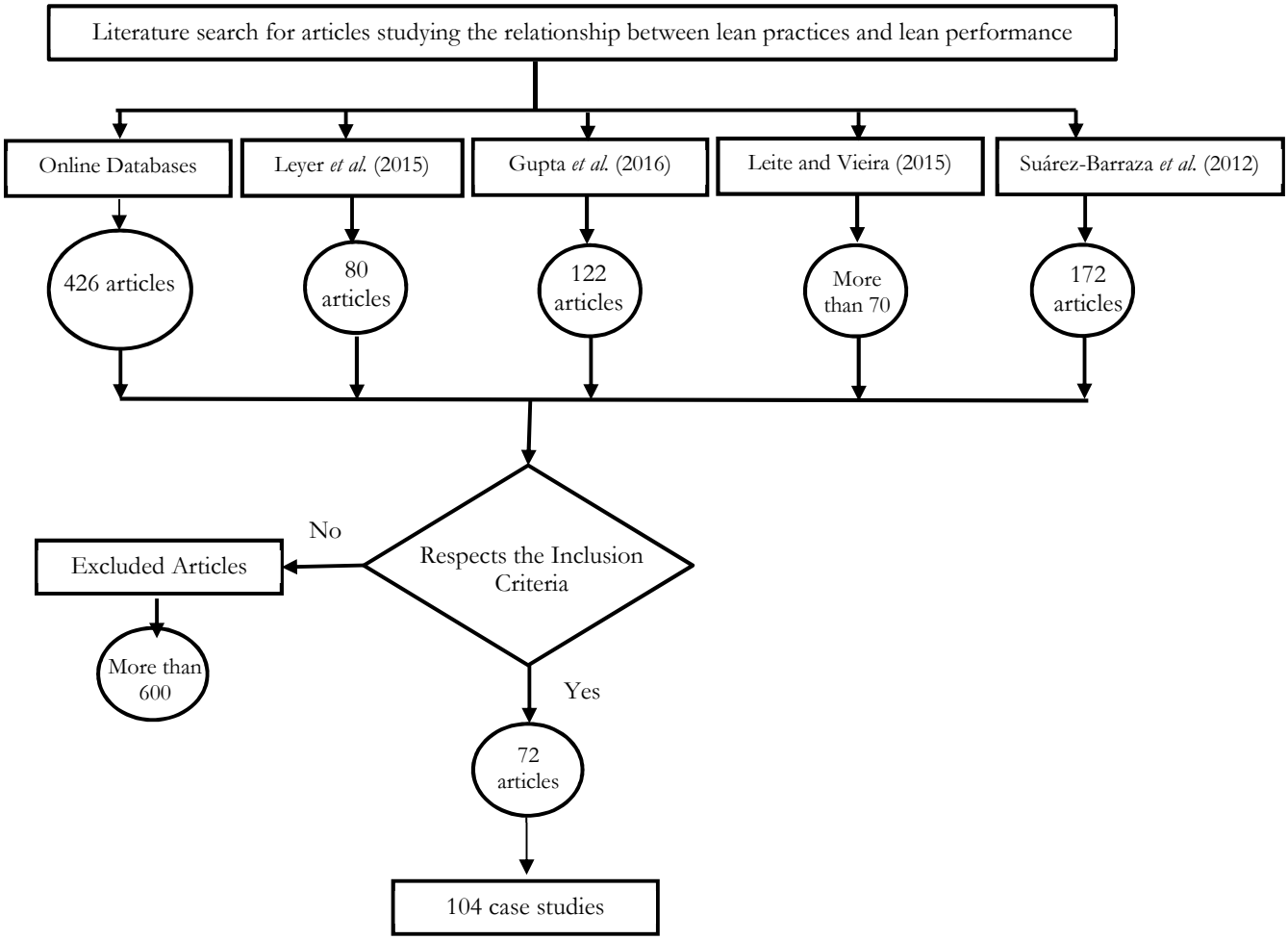

Figure 2: Process of articles selection

4. Main Results

In this chapter, it is presented the main results of this research. In Section 4.1, it is done a descriptive analysis regarding the final database that was obtained. In the following section, the correlations between the variables are analysed and, in Section 4.3, the results of the proposed models are presented. In the last section of the chapter, the main implications of this research are discussed.

4.1. Descriptive analysis

It was possible to obtain 104 valid companies in case studies to analyse the implementation of lean management.

The time of study was categorized in: 2002-2005, 2006-2009, 2010-2013, 2014-2018. The period 2006-2009 was the one comprising more case studies (41), followed by 2010-2013 (34).

Relatively to the company size, big companies stood out representing 50 companies of the studied 104. The company size was not identified for 22 companies due to lack of information.

This sample included companies from several countries such as Australia, Canada, China, Denmark, India, Italy, Mexico, Netherlands, Portugal, Scotland, Korea, Sweden, Spain, Thailand and Taiwan, being the most common cases United Kingdom (24%) and USA (10%), which lead us to conclude that lean is being implemented worldwide.

In which regards to the type of service, these companies are from very different sectors: engineering; education; banking, financial and insurance; healthcare; hotels, distribution, retail and logistics; public administration; IT and software; telecommunication, etc. It should be noted that healthcare was the most frequent service, representing approximately 32% of these companies.

Several practices were found to be used in these services: 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 in 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 part of these companies combined lean and six sigma, using methodologies such as DMAIC, SIPOC (suppliers, inputs, process, outputs and customers) and Voice of Customer.

Practices as preventive maintenance and breakdown maintenance were not found to be used as they are more linked with manufacturing.

Disregarding value stream mapping and *kaizen*, from the studied companies, the most used practices were slightly different depending on the type of service. For instance, for healthcare, the most common were elimination of waste, self-directed work teams and visual control while for bank, financial and insurance companies the most used were standardization and line balancing. Besides, call centers invested more in practices as cellular production, voice of customer and flexible, cross-functional teams and, on the other side, companies related to construction/engineering or until with public administration focused on elimination of waste.

It was registered some measures of performance: time measures, productivity/efficiency, quality/defects, revenues/cost savings and customer satisfaction, for example. In general, lean proved to be useful at improving performance in these aspects, which is consistent with the benefits presented by Gupta *et al.* (2016).

Finally, the existence of some critical success factors was also analysed. They were: management commitment, training/educational programs and organizational culture/employee involvement. Companies with lack of these factors showed indeed a worse performance than others. This is in line with Bhamu and Sangwan (2014) that defend that lack of these factors put at risk the effectiveness of lean implementation.

4.2. Correlations between the variables

In this section, it is done a correlation matrix analysis between the variables in order to assess the possible degree of explanation of the independent variables on lean performance. Table 9 presents the more significant correlations while the complete table is inserted in Appendix 2. The dependent variable is the number of performance measures classified with 4 or 5 (performance measures that were improved). We also analyse the dependent variable time, elimination of waste, productivity/efficiency, quality/defects, costs savings and customer satisfaction.

	Nperf>4	Time	Elimination of waste	Productivity	Quality	Costs savings	Customer satisfaction
Number 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.

Table 9: Spearman correlation matrix

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

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

In which regards to performance measures, costs savings is the one that is significantly and strongly correlated with more practices.

Going deeper in the analysis, it is verified a significant correlation between the first dependent variable – number of performance measures that were improved – and 10 variables. Four of them with a level of significance of 1% - number of practices adopted, voice of 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 these, the variables with stronger correlation with performance (rho>0,3) are the number of lean practices adopted, voice of customer and cross-functional teams. According to this bivariate analysis perspective, companies that use these practices tend to have a greater lean performance. The same happens to companies that invest in training and use as much practices as possible. The number of practices adopted turned out to be important since lean is guided for five principles (Womack *et al.*, 1996) and it can be inferred that it should be used different practices to address each of these principles. However, the use of PDCA, with a negative sign, is not associated to the same benefit.

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 greater level of performance in terms of time.

The variable elimination of waste has a positive and significant correlation with 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%. The use of these practices and investment in training tend to lead to a higher performance concerning 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 flexible, cross-functional teams tend to contribute to a greater productivity and efficiency, while PDCA does not seem to have the same benefit.

On the subject of quality, voice of customer, training and 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%. Then, the use of these practices, the existence of management commitment and investment in training leads to a higher quality. The same happens if companies use as much practices as possible.

In which respects to costs 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 (Furterer and Elshennawy, 2005; De Koning *et al.*, 2008). The same happens with number of lean practices adopted, VSM and supportive charts. Additionally, it was found a significant correlation with voice of customer and self-directed work teams at a level of 5%. With a negative sign, self-directed work teams does not tend to have the same positive influence as the remaining mentioned practices in this measure.

Finally, customer satisfaction has a significant correlation with voice of customer 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 voice of customer tends to help to have an increased customer satisfaction, which does not happen with line balancing.

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 lean 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 it is one of the most relevant measures linked to the emergence of lean management.

4.3.1 Results of model 1

The results of the first model are presented in the tables below.

Determinants		Estimate	Std. Error	t value	Pr(>|t|)
Practices	VSM	0,113	0,299	0,379	0,705
	Kaizen	-0,517	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	0,462	2,718	0,008***
	5 Whys	0,985	0,538	1,832	0,071*
	Supportive charts	0,903	0,379	2,384	0,020**
	5S	-0,347	0,327	-1,062	0,292
	Cellular production	0,143	0,283	0,504	0,615
	Kanban	-0,340	0,673	-0,506	0,614
	Heijunka	1,356	0,768	1,766	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	0,684	0,496
	Standardization	0,293	0,297	0,986	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	0,616	-0,121	0,904
	SIPOC	-0,023	0,504	-0,045	0,964
	VOC	0,686	0,298	2,304	0,024**
	Self-Directed Work teams	-0,016	0,295	-0,053	0,958
	Flexible cross-functional teams	0,564	0,317	1,779	0,079*
Critical success factors	Management commitment	0,122	0,076	1,621	0,100*
	Training	1,171	0,071	2,410	0,018**
	Employee involvement	-0,048	0,064	-0,754	0,453

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 26 and 77 DF p-value: 0.00009278

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

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

Table 10: Results of the first model

	Value	p-value	Decision
Global Stat	8,229449	0,08353	Assumptions acceptable.
Skewness	2,279978	0,13105	Assumptions acceptable.
Kurtosis	0,003097	0,95562	Assumptions acceptable.
Link Function	3,207442	0,07330	Assumptions acceptable.
Heteroscedasticity	2,738932	0,09793	Assumptions acceptable.

Table 11: Assessment of the linear model assumptions – model 1

We ensured the model met all linear model assumptions using the 'gvlma' package (Peña and Slate, 2014) in R version 3.5.0. This package implements the testing procedure developed in Peña and Slate (2006).

The Shapiro test was also used to test normality of residuals.

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

The results show that there are eleven factors that explain the impact of lean on performance. From these eleven factors, nine have a positive sign: Pareto analysis, 5 Whys, supportive charts, *heijunka*, pull system, 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 a higher lean 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 a higher lean performance (Cua *et al.*, 2001, Abdulmalek *et al.*, 2006, De Koning *et al,*, 2008). Still, the use of TPM did not prove to significantly help to improve it.

Besides, the positive and statistically significant sign of management commitment and training points out that the higher degree of management commitment and training, the greater lean performance. Indeed, these two are considered as critical success factors for the implementation of lean (Achanga *et al.*, 2006; Bhamu and Sangwan, 2014), and, for that reason, this result was expected. On the other hand, it was expected that the organizational culture/employee involvement as other of the critical success factors (Achanga *et al.*, 2006) was also highlighted in 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 a positive sign given the possibility of highlighting mistakes and defects provided by visual control (Russel *et al.*,2011) and the character of continuous improvement of *Kaizen* (Abdulmalek *et al.*, 2006). In the case of *kaizen*, it should be taken into consideration that it is based in a gradual and incremental change and its effects may not be readily perceived in a short period of time (Belekoukias *et al.,* 2014). Another possible explanation for these results may be some implementation issues with these lean practices and thus they were not fully and effectively implemented (Belekoukias *et al.,* 2014). Or, if these practices were implemented first, they may have had a significant improvement at that time while the recently implemented had currently a higher impact that was highlighted in this analysis.

4.3.2. Results of model 2

The results of the second model are presented below. Again, we ensured the model fulfils all linear model assumptions via the 'gvlma' package. The Shapiro test was also used to test normality of residuals.

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

	Determinants	Estimate	Std. Error	t value	Pr(>|t|)
Type of service	Banking, financial and insurance	-0,106	1,276	-0,083	0,933
	Call Center	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

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

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

Table 12: Results of the second model

	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.

Table 13: Assessment of the linear model assumptions - model 2

The results of this model show that nine factors explain performance in terms of quality, five of which have 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 the fact of being a company of this sector is a determinant to a greater lean performance, regarding quality. Software and IT appears to be a predisposed service to adopt lean management.

Another exploratory variable analysed in this model was if the number of practices used had influence on the performance. Again, the positive and statistically significant sign for this variable means that the more practices used, the higher the quality achieved. This is in accordance to what was expected, since lean is guided by five principles (Womack *et al.*, 1996) and all should be addressed in order to successfully implement it.

In this model, the use of line balancing proved to be a factor that contributes to a higher performance. This was also already presumed given the already presented motivations of JIT. Moreover, according to Belekoukias *et al.* (2014), JIT has the highest impact in performance in which regards to quality.

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

Again, in accordance to model 1, *kaizen* and visual control present a negative and statistically significant sign. In this model, the same happened when self-directed work teams are used.

Finally, the sign for the company size in terms of lean performance was expected to be either positive or negative since the larger the company the more financial capacities it has, but it also has less flexibility (Hadid and Mansouri, 2014). By these results, it is possible to conclude that the implementation of lean in medium-sized companies is not likely to be linked to a higher quality.

4.4 Implications

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

First, the case studies analysed were converted to observations in order to do a regression analysis and, up to our knowledge, this is the first time such an approach is followed in the literature to study lean in services.

Practically, this study can be of extreme help 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, managers

should put all their efforts when implementing lean management, by showing all their commitment and investing in educational programs in order to prepare the best assets of a company – the employees.

5. Conclusion

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

The results showed that value stream mapping and *kaizen* are undoubtedly the practices more adopted. 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. Besides, lean proved to be useful at improving measures such as time, productivity, quality, costs and customer satisfaction.

Individually, this analysis can provide some insights for managers that are thinking in implementing lean or in how to achieve better results with it. It should not be anticipated that all lean practices contribute to improve all performance measures. Voice of 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 the tested models, several factors have a positive influence in lean performance in a global way: the use of Pareto analysis, 5 Whys, supportive charts, *heijunka*, pull system, voice of customer and flexible, cross-functional teams. Specifically, in which regards to quality, line balancing can also be spotted. Thus, practices from the different bundles proved to have a positive influence in lean performance. Also, as expected, we can conclude that the more engaged managers are and the more they invest in the training of employees, the greater performance companies will achieve.

On the other hand, there are practices (e.g. *kaizen* and visual control) that have a negative coefficient in the regression explaining the lean 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. Also, future research should focus on how to implement lean management in services, for instance to find out which practices should be implemented in a simultaneous

way in order to achieve a greater performance simply by interacting with each other or if they should be implemented in a sequential way.

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Appendix 1 – List of studies included in the analysis

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)	European Journal of Marketing
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
McCulloch *et al.* (2010)	Bmj
Wang and Chen (2010)	Total Quality Management & Business Excelence
Laureani *et al.* (2010)	International Journal of Productivity and Performance Management
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
Mazzocato *et al.* (2012)	BMC health services research
Cheng and Chang (2012)	Total Quality Management & Business Excellence
Jaca *et al.* (2012)	Total Quality Management & Business Excellence
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
Kumar *et al.* (2013)	International Journal of Productivity and Performance Management
Di Pietro *et al.* (2013)	Total Quality Management & Business Excellence
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, Organization and Management
Mazzocato *et al.* (2014)	Journal of Health, Organization and Management
Gutierrez-Gutierrez *et al.* (2016)	International Journal of Lean Six Sigma
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

Appendix 2 – Spearman Correlation matrix

		Nperf>4	Time	Elimination of waste	Productivity	Quality	Costs savings	Customer satisfaction
Number of lean practices adopted	Correl.coef.	0,376**	0,068	0,102	0,157	0,275**	0,289**	0,159
	Sig.	0,000	0,494	0,301	0,112	0,005	0,003	0,107
VSM	Correl.coef.	0,197*	-0,019	-0,071	-0,053	0,207*	0,261**	0,103
	Sig.	0,045	0,844	0,474	0,592	0,035	0,007	0,297
Kaizen	Correl.coef.	-0,051	-0,012	0,015	0,045	-0,125	-0,087	-0,047
	Sig.	0,608	0,901	0,880	0,647	0,206	0,380	0,635
PDCA	Correl.coef.	-0,214*	-0,071	-0,114	-0,212*	-0,045	-0,149	0,109
	Sig.	0,029	0,471	0,248	0,031	0,651	0,131	0,272
Cause and effect diagrams	Correl.coef.	0,177	0,040	0,111	0,006	0,039	0,325**	0,047
	Sig.	0,072	0,690	0,261	0,953	0,693	0,001	0,633
Pareto analysis	Correl.coef.	0,260**	0,118	0,011	0,191	0,172	0,256**	0,017
	Sig.	0,008	0,235	0,912	0,052	0,081	0,009	0,864
5 Whys	Correl.coef.	0,115	-0,148	0,170	-0,009	0,030	0,000	0,073
	Sig.	0,247	0,135	0,085	0,927	0,760	1,000	0,460
Supportive charts	Correl.coef.	0,241*	0,120	0,129	0,116	0,012	0,265**	0,090
	Sig.	0,014	0,224	0,193	0,243	0,902	0,007	0,364
5S	Correl.coef.	-0,014	-0,121	0,090	0,019	0,062	-0,181	-0,075
	Sig.	0,889	0,222	0,366	0,844	0,529	0,066	0,449
Cellular production	Correl.coef.	0,207*	0,254**	0,208*	0,150	0,060	-0,025	0,135
	Sig.	0,035	0,009	0,034	0,129	0,547	0,803	0,171
Kanban	Correl.coef.	0,133	0,018	0,015	0,095	0,079	0,168	0,137
	Sig.	0,180	0,859	0,877	0,337	0,428	0,089	0,165
Heijunka	Correl.coef.	0,082	-0,059	-0,098	0,110	0,090	0,086	0,064

	Sig.	0,410	0,553	0,320	0,265	0,362	0,388	0,520
Visual control	Correl.coef.	-0,081	-0,104	-0,077	-0,059	-0,012	-0,052	-0,075
	Sig.	0,414	0,294	0,435	0,550	0,906	0,602	0,449
One piece flow	Correl.coef.	0,143	0,036	0,022	0,161	0,200*	-0,081	-0,058
	Sig.	0,147	0,719	0,823	0,103	0,041	0,416	0,559
Elimination of waste	Correl.coef.	0,069	-0,019	0,253**	0,016	0,077	-0,007	0,023
	Sig.	0,486	0,851	0,009	0,871	0,438	0,941	0,816
Standardization	Correl.coef.	-0,014	0,016	-0,020	-0,005	0,052	-0,046	-0,146
	Sig.	0,890	0,874	0,840	0,964	0,599	0,642	0,139
Line balancing	Correl.coef.	0,011	0,202*	-0,162	0,232*	0,061	-0,153	-0,198*
	Sig.	0,909	0,040	0,101	0,018	0,536	0,121	0,043
Pull system	Correl.coef.	0,177	0,164	0,029	0,264**	-0,033	-0,023	0,097
	Sig.	0,073	0,095	0,771	0,007	0,737	0,815	0,327
Six sigma	Correl.coef.	0,119	0,002	-0,079	-0,149	0,095	0,433**	0,107
	Sig.	0,227	0,981	0,425	0,131	0,339	0,000	0,278
DMAIC	Correl.coef.	0,241*	0,009	0,018	0,116	0,058	0,438**	0,074
	Sig.	0,014	0,930	0,856	0,243	0,556	0,000	0,453
SIPOC	Correl.coef.	0,102	0,041	-0,052	0,019	0,044	0,314**	-0,119
	Sig.	0,304	0,677	0,599	0,845	0,659	0,001	0,229
VOC	Correl.coef.	0,369**	0,069	0,123	0,075	0,327**	0,212*	0,420**
	Sig.	0,000	0,485	0,212	0,452	0,001	0,030	0,000
Self-directed work teams	Correl.coef.	-0,112	0,070	-0,073	0,061	-0,151	-0,237*	0,024
	Sig.	0,257	0,479	0,462	0,538	0,127	0,016	0,808
Flexible, cross-functional teams	Correl.coef.	0,355**	0,195*	0,203*	0,284**	0,203*	0,045	0,145
	Sig.	0,000	0,047	0,039	0,004	0,039	0,653	0,141
Management Commitment	Correl.coef.	0,124	0,052	-0,025	-0,124	0,210*	0,030	0,114
	Sig.	0,210	0,600	0,803	0,211	0,032	0,766	0,247

Training	Correl.coef.	0,240*	0,018	0,176	0,062	0,292**	-0,077	0,171
	Sig.	0,014	0,853	0,075	0,534	0,003	0,439	0,083
Employee involvement	Correl.coef.	-0,076	-0,114	0,035	-0,103	-0,095	-0,110	0,102
	Sig.	0,441	0,248	0,724	0,299	0,340	0,267	0,302