
A bibliometric study on the use of Lean thinking in services

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Biographical Notes

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Abstract

Purpose – With the increasing discussion about Lean management and growing application of Lean thinking in service industries, there is an urgent need of a systematic review of the literature to identify the hot topics within “Lean in services” and to link the scholarly findings with practical implementation. The purpose of this research is to establish a comprehensive chronological and geographical overview of the current issues that have been mostly discussed related to the use of Lean thinking in services, unveiling its main contributions, trends, gaps and weaknesses.

Design/methodology/approach – Bibliometric techniques are used in this study in order to deepen and systematize the analysis of the relevant literature. To achieve that, a wide collection of literature from two databases – Web of Science (WoS) and Scopus – were investigated and bibliometric analyses were conducted, namely publication counting and abstract analysis, co-citation analysis and co-word analysis.

Findings – Describing a Lean implementation project and evaluating its outcomes are the most frequent type of themes. Reducing waste and increasing efficiency are often mentioned as the benefits. There are clear gaps in research density between multiple service sectors and healthcare, and lack of established model/framework and extensive use of case study method are the weaknesses of the studies in this field.

Research limitations/implications – The data is only collected from WoS and Scopus, which can be subject to certain limitation. The study gathers the practices of implementing Lean in services and identifies the most popular and influencing practices. However, it does not necessarily mean that the most used ones are the best ones. There is a need for studies comparing those practices and evaluating their effects, in order to provide more insights for practitioners to choose the most fitted practices under specific condition.

Practical implications – This dissertation provides Lean thinking practitioners an easier access to the plenty of literature about Lean, allowing them to have a sketch of the landscape of this field and informing them the trends of applying Lean in services, thus helping them to make their own decisions in reality.

Originality/value – The dissertation is valuable on the aspect of summarizing the most salient themes in applying Lean thinking in service sectors, since though there are lots of literature exploring topics in Lean and how to implement Lean thinking, this is the first

efforts to synthesize those topics in service industry as a whole using bibliometric methods. It is also valuable, by analyzing the current literature, to identify the trends, gaps and weaknesses in this field.

JEL-codes: L80, M10

Keywords: Lean thinking, services, bibliometric, co-citation analysis, co-word analysis

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1. Introduction

Over the years, Lean thinking (or Lean philosophy, or simply Lean) has become a popular concept among manufacturing industry. The implementation of the improvement processes of Lean had written stories of prominent success in the manufacturing, production and construction industry (Oludapo, Puteri, & Cheng, 2017). In the meantime, the movement of reducing cost, improving quality and increasing flexibility has been lagging for service industry (Suarez-Barraza, Smith, & Dahlgaard-Park, 2012). The service sector takes up more than half of the gross domestic product (GDP) and employment of most modern economies, for example, the service sector accounts for eighty percent of GDP in the US, however, despite of its vital role in the US economy, the productivity level in service sector is far lower than that in the manufacturing domain (Leite & Vieira, 2015; Suarez-Barraza et al., 2012). Indeed, services with such mass economic volume and crucial influence on daily life cannot be overlooked for optimization. Realizing this, many scholars and practitioners have seen great potential in applying Lean thinking, a set of ideologies originated from manufacturing industry, to service sector, such as health care, finance, education and IT. Actually, Lean has already been applied in these sectors and is recently growing faster (Bhamu & Sangwan, 2014; Jasti & Kodali, 2014).

The growing discussion of Lean in services by scholars and use of Lean thinking by companies have markedly augmented the literature on this subject, which increases the need for organizing this body of knowledge. The dissertation targets to conduct a systematic review on the implementation of Lean thinking in services by using bibliometric methods. It provides not only academic researchers but also industry insiders an easier access to the plenty of literature about Lean and allows them to know the most salient themes in this field. The dissertation also identifies the most commonly used Lean tools, thus Lean practitioners can, considering different situations, choose the most appropriate techniques, derived from vast publications, for the practical implementation. Additionally, by analyzing the current literature, the study aspires at recognizing the trends, gaps and patterns in this field, undertaking a related thematic, chronological and geographical analysis of the literature, which will benefit scholars a lot in recognizing future research directions. At the same time this research was being conducted, an internship at Li & Fung (Portugal) Lda., the branch in Porto of the multinational group, was performed as a

requirement for curricular internship from the QTEM program of the Master program. All the details about the company and activities performed are included in Appendix 1.

With these research purposes in mind, we perform a bibliometric analysis on the literature. This methodology is effective to serve our purposes because it collects bibliographic information created by researchers working in the area and from this information it generates insights into the area's literature structure and topical interests (Zupic & Cater, 2015). Compared with traditional qualitative literature review, it uses a quantitative approach and aggregates data from numerous studies and scholars instead of manual selection. Therefore, bibliometric methods increase rigor and objectivity, and neutralize researcher bias in reviews of scientific literature (Zupic & Cater, 2015).

To successfully conduct a bibliometric analysis and reach the research purposes, the dissertation is organized as follows. In Chapter 2, a literature review is performed to introduce the concepts of Lean thinking and its implementation, the characteristics and classification of services, as well as some similar studies of systematic reviews on Lean in services. The bibliometric methods, which are the methodologies employed in this dissertation, are presented in Chapter 3, and following that their results are given and interpreted in Chapter 4. Finally, Chapter 5 is dedicated to the conclusions.

2. Literature Review

This section is divided into three parts: Lean thinking, Services, and Similar Studies. In the first part, it is presented a brief history of Lean, the principles, some common practices and tools of Lean and a short discussion about Lean implementation. In the second part, the definition of service is introduced, the characteristics of services and the classification of services. Finally, some studies similar to this dissertation are reviewed: bibliometric reviews of Lean implementation in the scope of a service sub-sector, and non-bibliometric reviews of Lean implementation in the scope of the general service sector.

2.1 Lean Thinking

2.1.1 Theoretical Background

Lean was originated in a series of innovations in Toyota Motor Corporation in facing with scarce in resources and intense competition (Monden, 2011; Ohno, 1988; Shingo, 1988; Shingo & Dillon, 1989). These innovations included e.g., the just-in-time production system and the kanban method of pull production. The Lean operations management system contains methods that aim to achieve waste minimization without sacrificing productivity. The waste and excess from the tactical product flows at Toyota also include waste created through overburden and waste created through unevenness in workloads (Hines, Holwe, & Rich, 2004). The steady growth of Toyota and its superior performance over the traditional mass production system designs had attracted attention on how it has achieved this success, however, western manufacturers only were able to investigate the lean approach in 1970s (Hines et al., 2004).

The term “Lean production/manufacturing” is popularized by Womack, Jones, and Roos (1990) through their book *The Machine that Changed the World* in which the performance gaps between Toyota and other car manufacturers were revealed. However, many early Lean efforts were restricted by the difficulty of changing organizational culture and mindset required by introducing Lean thinking. As a result, the overall impact on performance was not satisfactory since the tool-focused implementation of Lean in this period neglected influencers in terms of “human” of the success of Lean manufacturing practices (Holweg & Pil, 2001).

In 1990s, a broader focus on Lean appeared. The adoption and imitation of Lean manufacturing came to a milestone by applying new designs developed based on Lean

principles to production system (Hines et al., 2004). The first complete Lean model was proposed by Womack and Jones's book *Lean Thinking* in 1996. These principles involved the customer value identification, the value stream mapping, the flow production system, the "pull" mechanisms to assure the flow of materials, and the pursuit of perfection by continuously reducing all forms of waste (Womack & Jones, 1996). Also during that decade, the value stream concept expanded beyond manufacturing and individual company to include the entire chain from customer needs to raw material sources, thus for the first time the up and downstream companies were also included in the production "pull" and the linkage between Lean and supply chain was built (Hines & Rich, 1997; Rother & Shook, 2003).

2.1.2 Principles, Practices and Tools

There is no unified definition of Lean thinking, but it may be considered as a set of principles and tools in production to increase product or service quality, profit margins and market share by continuously improving processes and focusing on customer satisfaction and well-being of employees (Kim, Spahlinger, Kin, & Billi, 2006; Liker, 2004). The principles of Lean are first proposed by Womack and Jones (1996). For decades they are the basis of production systems of many western companies which successfully adapted Toyota Production System (Hines et al., 2004). According to Womack and Jones (1996), the five principles are:

1. Value Identification

The value of the product or service should be reviewed from the customer's standpoint, for example, what the customer really need, how the customer is benefited from the product. This reflects the customer-focus nature of Lean.

2. Value Stream Mapping

Once the value is defined, the process that fulfills the goal should be designed. The manager should draw a physical map for every step of the process for each part of the business and make sure every part of the process is adding value.

3. Creating Flow

After the value stream map is drawn, it should be analyzed and optimized to make it run smoothly, efficiently and without waste. Manager should reduce friction between each step,

eliminate unnecessary steps and assemble the steps in a streamlined way, thus creating a flow.

4. Pull System

Bringing the customer exactly what they need at exactly the right time is the revolutionary idea of Lean production. Instead of preparing materials, planning production, stockpiling products and waiting for customer's order, look reversely through the value stream map and let the customer triggers the whole chain at the end point. Establishing the Pull system can reduce waste while addressing the customer's true needs.

5. Perfection/Continuous Improvement

Finally, managers should constantly revise the whole process, find areas of improvement and try to make every step increase value. The five Lean principles should be performed continuously and repeatedly in pursuit of perfection.

The House of Lean Production, shown in Figure 1, is the symbol of the Lean principles.

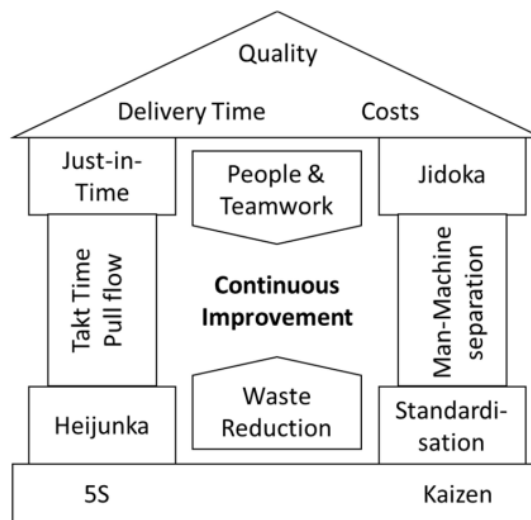


Figure 1 House of Lean Production

Source: Adapted from Liker (2004); Ohno (1988)

The key performance indicators (KPIs) – quality, delivery time and costs – make the roof of the House, showing that customer-oriented is the key focus of Lean (Liker, 2004; Ohno, 1988). At the center of the House is the basic approach of Lean production – continuous

improvement. It is surrounded by a set of principles and techniques to eliminate waste, namely:

The techniques: 5S, Kaizen, Just-in-Time (JIT), Jidoka, Heijunka, Standardization, Takt time, Pull flow, Man-machine separation; and the principles: People and teamwork, and Waste reduction.

There are plenty of Lean tools/techniques, and Table 1 describes some common ones.

Lean tools	Description
5S	Guidelines to organize the work place: Sort (remove unnecessary items and obstacles), Set in order (arrange necessary items to make them easily accessible), Shine (keep work area clean), Standardize (make rules to keep the practices), Sustain (maintain the good state by training and self-discipline).
Heijunka	Leveling the type and quantity of production in order to reduce lead times and waste.
Jidoka	Automate the processes and stop automatically when detecting problem, so that it will not produce defected products.
Kaizen	Employees work together to improve the production process regularly, proactively and continuously.
Standardization	Document the work procedures that capture best practices. The documentation should be easy to update.
Takt Time	Align the production pace with customer demand. For example, the customer needs one piece of product every 30 seconds on average so the company should produce one piece every 30 seconds.

Table 1 Some Common Lean Tools

Source: Liker (2004); Ohno (1988)

2.1.3 Implementation of Lean

The implementation of Lean, from its birthplace, the auto industry, to the overall manufacturing industry, and further to the service sector, has generated both qualitative and quantitative benefits recognized by researchers (Bhamu & Sangwan, 2014; Gupta, Sharma, & Sunder, 2016; Leite & Vieira, 2015). Table 2 summarizes the benefits of Lean implementation in manufacturing and in some services.

Sector	Benefits
Manufacturing	Reduced production lead time; improvement of setup, cycle and processing times; less defects and scrap; larger overall equipment effectiveness (OEE); improved job satisfaction; better communication, etc.
Services	Healthcare Decreased waiting time and better quality of care
	Software Lower variability of performance and less defects and rework
	Education Improved relevance of course materials and reduced delivery time of knowledge

Table 2 Benefits of Lean Implementation in Several Sectors

Source: Bhamu and Sangwan (2014); Gupta et al. (2016)

Table 3 shows some results of service companies after applying Lean.

Sector	Company	Results of Lean implementation
Airline	Southwest Airlines	Created flow and speed of service delivery, reduced service costs
Entertainment	Disney Theme Parks	Improved processes to ensure quality
Finance	Jefferson Pilot Financial Company	Better operation and higher revenue. Reduced by 70% the time of dealing a request, 26% the labor cost and 40% errors.
Healthcare	Shouldice Hospital	High rates of recovery of patients, reduced cost, greater availability of operating rooms and hospitalization
	LifeCare Hospital	Reduced 87% of infections caused by transfusion
	Monongahela Valley Hospital	Significant reduction in infections
	UPMC Health System	
	Allegheny General Hospital	
IT	Fujitsu services	Decreased by 40% customer complaints, improved customer satisfaction and reduced operating costs
Restaurants	Taco Bell	One of the first companies in service sector on record to introduce Lean. Solved the tradeoffs between efficiency and flexibility, improved human resource management and increased focus on customer and on quality
	McDonald's	Improved processes to ensure quality
Retail	Tesco Retailer	Reached a level of service above 96%, and became the market leader in the UK
	Walmart	Avoided holding stocks in the back of the store or in a warehouse
	Zara	Avoided large inventories and established a quick response to the market
	Lotte Mart	Substantial cost saving by outsourcing logistics

Table 3 Examples of Service Companies Implementing Lean and Their Results

Source: Adapted from Leite and Vieira (2015)

The implementation of Lean is the key part of Lean management. Although well known the merits of Lean, many organizations failed to successfully put the philosophies into practice (Bhamu & Sangwan, 2014). Literature has identified several issues related to difficulties of Lean implementation. Bhamu and Sangwan (2014) sorted these issues into three categories: pre-implementation issues (e.g., lack of Lean awareness programs for all employees), implementation issues (e.g., lack of effective customer-supplier relationships) and post-implementation issues (e.g., lack of review of employees for recognition and awards). Jadhav, Mantha, and Rane (2014) pointed out 24 barriers to effective Lean implementation, among which lack of resources to invest, lack of top management involvement and negative attitude or resistance of workers are the barriers most frequently mentioned by literature.

Apart from difficulties of introducing Lean into organizations, managers should also pay attention to the question “how extensively should Lean be implemented into my organization and which Lean practices and tools should we choose?”, because organizational characteristics often determine whether particular management practice will be successful or not, thus different organizations will and should implement different sets of practices (Galbraith, 1978). Researchers have found empirical evidence showing that organizational context, for example, plant size, unionization and plant age, plays an important role in Lean implementation; especially for the plant size, substantial evidences suggest that larger plants are more likely to extensively implement Lean practices than smaller ones (Shah & Ward, 2003; White, Pearson, & Wilson, 1999; Yang, Hong, & Modi, 2011).

2.2 Services

2.2.1 Definition and Characteristics of Services

Nowadays the service industry is vital to the global economy and closely connected to our daily life. It contributes to more than half of the GDP and employment of major economies (Leite & Vieira, 2015). According to Kotler (2003, p.443), “Service is any act or performance that one party can offer to another that is essentially intangible and does not result in ownership of anything”. The production of services may or may not need the existence of a physical product. To distinguish services from goods, scholars have

conceptualized a variety of characteristics of service. After reviewing 46 pieces of literature from 1963 to 1983, Zeithaml, Parasuraman, and Berry (1985) identified the most frequently cited characteristics: intangibility, inseparability, heterogeneity and perishability.

Intangibility means that services are not always composed of physical attributes and their quality are difficult to describe to prospective customers (Berry, 1980; Haywood-Farmer, 1988). Inseparability signifies that production and consumption of services happen simultaneously (Cowell, 1986). Heterogeneity or non-standardization indicates that services generate performance with greater variability than goods which can be described or evaluated by more lucid and constant attributes (Haywood-Farmer, 1988; Zeithaml et al., 1985). As for perishability or inability to inventory, a common statement is that services cannot be saved, stored for reuse in the future, resold, or returned (Edgett & Parkinson, 1993). It is worth mentioning that the IHIP (intangibility, heterogeneity, inseparability and perishability) characteristics are not applicable to all services, and some services may not have some of these characteristics (Lovelock & Gummesson, 2004).

2.2.2 Classification of Services

As one of the pillars of modern economies, the service industry contains a lot of sub-sectors. According to Cobra (2004) (cited in Leite and Vieira, 2015), there are five major service sub-groups:

- 1) Business: consulting, finance, banks, etc.
- 2) Commercial: retail, maintenance, repairs, etc.
- 3) Infrastructure: communications, transportation, etc.
- 4) Social and personal: restaurants, supermarkets, health, etc.
- 5) Public administration: education, government, etc.

Since services cover a particularly wide range of activities, the difference between, not only service organizations among the same group but also service departments within the same firm, is comprehensive. The variety is so large that any global, all-embracing approach to service management is inaccurate (Haywood-Farmer, 1988). There must be a classification scheme to segment those services by their behaviors. Maister and Lovelock (1982) and Schmenner (1986) suggested a kind of two-by-two matrix to classify service activities based

on how the service is produced (see Figure 2). Although their names of the axis labels are different, the concepts behind are similar.

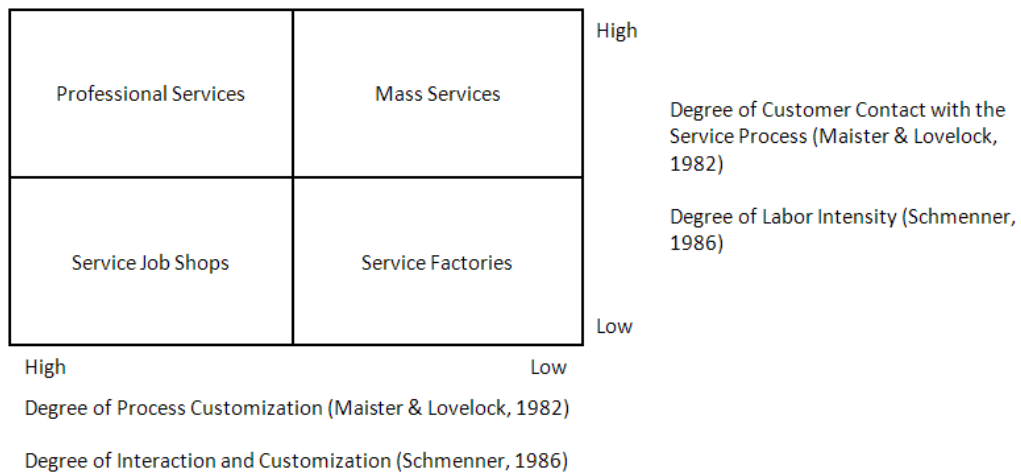


Figure 2 Services Classification Schemes

Source: Adapted from Maister and Lovelock (1982); Schmenner (1986)

2.3 Similar Studies

This dissertation is the first attempt to perform a bibliometric analysis on the topic of Lean implementation in the general service sector. Similar studies regarding Lean implementation are, mainly, of two kinds: i) bibliometric reviews in the scope of a specific sub-sector in services and ii) other type of systematic literature reviews (instead of bibliometric methods), in the scope of the entire service sector. Throughout this section it is briefly discussed similar studies from these two categories. A third category could be included (reviews on Lean implementation in sub-sectors in services using non-bibliometric methods) but, as they share less similarities to this study, are in an enormous number, and are often reviewed by the studies from the mentioned two categories, will not be discussed here.

2.3.1 Bibliometric Reviews of Lean Implementation in a Specific Service Sector

Not only there was no attempt to analyze Lean implementation in services as a whole using bibliometry, but also the efforts on a narrower scope are quite few. It was only found three bibliometric studies about Lean implementation in service industry and all of them fall into

healthcare sector. It is probably due to the huge number of studies about using Lean in healthcare, and also because the concept of continuous improvement and practice like staff empowerment in Lean thinking make Lean more adaptable to healthcare to have sustainable results (de Souza, 2009).

The articles are extremely latest with one published in 2012 and other three published in 2017. Plytiuk, Pasqualine, da Costa, and de Lima (2012) conducted both descriptive analysis and bibliometric analysis on 242 documents from 1998 to 2011. Filser, da Silva, and de Oliveira (2017) bibliometrically evaluated 304 documents from 2002 to 2015 about Lean Healthcare. Aleu and Van Aken (2017) used the database of 302 related publications from 1995 to 2014. All of them used Web of Science as the source of bibliographic data and two used Scopus. Publication counting, citation analysis, co-citation analysis and co-author analysis are the bibliometric methods they used, thus the present dissertation that will use co-word analysis will be a good supplement to the research field. Apart from this, the time range of publication analyzed of this dissertation is from 1998 to the first quarter of 2018, being not only the longest but also the most recent one.

Table 4 synthesizes the comparison of the three studies.

Author s	Scope	Source of data	No. of pub. analyzed	Bibliometric methods used	Time range of pub. analyzed	Major findings
Plytiuk et al. (2012)	Health care sector	WoS, Scopus, Emerald, OvidSP, ScienceDirect, Wiley	242	Citation analysis co-citation analysis	1998-2011	<ul style="list-style-type: none"> • absence of methodological rigor among the studies • very recent and immature domain (using of Lean in healthcare) • roots of Lean, different aspects of quality in hospitals and Lean Six Sigma are the main themes in this group

Filser et al. (2017)	Scopus, WoS	304	Publication counting, citation analysis	2002-2015	<ul style="list-style-type: none"> • relatively young area • new direction of existing literature should be encouraged • four future tendencies: evaluate the implementation; amplify basic knowledge; investigate challenges and success stories; expand the focus
Aleu and Van Aken(2017)	ProQuest, EBSCO, WoS, Engineering Village	302	Publication counting, co-author analysis:	1995-2014	<ul style="list-style-type: none"> • hospital CIPs are increasingly attracting new scholars each year. Authors publishing in this area can be described as a relatively new international community • lack of methodological rigor and the missing of a solid framework for assessing implementations in practice • most articles describe CIP implementation using case studies as research methods

Table 4 Bibliometric Reviews of Lean Implementation in One Specific Service Industry

Source: own elaboration

All the three studies found that the research field of Lean implementation in healthcare is very young. Plytiuk et al. (2012) noticed that the first researches in this domain appeared between 2002 and 2006, and then in the next five years there was a significant increase in the number of articles which takes up nearly eighty percent of total samples evaluated, showing that the majority of this knowledge base is less than ten years old. Aleu and Van Aken (2017) identified a significant increase in number of new authors after 2010. Filser et al. (2017) recognized that this area was relatively young, so, by structuring this body of knowledge they acknowledged and encouraged the direction of existing literature and addressed four future tendencies: evaluate the implementation, amplify basic knowledge, investigate challenges and success stories, and expand the focus.

It is important to stress that all of them pointed out a prominent weakness among studies in this area: the lack of methodological rigor. Aleu and Van Aken (2017) studied the use of continuous improvement projects (CIPs) in hospitals, and they found that most articles describe CIP implementation using case studies as research methods, reflecting the lack of

methodological rigor and the missing of a solid framework for assessing implementations in practice.

2.3.2 Non-bibliometric Reviews of Lean Implementation in General Service Sector

Literature reviews of Lean implementation in the scope of entire service sector using other systematic methods, though having more diversity, still are small in quantity. The three studies are also very recent: one in 2012, one in 2015 and another in 2016. Table 5 exhibits the summary of the three studies.

Authors	Research Method	No. of public. analyzed	Major findings
Suarez-Barraza et al. (2012)	Systematic review methodology (SRM)	172	<ul style="list-style-type: none"> • “Lean Service” publications were classified into four categories: the meaning of the concept, the applications, theoretical frameworks, and new definitions • gaps and directions for future studies suggested by the authors
Leite and Vieira (2015)	Bibliographic study	70	<ul style="list-style-type: none"> • there was no single standard set of practices and tools in Lean Service: a mix of tools and practices should be chosen under different circumstances • although the lack of standards and methodology for applying in services, the Lean toolbox inherited from manufacturing can generate considerable outcomes when used in services
Gupta et al. (2016)	Traditional literature review	122	<ul style="list-style-type: none"> • the literature was classified by “time” dimension and “content” dimension • it was found limitations in transferring Lean manufacturing principles to services due to process difference • there is a lack of standardized Lean Service definition, principles and tools, and theoretical guidelines for its implementation

Table 5 Non-bibliometric Reviews of Lean Implementation in General Service Sector

Source: own elaboration

Adopting systematic review methodology (SRM), Suarez-Barraza et al. (2012) classified 172 publications related to the topic “Lean Service” into four categories — the meaning of the concept, the applications, theoretical frameworks, and new definitions. Under the category of applications, sub-sectors were identified such as health care sector, financial institutions,

education, airline industry, hotels and restaurants. They also suggested gaps and directions for future studies. This dissertation is the first effort to classify Lean Service and make an overview of literature about this term. It inspires researchers and professionals and helps them better understand Lean management in services.

Leite and Vieira (2015) conducted a bibliographic study reviewing 70 papers focusing on Lean thinking in service companies. They presented the principles of Lean service and best practices and tools of Lean service implementation. Gupta et al. (2016) performed an exhaustive literature review of implications and applications of Lean in services from its initiation in 1990s to recent 2016. They classified the literature, under “time” dimension, into Pre-Lean era, Lean awareness era, Lean Exploration era and Lean implementation era. Also under “content” dimension, the literature can be divided into theoretical foundation, frameworks/models and application/case studies, which are categories similar to those from Suarez-Barraza et al. (2012).

The studies also pointed out the same fact mentioned by the bibliometric studies of Lean implementation in health care in the previous section: the lack of frameworks/standards and methodology among the studies. Suarez-Barraza et al. (2012) referred that there was a clear theoretical gap in defining and profiling the conceptual framework of Lean Service, and most of the literature were adopting a practitioner approach with little empirical support. They also addressed that in aspect of specific application, most articles are case-stories, anecdotes and general accounts from a practitioner standpoint showing the positive result of the application without indicating practically any inhibitor to the improvement. Gupta et al. (2016) also identified the lack of standardized Lean Service definition, principles and tools, as well as theoretical guidelines for the implementation of Lean service. Therefore they stressed that a standard model/framework for Lean services is in urgent need. Leite and Vieira (2015) found that there was no single standard set of practices and tools in Lean service, instead, they argued that a mix of tools and practices should be chosen under different circumstances.

Additionally, these studies realized the barriers of introducing Lean into service industry. Gupta et al. (2016) found limitations in transferring Lean manufacturing principles to services due to process difference between the two industries, and respecting people and employment engagement is crucial for Lean in service. However, Leite and Vieira (2015) pointed out that though being lack of standards and methodology for application in

services, the Lean toolbox inherited from manufacturing can generate considerable economic and financial outcomes, as well as improvement in employees' behavior, when used in services. They further confirmed that despite some limitations and resistance of the application of Lean in services, the Lean movement in service will accelerate and have a promising future.

3. Methodology

This section is dedicated to the adopted methodology — bibliometrics. It is briefly introduced the bibliometric study background in Section 3.1, and then the research design and chosen bibliometric methods are explained in Section 3.2. Finally, it is presented the bibliometric data assembling process in Section 3.3.

3.1 The Bibliometric Study

Although it is widely accepted that bibliometric methods have been applied for at least a century, the development of bibliometrics in terms of a scientific field only started in the 1960s which can be attributed to the Institute for Scientific Information (ISI), Science Citation Index (SCI) — a logical continuation of Eugene Garfield’s drive to support scientific literature searching (Garfield & Merton, 1979). Pritchard (1969) proposed the word “bibliometrics” for the first time and defined it as the application of mathematics and statistical methods to books and other media of communication. To be specific, bibliometrics is an approach examining a large body of academic literature quantitatively in order to assess the development of a certain research field, especially the intellectual structure of literature in that field (Giannakis, 2012).

The different descriptions of bibliometric analysis contain similar function of conducting the analysis (Osareh, 1996). Using quantitative methods for describing, evaluating, and monitoring the literature, the analysis targets to perform a systematic, well-understood and reproducible review process and thus improve the reliability and consistency of the analysis (Zupic & Cater, 2015). It is notable that mapping the research field without subjective bias is an advantage of bibliometric analysis (Zupic & Cater, 2015), compared to narrative literature reviews which are subjected to bias, for example, the publication bias of researchers in meta-analysis (Rothstein, Sutton, & Borenstein, 2006).

Conducting bibliometric analysis has certain procedures. Zupic and Cater (2015) proposed the workflow into five steps (shown in Figure 3), which will be followed in this study.

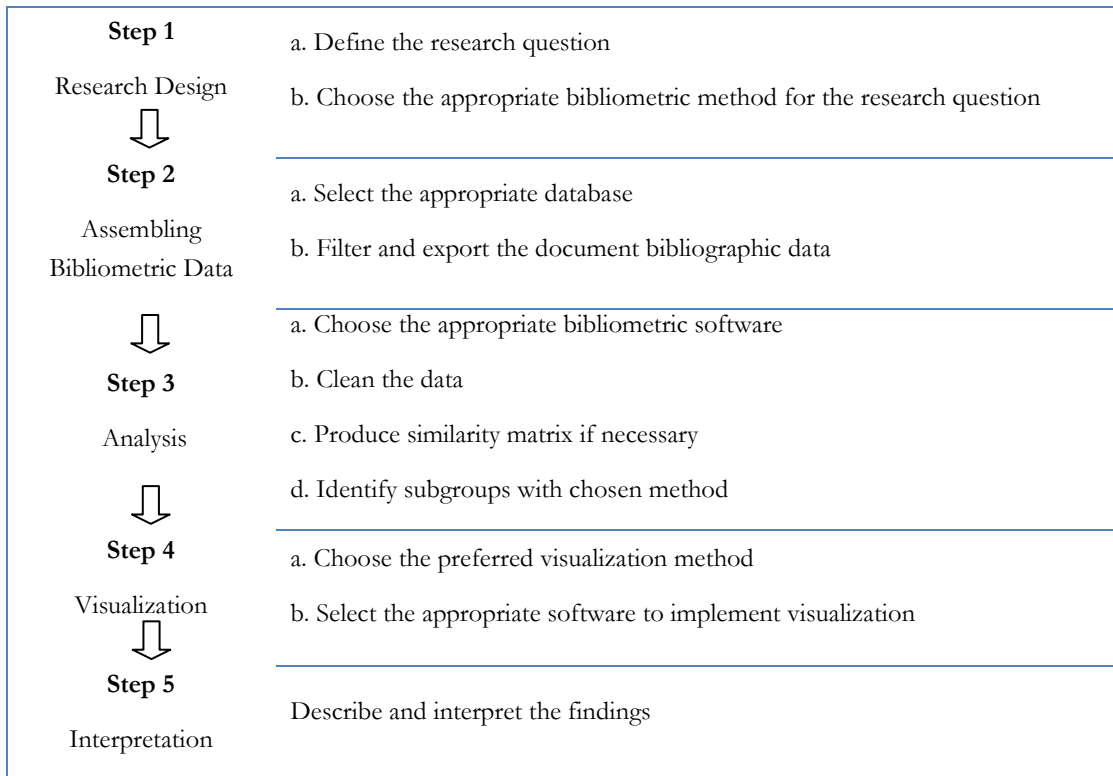


Figure 3 Workflow for Conducting Bibliometric Methods

Source: Zupic and Cater (2015)

3.2 Research Design

The first step – research design – is to define the research questions and choose appropriate bibliometric methods to answer the research questions. The research questions aiming to fulfill the main purpose of this investigation are listed below.

Research questions:

1. What are the most popular topics in applying Lean thinking in major service sectors?
2. What are the trends, patterns, gaps and weaknesses in this field in a chronological analysis (a) and geographical analysis (b)?
3. Which Lean tools are often used?

Table 6 shows the bibliometric methods chosen and their description. It can be seen that different methods have different functions, thus will answer different questions.

Bibliometric Method Designation	Description of the Method	Function	Research Questions can be answered	Authors
Publication counting and abstract analysis	A quantitative and qualitative indicator of the productivity of a field of study in terms of the output delivered in academic publications	Evaluate the basic information of the publications and compare the research performance of individual researchers, research institutions and nations	<p>RQ1 What are the most popular topics in applying Lean thinking in major service sectors?</p> <p>RQ2 What are the trends, gaps and weaknesses in this field?</p>	
Co-citation analysis	Connects documents, authors, or journals on the basis of joint appearances in reference list	<p>Represent a link between documents</p> <p>Identify the knowledge base of a topic/research field and its intellectual structure</p>	RQ2 What are the trends, gaps and weaknesses in this field?	<p>Cobo et al., 2011</p> <p>Zupic & Cater, 2015</p>
Co-word analysis	Uses the words in documents to establish relationships and build a conceptual structure of the domain	<p>Find the network of themes and their relations that represent the conceptual space of a field.</p> <p>Track the evolution of a certain concept</p>	<p>RQ2 What are the trends, gaps and weaknesses in this field?</p> <p>RQ3 Which Lean tools are often used?</p>	<p>Cobo et al., 2011</p> <p>Zupic & Cater, 2015</p>

Table 6 Bibliometric Methods Chosen and Research Questions Answered

Source: own elaboration

3.3 Assembling Bibliometric Data

After the research design, the next step is to assemble bibliometric data. First of all, the source of bibliographic data should be defined. It was chosen the Web of Science (WoS) and the Scopus as the databases for this research. Both databases are useful for building the bibliographic base.

Scopus is the largest abstract and citation database of peer-reviewed literature: scientific journals, books and conference proceedings (ELSEVIER, 2017). Web of Science is the world’s oldest citation resource and features the most prestigious academic journals (Pato & Teixeira, 2016). It provides access to a comprehensive breadth of world-class research literature from rigorously selected core of journals totaling over 33,000 (ClarivateAnalytics, 2017). With these two of the world’s largest citation indexes and search platforms, the collection of comprehensive and reliable publications is assured and simplified.

To conduct the search, the keyword should be defined. The topic of this research consists of 3 factors, so we defined 3 groups of keywords (shown in Table 7). The main topic is Lean, the scope is service, and the action is implementing or applying or using Lean. The keywords were searched on “Title, authors, abstracts and keywords” in WoS and Scopus. In WoS, the database of searching was set as “All databases”.

Main Keywords	Secondary Keywords	Tertiary Keywords
<ul style="list-style-type: none"> • Lean • Lean thinking • Lean philosophy • Lean practice • Lean tool • Lean technique 	<ul style="list-style-type: none"> • Service • Service sector • Service industry 	<ul style="list-style-type: none"> • Implement • Implementation • Apply • Application • Adopt • Adoption • Use • Introduce • Introduction

Table 7 Keywords for Searching

Source: own elaboration

After the preliminary search in both databases, Scopus returned 3,036 results and Web of Science supplied 548 results. After eliminating duplications there remain 2,259 publications. The results need careful screening because not all of them are related to the topic “Lean implementation in services”. For example, the word “lean” can have different meanings such as “slim” which results in the inclusion of articles studying obesity and nutrition, and its appearing in phrase “lean on” also leads to some irrelevant papers. Apart from these, there are many articles which mention “service” in the abstract but their main focus is in

manufacturing industry. Figure 4 presents the whole screening process. In the end, 378 articles were remained as the final database, and the complete list of them is in Appendix 2.

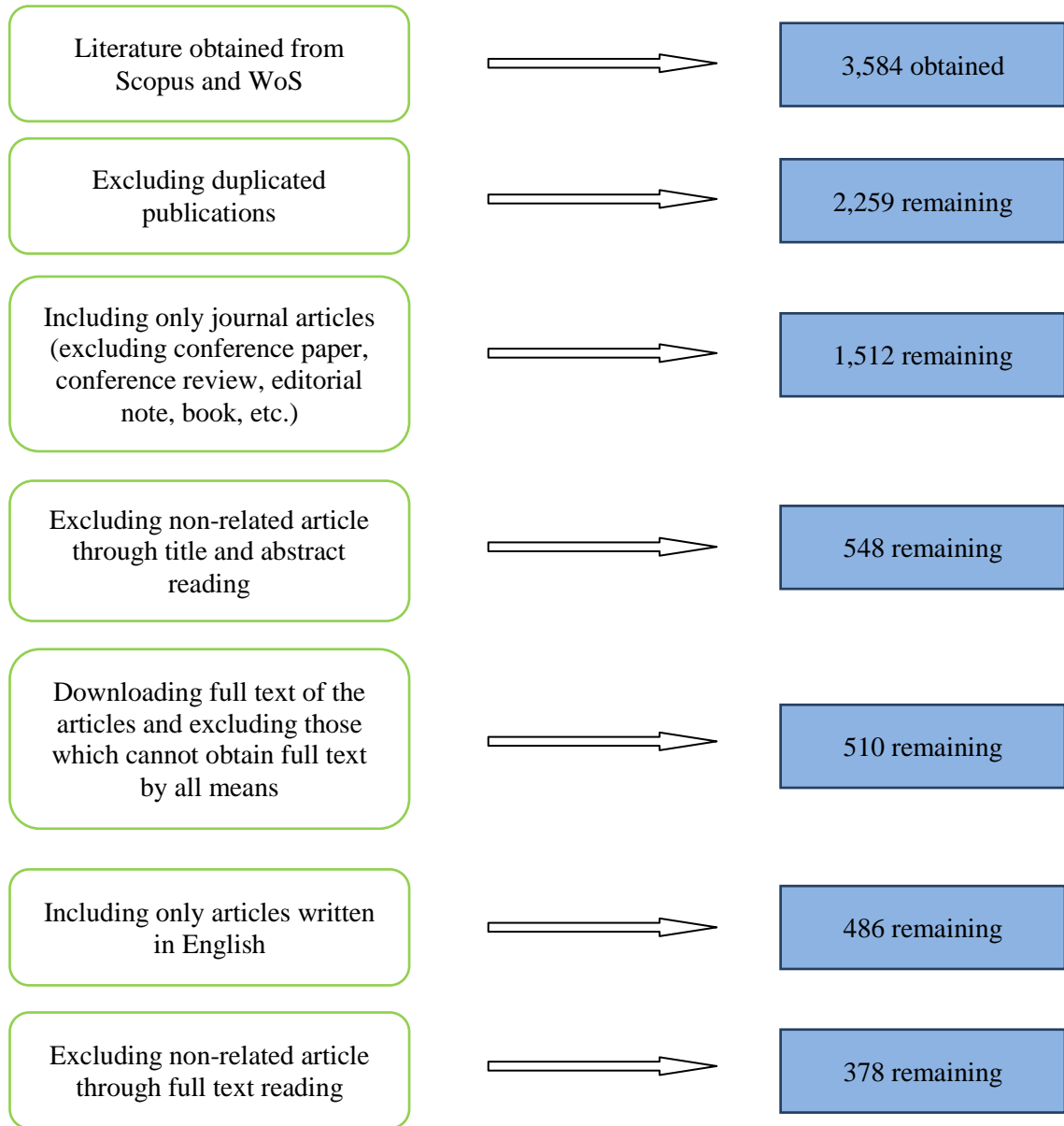


Figure 4 Screening Process

Source: own elaboration

During the screening process when reading all the articles' titles, keywords, abstracts or full texts, it was registered the bibliographic information of those wanted articles, and also identified their geographic focus (country or region), target industry, department or certain

activity, and their main themes. The category of themes was developed and synthesized based on the research areas, research categories, or research directions identified by previous literature reviews on Lean studies (Danese, Manfè, & Romano, 2017; Filser et al., 2017; Marodin & Saurin, 2013; Suarez-Barraza et al., 2012), and also was adjusted during the reading process. The final list of themes is shown below.

1. Application of Lean in an activity
2. Application of Lean in an organization
3. Application of Lean in an industry
4. Evaluation of outcomes of Lean implementation in an activity
5. Evaluation of outcomes of Lean implementation in an organization
6. Evaluation of outcomes of Lean implementation in an industry
7. Development of a model/framework for Lean implementation
8. Assessment of a model/framework for Lean implementation
9. Discussion of Lean's transfer to or implementation feasibility in services
10. Drivers/Enablers for adoption of Lean
11. Extent of Lean implementation in an organization
12. Extent of Lean implementation in an industry
13. Extent of Lean implementation in a country/region
14. Key success factors (KSFs)/critical success factors (CSFs) of Lean implementation
15. Other factors of Lean implementation
16. Improvement of Lean implementation process
17. Lean implementation issues/challenges
18. Lean tools/practices
19. Relationship between Lean and overall performance
20. Sustaining/improving Lean implementation outcomes

3.4 Procedure of Co-citation Analysis

Co-citation analysis is to identify the intellectual structure of a research field by counting the frequency of two references being cited together and building a network for all the references based on this linkage (Zupic & Cater, 2015). The first thing to do is to obtain the knowledge base, in other words, all the cited references, of our selected 378 articles. The bibliographic data of the 378 articles was downloaded from either Scopus or WoS, and a data cleanup program was used to extract and clean their references. The cleanup work is necessary because the same publication may be in different formats and there also exist a lot of mistakes in authors' names, titles and journal names. The mistakes should be corrected and different references which refer to the same publication should be unified into one unique format. The unifying work was accomplished first by the "clustering" feature in the data cleanup program and then by going through a manual inspection in Microsoft Excel. Finally, 12,642 references were obtained.

The next step is to calculate, within the 12,642 references, the frequency of a pair of references being cited at the same time by an article among the 378 articles. The counting was performed in Microsoft Access and a "network" of co-occurrence of the references was obtained. It is worth mentioning that if a reference is highly co-cited with another reference, it means that the two references themselves are individually highly cited (Jarneving, 2005). Therefore, for the purpose of focusing only the influential publications and limiting the network to a manageable size, it is necessary to set up a threshold. The network was ranked from the highest times of co-occurrence to the lowest, and the pairs with less than 10 times of co-occurrence were excluded from the network. Finally, the network was imported into VOSviewer, software specially for creating maps based on network data, for visualization.

3.5 Procedures of Co-word Analysis

The fundamental logic behind co-word analysis is the same with that behind co-citation — the items need for counting of times of co-occurrence is changed from references to words. The analyzing material for co-word analysis can be titles, keywords, abstracts or full texts. Solely using titles or keywords may be affected by "indexer effect", which means the titles and keywords are too narrow to cover all relevant concepts of the text; however, using

abstracts or full texts will suffer from noises brought by the large amount of irrelevant words (Zupic & Cater, 2015). We decided to use abstracts as the middle way to avoid indexer effect and also to mitigate the noises by using more concise texts.

The next step is to select a list of words whose frequency of co-appearance in the abstracts will be counted. Microsoft Excel was used to find the most frequently used words in the author keywords and abstracts of the 378 articles, and among them we selected 83 words (see Appendix 3). This list of words can be considered as a “hotchpotch” of mostly mentioned concepts in this research field, including topics, research methods, industries, Lean tools, and all kinds of Lean terminologies. The words also need unification, for example, “healthcare”, “health care”, and “health-care” were all unified into “healthcare”; “value stream mapping”, “value stream map”, and “VSM” were reconciled as “VSM”; “case stud” was used for representing both “case study” and “case studies”.

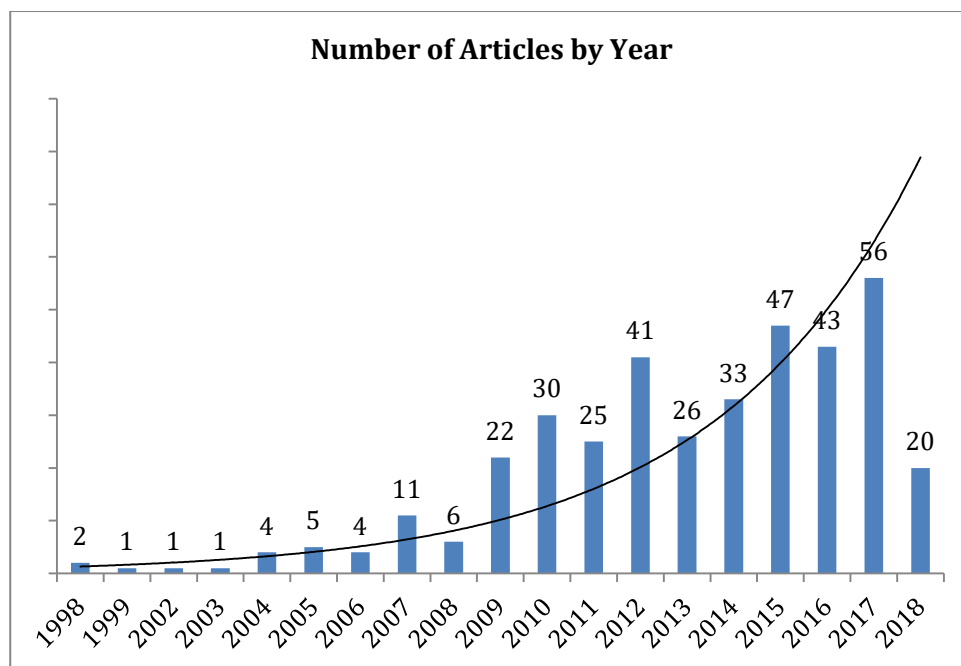
In order to analyze the evolution and trend of the research field, the 378 articles were divided into two time periods – 1998-2008 and 2009-2018 – for the purpose of a longitudinal comparison. Co-word analysis was conducted twice to these two groups of articles. Also, a co-occurrence threshold of no less than 5 times was applied. The number of items (words) in co-word analysis is much less than the number of items (references) in co-citation analysis, so the threshold was set lower to include more items. The final process was identical with that of co-citation: Microsoft Access was used to calculate the words’ frequency of co-occurrence in the abstracts and the resulted networks were visualized in VOSviewer.

4. Results

4.1 Publication Counting and Abstract Analysis

4.1.1 Chronological Analysis of the Articles

The chronological development of the articles (Figure 5) shows that the “use of Lean in services” is a very young research field, with the first related paper published in 1998 and the majority of literature concentrating in recent years. The exponential-like increase also suggests that the knowledge body is growing rapidly. It is worth mentioning that the bibliometric data was retrieved on March 30th, 2018, thus the articles in 2018 only include those published within the first three months, which has 20, so we can expect the total number of articles in 2018 to be around 80, reaching the new height.



Note: The articles in 2018 only include those published before March 30th, 2018, which is the time the data collection was conducted.

Figure 5 Number of Articles by Year

Source: own elaboration

4.1.2 Geographic Analysis of the Articles

The geographic analysis of the articles presents the geographic focus of the literature. Among the 378 articles, 305 are empirical studies with specified countries/regions or theoretical studies having a certain geographic context. The rest of the articles do not have a geographic focus and are mainly theoretical papers or reviews.

We ranked the countries according to the times they are mentioned as the geographic context used in the publications, and Table 8 contains the top 10 of them. The US is the most mentioned country (114 articles), and along with the UK (60 articles), they have the dominant numbers of publications, showing that Lean is most extensively used in service sector in these two countries.

Country	No. of Articles
US	114
UK	60
Canada	16
Sweden	12
India	12
Italy	9
Netherlands	8
Australia	6
Brazil	5
Norway	5

Table 8 Geographic Focus of the Articles – Top 10 countries

Source: own elaboration

It was also integrated the countries/regions into their continent accordingly as shown in Figure 6, and we can see that North America and Europe together take up 82% suggesting that these two continents are the pioneers of implementing Lean in services.

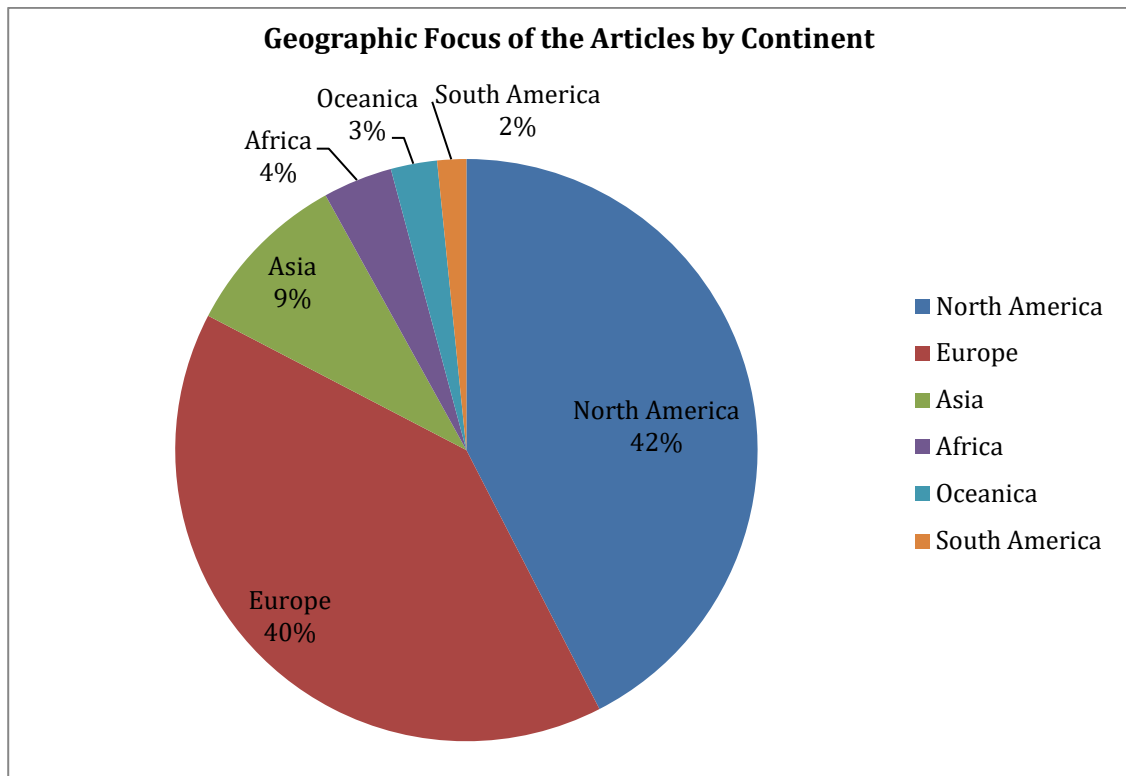
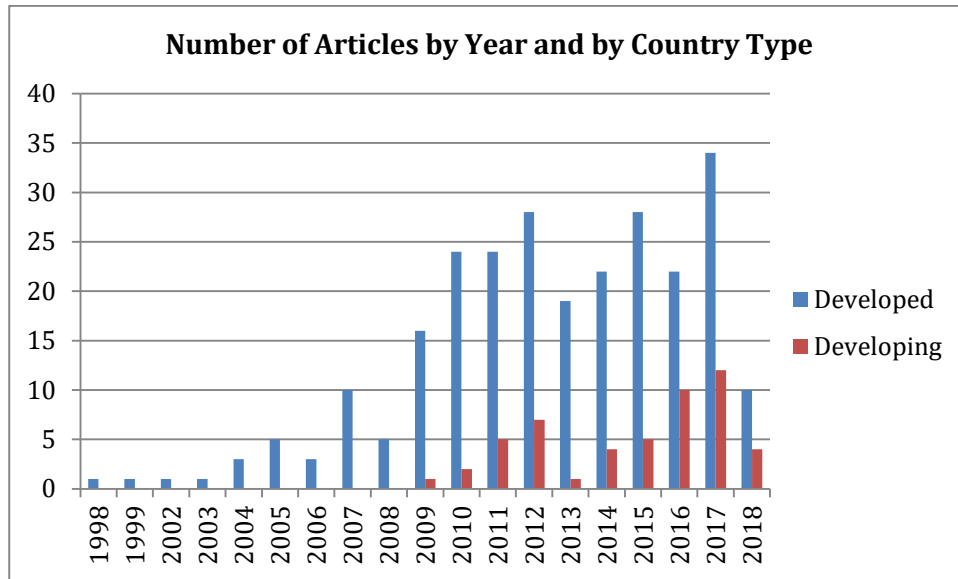


Figure 6 Geographic Focus of the Articles by Continent

Source: own elaboration

To have a further understanding of the trend of Lean in services chronologically and geographically, the countries were classified into developed countries and developing countries (based on International Monetary Fund, World Economic Outlook, October 2017), and, combining the publishing year, obtained the chronological evolution of the number of publications by country type (Figure 7). The first publication that studying “Lean in services” in developed countries was published in 1998 and the number of studies rose rapidly after 2008. In comparison, the study focusing in developing countries only started in 2009 and both the publications per year and growing speed are lower than those of developed countries, meaning that the study in developing countries is still in the infancy stage.



Note: The total number is not equal to 378 because some articles do not have a specific geographic focus while some have multiple ones.

Figure 7 Number of Articles by Year and by Country Type

Source: own elaboration

Combining this result with the information in Table 8 and Figure 6, one can conclude that the topic “Lean in services” are mostly discussed in the developed economies, and since the majority of the academic literature are empirical (will be justified in Chapter 4.1.4), one can deduce that Lean is more often implemented in services in developed countries than in developing countries.

Therefore, we can have a sketch of the chronological and geographical development of “Lean in services”: Beginning from the end of last century, Lean was first discussed and transferred to services in developed world in North America and West Europe, and after one decade spread to developing countries like India and Brazil.

4.1.3 Researched Industries

Among the 378 articles, 23 of them do not have a specific industry focus — 12 articles explore Lean implementation in services in a general sense and 11 articles study the topic in a wider range, covering both manufacturing and service sector. For the rest of 355 articles investigating Lean implementation in a specific service industry, we identified their industries and ranked them in Table 9. The studies in Healthcare sector (247 articles) take the dominant percentage of 69.6%, followed by Public sector (31 articles) making up 8.7%. Other industries though have a large variety, are no match for Healthcare in numbers. The

extensive adopting of Lean thinking in Healthcare demonstrates that this sector has an urgent need for quality improvement and cost saving, and is adequate for Lean transfer.

Industry	No. of Articles	Percentage
Healthcare	247	69.6%
Public	31	8.7%
Finance	16	4.5%
Supply Chain	11	3.1%
Education	9	2.5%
Telecom	8	2.3%
IT	8	2.3%
Transport	6	1.7%
Library	3	0.8%
Hospitality	2	0.6%
Other	14	4.0%
Total	355	100.0%

Note: The total number is not equal to 378 because some articles do not have a specific industry focus while some have multiple ones.

Table 9 Number of Articles by Industry

Source: own elaboration

4.1.4 Category of Themes

Table 10 ranks the 20 themes by their times of being discussed in the 378 articles. At present we can give a preliminary answer to our first research question. The most salient themes in the 20 years research of Lean thinking in services are “Application of Lean in an organization” (117 times) and “Evaluation of outcomes of Lean implementation in an organization” (110 times). Following these two themes, “Application of Lean in an activity” (75 times) and “Evaluation of outcomes of Lean implementation in an activity” (47 times) are the second most discussed pair of themes. This shows that the study of Lean in services is mainly empirical studies which record one or several Lean improvement projects and assessing their outcomes, and sometimes even do not have the following assessment. In contrast, “Development of a model/framework for Lean implementation” (31 times) and “Assessment of a model/framework for Lean implementation” (7 times) are far less explored themes. This result echoes with conclusions of other systematic reviews

mentioned in Chapter 2 that the current research of Lean in services is mainly occupied with case studies and is lack of research rigor and mature model/frameworks (Aleu & Van Aken, 2017; Gupta et al., 2016; Leite & Vieira, 2015; Plytiuk et al., 2012).

“Discussion of Lean’s transfer to or implementation feasibility in services” (42 times) and “Lean implementation issues/challenges” (49 times) are also popular themes. This shows the researchers’ passion to explore the feasibility of Lean thinking in service sector both empirically and theoretically, and at the same time they have encountered a lot of problems and identified many areas that need concerns.

Themes	Times discussed
Application of Lean in an organization	117
Evaluation of outcomes of Lean implementation in an organization	110
Application of Lean in an activity	75
Lean implementation issues/challenges	49
Evaluation of outcomes of Lean implementation in an activity	47
Discussion of Lean’s transfer to or implementation feasibility in services	42
Development of a model/framework for Lean implementation	31
KSFs/CSFs of Lean implementation	27
Extent of Lean implementation in an industry	25
Lean tools/practices	22
Relationship between Lean and overall performance	20
Other factors of Lean implementation	18
Evaluation of outcomes of Lean implementation in an industry	16
Drivers/Enablers for adoption of Lean	7
Assessment of a model/framework for Lean implementation	7
Sustaining/improving Lean implementation outcomes	4
Improvement of Lean implementation process	4
Application of Lean in an industry	3
Extent of Lean implementation in a country/region	2
Extent of Lean implementation in an organization	2

Table 10 Rank of Themes Discussed

Source: own elaboration

4.2 Co-citation Analysis

After excluding the references which are co-cited less than 10 times, 71 most influential references are remained for co-citation analysis. The network of these citations is visualized in Figure 8. Each bubble stands for one reference and bigger bubble size means higher cited times. “Association strength” is chosen as the method to normalize the strength of the links between units (Van Eck & Waltman, 2018). The lines connecting the bubbles represent the linkage between the documents and shorter distance between bubbles indicates stronger connection they have. Five clusters can be identified from this network, as shown in Figure 9.

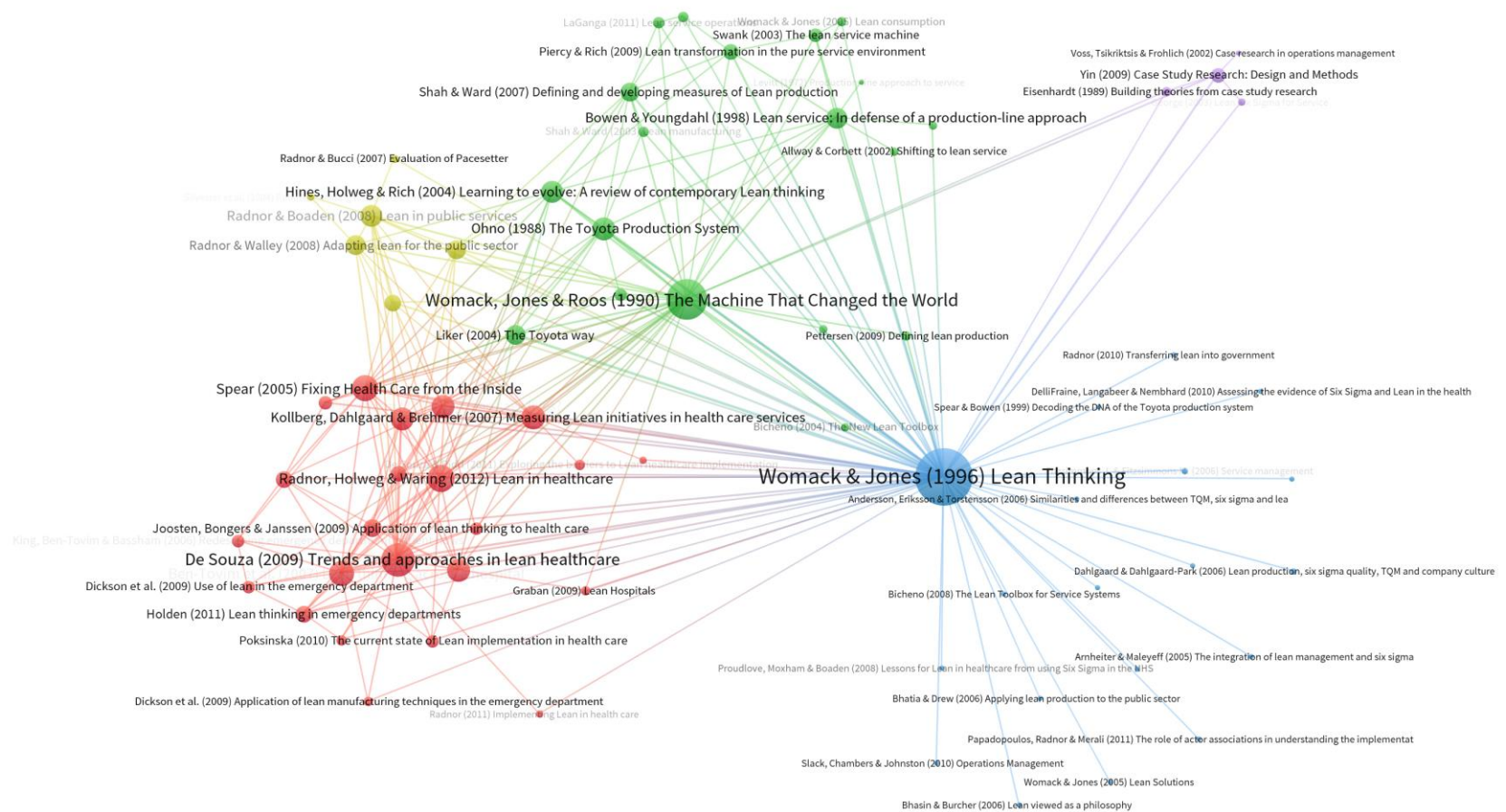


Figure 8 Visualized Co-citation Network

Source: own elaboration

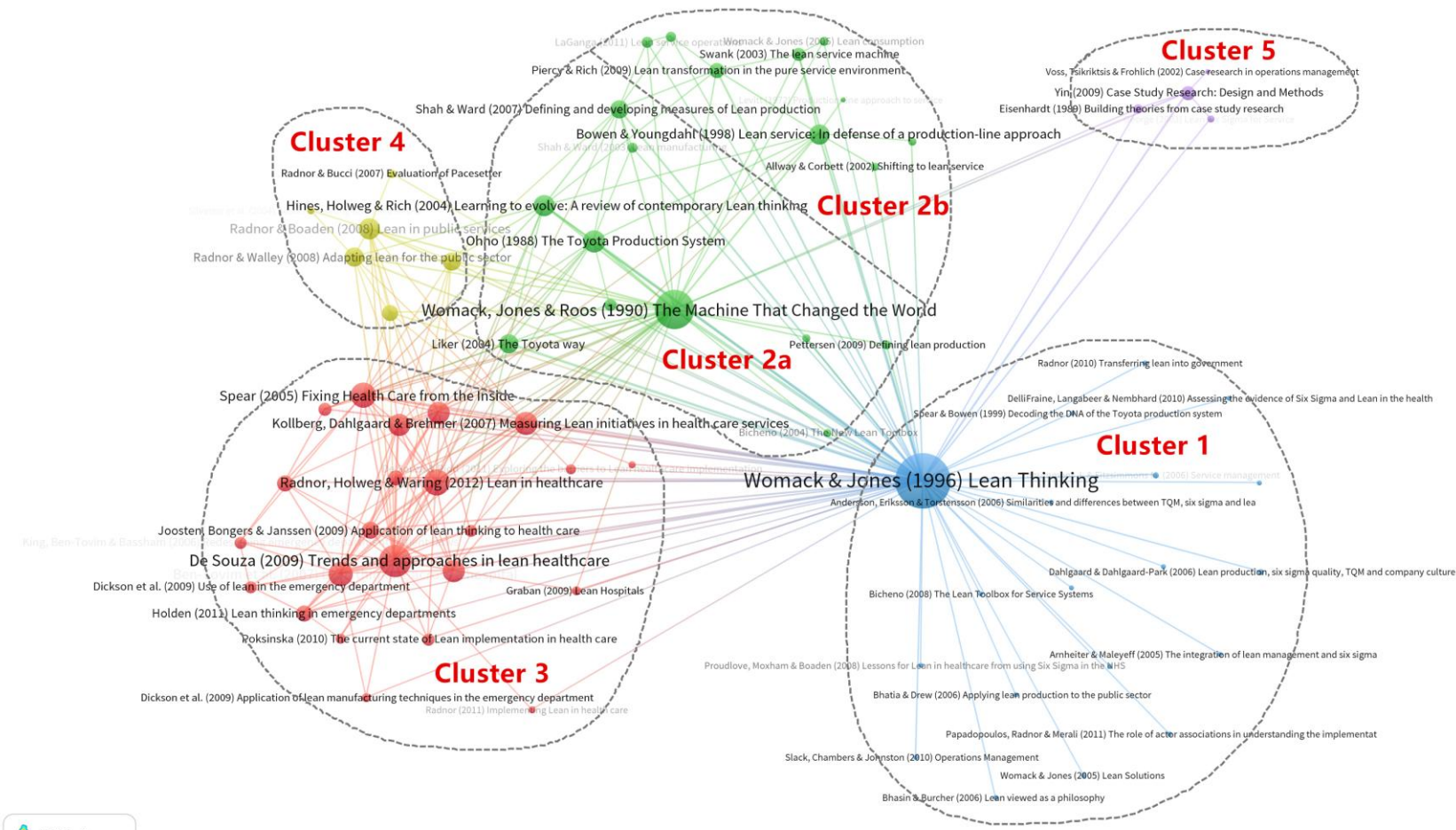


Figure 9 Visualized Co-citation Network with Clusters Identified

Source: own elaboration

The biggest bubble alone with those smallest ones composes the first cluster. The big one is the famous book *Lean Thinking* written by Womack and Jones in 1996. This book first popularized the term “Lean thinking” by its title and proposed the five Lean principles — “value”, “value stream”, “flow”, “pull”, and “perfection”. It is not surprising that this book is cited and co-cited the highest times, for it can be regarded as one of the foundations of Lean.

Those small bubbles surrounding the big bubble are publications which are less influential and come from different topics. They are all connected to Womack & Jones (1996) but have no connections with each other or any other publications in this network. This may be because i) Womack & Jones (1996) is like a “textbook” in this research area and is likely to be co-cited with publications from varied topics within this area, and ii) those small citations may actually have linkage with others but the connections are not strong enough (co-cited times less than 10) to be visualized in this network, that is why they are shown as scattered and lonely satellites around the star. Therefore, in defining this cluster these small citations are insignificant and the cluster can be considered as solely represented by Womack & Jones (1996). We name it as “Lean Principles”.

The second cluster can be divided into two sub-groups. The lower part closer to the center includes Lean roots that are even older than Womack & Jones (1996), for example, the very first “Lean” coined in *The Machine That Changed the World*, written by Womack, Jones and Roos in 1990, and the precursor of Lean—The Toyota Production System, discussed by Ohno (1988) *The Toyota Production System* and Liker (2004) *The Toyota Way*. Also, within this group there are some summarizing works about Lean, for instance, Hines et al. (2004) reviews the evolution of Lean thinking and Shah and Ward (2007) clarifies concepts about “Lean production” by a large-scale study. Apart from these, Rother and Shook’s book in 2003 *Learning to See* also belongs to this group. Published by Lean Enterprise Institute, an organization founded by James Womack, it is a “textbook” teaching one of the core Lean tools — value stream mapping. Given the above, this sub-group was defined as “Lean History I - Lean Foundations”.

If we say the lower part of the second cluster depicts the early history of Lean, then the upper part reflects the history when researchers were discussing Lean’s transfer to services.

From the influential citations we can know that the exploration of Lean services in academic world began in as early as 1998, and the discussion was heated during the early years of this century. These publications can be considered as the theoretical foundation for the later studies investigating the feasibility of Lean in services in empirical manners. We gave the title “Lean History II - Lean Transfer to Services” to this sub-group.

Tightly following the discussion of Lean transfer to services, studies in Cluster 3 and Cluster 4, which are all after 2005, mainly deal with Lean implementation in specified service sectors. References in Cluster 3 are all related to “Lean in Healthcare”, and this cluster is the biggest one. This is easily understandable since studies investigating Lean implementation in healthcare take a dominant percentage in the 378-article database. Similar to Cluster 3, Cluster 4 mainly focus on “Lean in Public Sector”, as public sector is the second most discussed sector following healthcare. It is notable that the three representative articles in this cluster all have Radnor Z. as the first author (Radnor & Boaden, 2008; Radnor & Walley, 2008; Radnor, Walley, Stephens, & Bucci, 2006), and Radnor also has two influential works in Cluster 3 (Radnor, 2011; Radnor, Holweg, & Waring, 2012), suggesting that she is an expert in Lean implementation in these two sectors.

The fifth cluster is the smallest one but it gives interesting information. Three representative references in this cluster are about case study research method, explaining the use of case study method as a valid research tool. It demonstrates that case study method is a popular methodology adopted when investigating Lean implementation in services, and again reinforced the argument that this research area is lack of standard framework because case study method limits the generalization of the outcomes (Easton, 1995; Plytiuk et al., 2012).

Regarding the locations of the clusters on the map, it is observable that Cluster 1 (mainly refers to Womack & Jones (1996)) and Cluster 2a are at the center of the map, suggesting they have the strongest associations with other clusters, based on the assumption that a topic closer to the center has higher centrality in the network (Romo-Fernández, Guerrero-Bote, & Moya-Anegón, 2013). Cluster 3, Cluster 4 and Cluster 5 are at the periphery reflecting their lower centralities. Cluster 5, in particular, stretches far away from the center and has the least links with others, illustrating it is the most specialized cluster.

Table 11 lists the representative references of each cluster.

Cluster	Representative References
Cluster 1 Lean Principles	<ul style="list-style-type: none"> Womack & Jones (1996) Lean Thinking: Banish Waste and Create Wealth in Your Corporation
Cluster 2a Lean History I - Lean Foundations	<ul style="list-style-type: none"> Womack, Jones & Roos (1990) The Machine That Changed the World: The Story of Lean Production Ohno (1988) The Toyota Production System: Beyond Large-Scale Production Liker (2004) The Toyota way, 14 principles of management from the world's greatest manufacturer Hines, Holweg & Rich (2004) Learning to evolve: A review of contemporary Lean thinking Shah & Ward (2007) Defining and developing measures of Lean production Rother & Shook (2003) Learning to See: Value Stream Mapping to Add Value and Eliminate Muda
Cluster 2b Lean History II - Lean Transfer to Services	<ul style="list-style-type: none"> Bowen & Youngdahl (1998) Lean service: In defense of a production-line approach Piercy & Rich (2009) Lean transformation in the pure service environment: The case of the call service centre Swank (2003) The lean service machine Allway & Corbett (2002) Shifting to lean service: Stealing a page from manufacturers' playbooks Abdi, Shavarini & Hoseini (2006) Glean Lean: How to Use Lean Approach in Services Industries?
Cluster 3 Lean in Healthcare	<ul style="list-style-type: none"> De Souza (2009) Trends and approaches in lean healthcare Spear (2005) Fixing Health Care from the Inside, Today Radnor, Holweg & Waring (2012) Lean in healthcare: The unfilled promise? Young & McClean (2008) A critical look at lean thinking in healthcare Mazzocato, Savage, Brommels, Aronsson & Thor (2010) Lean thinking in healthcare: A realist review of the literature Fillingham (2007) Can lean save lives? Ben-Tovim, Bassham, Bolch, Martin, Dougherty & Szwarcbord (2007) Lean thinking across a hospital: Redesigning care at the Flinders Medical Centre Joosten, Bongers & Janssen (2009) Application of lean thinking to health care: Issues and observations Kollberg, Dahlgaard & Brehmer (2007) Measuring Lean initiatives in health care services: issues and findings Holden (2011) Lean thinking in emergency departments: A critical review
Cluster 4 Lean in Public Sector	<ul style="list-style-type: none"> Radnor & Boaden (2008) Lean in public services - Panacea or paradox? Radnor & Walley (2008) Learning to walk before we try to run: Adapting lean for the public sector Radnor, Walley, Stephens & Bucci (2006) Evaluation of the Lean Approach to Business Management and Its Use in the Public Sector
Cluster 5 Case Study Research Method	<ul style="list-style-type: none"> Yin (2009) Case Study Research: Design and Methods Eisenhardt (1989) Building theories from case study research Voss, Tsikriktsis & Frohlich (2002) Case research in operations management

Table 11 Representative References of Each Cluster

Source: own elaboration

4.3 Co-word Analysis

Figure 10 and Figure 11 describe the visualized networks of the selected keywords for the two time periods, and clusters are identified. As the same in co-citation analysis, the normalization method is “association strength”. The bubble size reflects the appearing frequency of the word and the distance between bubbles infers the strength of their connection.

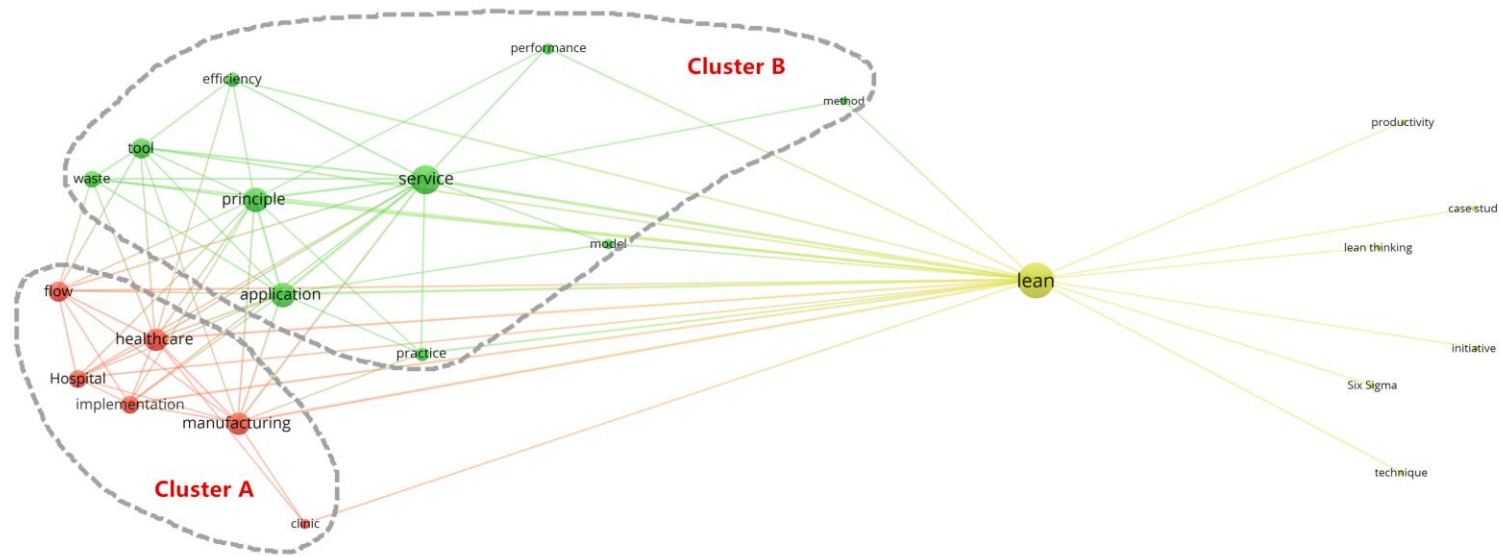


Figure 10 Visualized Co-word Network, 1998-2008

Source: own elaboration

From the map of the period 1998-2008 we can know that healthcare was the first prominent service sector where Lean was applied, and to be specific, hospital and clinic are mainly the discussed organizations in this sector. The word “flow” is closely connected to them because most articles were studying creating a flow in hospital to improve service quality. The word “manufacturing” has a high frequency in this cluster because researchers were saying “Lean is transferred from manufacturing industry to service sector”. Apart from these, “Lean principle(s)”, “tool(s)”, “waste” and “efficiency” are often mentioned concepts in this period. We can deduce that the contributions of Lean principles or Lean tools are often recognized as reducing waste and improving efficiency. Those minor words at the right side of “Lean” are not significant in this map, as explained in the third paragraph of Chapter 4.2, but they still can inform us that “case study(ies)” were used and “Six Sigma” was already discussed before 2008. Therefore, we can identify two clusters in this period:

- Cluster A – “Adoption of Lean in healthcare in 1998-2008”, with representative words “healthcare”, “hospital”, “clinic”, “implementation” and “flow”; and
- Cluster B – “Major themes of ‘Lean in services’ in 1998-2008”, with representative words “service”, “principle”, “application”, “tool”, “waste”, “efficiency” and “performance”.

The first thing that can be noticed after seeing the map of the period 2009-2018 is that the keywords increased significantly both in frequency and in variety. It demonstrates that the research field has been growing rapidly and the literature has greatly enriched. All the keywords that appeared in last period remain to be important in this period with higher frequency.

Before looking into details, it is needed to clarify two things:

1. One can observe that the clusters have some overlaps with others, which is a normal situation, suggesting that there are connections between words that from different clusters (Romo-Fernández et al., 2013). For example, “NHS” (National Health Service) is painted in blue and belongs to Cluster 3, but clearly it has very close connection with “healthcare” thus it can also be included in Cluster 1.
2. “Lean”, “service”, and “implementation” are words with extremely high centrality, which can be regarded as components in any cluster, thus they are not considered as representative words in any cluster.

Cluster 1

Begin with the first cluster, the words “healthcare”, “hospital” and “clinic” are still three very influential words indicating that healthcare is still the leading service industry of implementing Lean and the number of related studies increased a lot. Besides “hospital” and “clinic”, there emerged quite a bit sub-sectors or departments in healthcare, such as “NHS”, “emergency department”, “pharmacy”, “operating room”, “acute care”, “primary care”, “nursing” and “radiology”, demonstrating that Lean implementation in healthcare grows not only in quantity but also in comprehensiveness. The word “flow” is still closely related to this cluster and now we know that creating “flow” to reduce “waste”, increase “efficiency” and improve “patient satisfaction” is the common target of Lean implementation in healthcare. We define this cluster as “Adoption of Lean in healthcare in 2009-2018”.

Cluster 2

“Application” and “tool” are still remarkable but around them there aroused many words that newly become significant, like “method”, “technique”, “model”, “framework”. This

manifests that as the adoption of Lean increases, more and more Lean tools, techniques and methodologies are used in service industry, and frameworks and models are established based on successful cases. Indeed, some new bubbles are notable like “VSM” (Value Stream Mapping), “LLS” (Lean Six Sigma), “DMAIC” (Define, Measure, Analyze, Improve and Control), “5S” (sort, set in order, shine, standardize and sustain) and “Kaizen”. It is worth mentioning that these tools are not all in the same cluster because one paper normally uses only one or two tools thus it is not often to see two tools appear jointly, as a result, they are scattered on the map and have no mutual connections. The name “Updating of Lean implementation” is given to this cluster.

Cluster 3

The mainstream research method of the literature is still “case study” (in Cluster 2). “Interview” and “survey” are common ways of data collection. “Initiative”, which refers to one-time Lean improvement project, is often the research subject. The frequency of “qualitative” is higher than that of “quantitative”. These jointly reinforce the argument that the research field is short of research rigor and generality (Aleu & Van Aken, 2017; Gupta et al., 2016; Leite & Vieira, 2015). Also, the linkage of “case study-performance-practice” (in Cluster 2) indicates that many articles are empirical case studies assessing the performance of an organization or a process after Lean practices. These studies are more like “verifying” the effectiveness of Lean instead of “concluding” it, as Plytiuk et al. (2012) states, the empirical case studies in this field, though have made considerable efforts, are merely describing certain practices, reporting their results of the initiatives, and have no intention to validate and establish theories.

Another two fresh words “challenge” and “barrier” within this cluster demonstrate that the process cannot always go smoothly. It is certain that along with the deepening of the application, researchers will find more and more challenges and barriers that need to be solved. To summarize, the third cluster can be called as “Current state of Lean research methodology”, consisting of “interview”, “survey”, “initiative”, “qualitative”, “quantitative”, “challenge” and “barrier”.

Cluster 4

Lastly, the smallest cluster “Adoption of Lean in public sector in 2009-2018” represented by “public sector” and “public service” shows the transfer of Lean to public sector has

begun in the new era. However, its tiny scale and marginal location manifest that the popularity of “Lean in public sector” cannot yet compare with that of healthcare.

Table 12 enumerates the clusters of period 2009-2018.

Cluster	Representative Words
Cluster 1 Adoption of Lean in healthcare in 2009-2018	healthcare, hospital, clinic, flow, waste, efficiency, patient satisfaction, NHS, emergency department, pharmacy, operating room, acute care, primary care, nursing, radiology
Cluster 2 Updating of Lean implementation	Application, tool, method, technique, model, framework, VSM, LLS, DMAIC
Cluster 3 Current state of Lean research methodology	interview, survey, initiative, qualitative, quantitative, challenge, barrier
Cluster 4 Adoption of Lean in public sector in 2009-2018	public sector, public service

Table 12 Clusters and Representative Words in Co-word Analysis, 2009-2018

Source: own elaboration

5. Discussion and Conclusion

As Lean thinking has been applied increasingly in service industry, the related literature is growing fast and accumulated substantial amount. It is necessary to perform a systematic review on the literature using bibliometric methods to depict its current landscape and to guide future studies. The present dissertation reviewed 378 articles related to “Lean implementation in services” between 1998 and 2018 found on Scopus and WoS. Their abstracts or full texts were read and categorized through publication counting and abstract analysis, their knowledge base was identified by co-citation analysis and their thematic evolution was explored using co-word analysis.

Through publication counting and abstract analysis it was found that the research field began its explosion after 2009 and is still increasing rapidly. The studies happened mostly in developed countries whereas studies in developing countries were lagging and only began from 2009. Articles focusing in healthcare sector have the dominant number which is eight times the number of the second place, public sector. Most of the studies were of an empirical nature describing application of Lean in an organization or activity and evaluating the outcomes, while theoretical studies developing and assessing a model/framework for Lean implementation are much fewer. The researchers also encountered a lot of challenges when transferring Lean into services.

Co-citation analysis identified the knowledge base of the 378 articles and classified them into five clusters, namely “1-Lean Principles”, “2a-Lean History I – Lean Foundations”, “2b-Lean History II – Lean transfer to Services”, “3-Lean in Healthcare”, “4-Lean in Public Sector” and “5-Case Study Research Method”. From its knowledge base we can also learn that the research field is very young, with the root of Lean being in 1990-1996, the discussion of Lean transfer to services happening in 1998-2006, and the application of Lean in services only scaling after 2005.

We also explored the thematic evolution of this topic by conducting co-word analysis to the former and later time periods respectively. Healthcare is the only industry that is significant in both periods, and the trend is that the application in healthcare is becoming more and more comprehensive and covers plenty of sub-sectors. Applying the Lean principle, flow, to reduce waste and increase efficiency is the mainstream target of the literature. Lean tools that come into force are enriched, with VSM, LLS, DMAIC, 5S and Kaizen as the most prominent ones. Case study method is always the common research

method and interview and survey are popular data collection manners. It can also be interpreted that researchers will encounter more problems as the Lean reform in service industry goes to deeper ground.

According to Chang, Huang, and Lin (2015), combining different bibliometric methods can help to reveal more details about a research field, which include not only research topics, purposes, but also commonly used methodologies. Indeed, from the three analyses we obtained a grand picture of Lean development in services full of details. Now we have a better understanding of its chronological development, the most common research themes and purposes, the most studied industries and regions, the most used Lean tools and the most adopted research methodologies. The obvious gap of this field is the insufficient studies in other service sectors except for healthcare and in other part of the world except for advanced economies in North America and Europe. The weakness is mainly related to the methodologies. The majority of the empirical studies are case studies, whose limitation in generalization makes the articles into silos—though large in numbers but lack of mutual connection. The deficiency of mature model or framework inhibits the expansion of Lean implementation in services.

Although being the first bibliometric study investigating Lean implementation in whole service sector at full time range, the dissertation is not free of gaps and limitations. The researched articles are only collected from Scopus and WoS, so some influential articles from other databases may be missed out. The screening and categorizing process was done manually, thus may suffer from personal bias. Regarding the co-citation analysis, Franceschini, Maisano, and Mastrogiacomo (2016) have reported errors in both the databases of Scopus and WoS, which will affect the accuracy of the cited references. As for the co-word analysis, the time period can be further divided into shorter segments to know more subtle changes.

Therefore, future researches can extend the data collection range outside Scopus and WoS. They may also focus the attention in certain sub-sector or certain countries to better detect the research patterns and trends. Moreover, the future works can develop an advanced screening and categorizing method to avoid individual bias.

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Appendix 1

Internship Report

*Except for the company name “Li & Fung”, other names of brands, customers and suppliers are disguised.

To fulfill the requirement of a curricular internship from the QTEM Master’s program, also, to examine the knowledge and skills acquired and have a contact with the real business world, the author is currently working as a trainee at Li & Fung (Portugal) Lda., the branch in Porto of the multinational group. This chapter will briefly introduce the company, the job as a trainee, and discuss the contribution of the author’s work to the company and to the knowledge.

Li & Fung was founded since 1906 in Guangzhou, China, and began its trading business in porcelain and silk. In 1937 it moved to Hong Kong and during 1949-1979, it grew fast along with the flourishing of Hong Kong as a manufacturing city for labor-intensive goods. At that time, Li & Fung was one of the largest exporters of garments and toys in Hong Kong. After China’s Opening-up in 1979, Li & Fung was able to outsource its labor-intensive part to mainland China where exists one-quarter the world’s labor. As the process of globalization continued, Li & Fung had changed from an Asian-based trading business to a global supply chain manager. It handles mainly soft goods like garments and apparel, and hard goods like toys, home products, sporting equipment and beauty products. In 2017, it had annual turnover of 13.5 billion dollars and a network of more than 15 thousand suppliers [1].

Li & Fung’s strategy is being “asset light” and acting as “the ultimate middlemen”. It tries to avoid holding any part of the supply chain it managed and focusing on trading and logistics. It can provide a dedicated and flexible supply chain solution, finding within its global network the right supplier and the right factory to fulfill the customer’s need in a quickest and cheapest way:

“...fabric for a garment order could be woven in China, sent to Korea for printing, and then to Guatemala for sewing. The order could be modified before each production step, for example, before

the fabric was dyed the customer could change the color, or before the garment was cut the client could change its design. Li & Fung virtually offered 'just-in-time' coordination for its customers.” [2]

Li & Fung (Portugal) Lda. is one of the components of Li & Fung's global trading network. It locates in Porto, north of Portugal, where the country's textile industry is concentrated. It manages procurements from local and also from China, Pakistan and India, and mainly serves markets in the UK and the US.

The company consists of several departments. There are merchandise teams dealing with trading of fashion, home textiles and ceramics; brands team that buy licenses of designers, manage product development and business development; corporate department that works on order management and logistics; and operation department responsible for internal operations, finance and IT.

The author's job as a trainee in the company is to learn the business process and help to improve the process, increase the efficiency and facilitate the decision-making of the management. Below is the explanation of some of the jobs and their contributions to the company.

Sales & stock analysis of brands GD and SD

Every week a sales report is received from the retailer, and the author has to keep on track the remaining stock (both the retailer's shop inventory and the stock in the warehouse) and record the sales trend.

It is necessary to know the status of the stock to avoid shortage, taking into account the shipment time. Also, the sales report from the retailer is a good feedback about the product, for example, under the same brand which design sells better than other designs.

Sales & margin analysis of the teams

The author exacts data from the internal digital platform about the sales performance of all the teams, and calculates their margins.

It is important to know the performance each period of each team. The total turnover and percentage of margin are critical indexes of the company's profitability. It is also necessary to look at each team separately to identify growth opportunity or problem.

Costing model & freight rates for BBB

The author learnt about the costing model to know the details about how a product goes through a logistics chain and how costs are distributed to each part. The author helps to maintain the costing model and is responsible for updating it when the freight rates are changed.

The freight rates are negotiated contracts between Li & Fung Logistics and freight companies that state the freight costs. The list consists of prices of different types of containers for thousands of routes globally. Every time the rates or the routes are changed, the operator has to identify the changes and establish the costing model again, which is a time-consuming job. The author used Microsoft Excel to improve this process. Now the operator only needs to input the new data and the costing model will automatically find the rates it needs and update itself.

Online stores product research

The author conducted product research about home goods on several online stores in the UK and the US. The author compares the popularity, price, size, material, pattern and construct of the same type of product under different price segments. In the end the author generates reports of the market and gives his own insights for future product development.

The report provides good insights for the sales team and designers, helping them to know the market and better prepare the products for next season.

Label & bags costing model of LA SS18, SD SS18

Different products (like comforter set, sheet set, sham, etc.) with different sizes need to be packaged with different bags, tags and labels. The author built costing model of packaging for all range of products of several series that will launch in the new season of 2018.

It is an important part of the total costing model, which can predict the profitability of the coming series in the new season.

Credit/Debit Notes and Customer Claim

These are related with the corporate department. The company needs to issue credit/debit notes to customer/supplier during every order. Sometimes it receives customer claims about quality issues, delivery issues, documentation errors or regulation violation, in sequence the company may choose to locate the cost to the suppliers and issue debit notes to them.

These works need great carefulness and patience, and are critical to the operation of the company. Errors will not only affect the accounting of the company but also undermine the relationship with the customers and suppliers.

From this internship the author became familiar with the business model of Li & Fung, a global supply chain provider, and knew more about international trading and supply chain management. It contributes to the author's understanding of Lean from a practical perspective, that "speed" and "value" are critical to supply chain provider. Speed will not only help the company to stand out from the competitive industry, but also equip the company with agility in response to changing customer needs. For example, Li & Fung is aiming to reduce the time of developing a product to less than 48 hours, a time which is 4 months traditionally. So, if you are a fast fashion brand who has a need of changing several designs within one season, you will undoubtedly choose the supply chain provider who can develop a product within 48 hours instead of 4 months. Creating value in an efficient manner, in other words, is "do right with less", which means the company has eliminated non-value-added activities and only delivers what the customer truly want.

[1] Li & Fung Limited (2018) Creating the Supply Chain of the Future: Annual Report 2017

[2] McFarlan, F.W., Chen, M.S., & Wong, K.C. (2012) *Li & Fung 2012*: Harvard Business Publishing

Appendix 2

Author	Year	Title
Aaltonen, P. M., Foli, K. J., Kirby, K. F., Simpson, V. L., & Walters, B.	2015	Improving teaching assistants' orientation in a school of nursing.
Abdelhadi, A.	2016	Using lean manufacturing as service quality benchmark evaluation measure.
Abdelhadi, A., & Shakoor, M.	2014	Studying the efficiency of inpatient and outpatient pharmacies using lean manufacturing.
Aboumatar, H. J., Winner, L., Davis, R., Peterson, A., Hill, R., Frank, S., . . . Farmer, D.	2010	Applying Lean Sigma solutions to mistake-proof the chemotherapy preparation process.
Adebanjo, D., Laosirihongthong, T., & Samaranayake, P.	2016	Prioritizing lean supply chain management initiatives in healthcare service operations: a fuzzy AHP approach.
Agbodzakey, J. K., & McCue, C. P.	2015	The key enablers for the adoption of lean thinking by public purchasing departments.
Agbulos, A., Mohamed, Y., Al-Hussein, M., Abourizk, S., & Roesch, J.	2006	Application of lean concepts and simulation analysis to improve efficiency of drainage operations maintenance crews.
Ahakchi, R., Ahakchi, R., Yangjh, B. S., & Alilou, M.	2012	Lean accounting, adaptation tool lean thinking and lean production.
Ahmed, R. A. H. S.	2010	Roadmap for continuous quality improvement and sustainability: A case study in Egyptian service sector organisation.
Akdag, H. C., & Cantürk, N. Z.	2017	Improvement of breast cancer patient pathway using EUSOMA standards and European guidelines.
Al Muhareb, T., & Graham-Jones, J.	2012	A review of lean management models at King Khaled International Airport
Alagaraja, M.	2010	Lean Thinking as applied to the adult education environmentLean Thinking as applied to the adult education environment.
Al-Araidah, O., Momani, A., Khasawneh, M., & Momani, M.	2010	Lead-time reduction utilizing lean tools applied to healthcare: the inpatient pharmacy at a local hospital.
Aleem, S.	2013	Translating 10 lessons from lean six sigma project in paper-based training site to electronic health record-based primary care practice: Challenges and opportunities.
Alexander, G., & Williams, J. H.	2005	The impact of an accelerated improvement workshop on ordering and receiving.
Alhuraish, I., Robledo, C., & Kobi, A.	2016	Assessment of Lean Manufacturing and Six Sigma operation with Decision Making Based on the Analytic Hierarchy Process.
Allaudeen, N., Vashi, A., Breckenridge, J. S., Haji-Sheikhi, F., Wagner, S., Posley, K. A., & Asch, S. M.	2017	Using Lean Management to Reduce Emergency Department Length of Stay for Medicine Admissions.
Allen, D., Blaylock, W., & Mieczkowski, S.	2009	Local implementation of the crisis model: The Buckinghamshire community acute service.
Alshahrani, S., Rahman, S., & Chan, C.	2018	Hospital-supplier integration and hospital performance: evidence from Saudi Arabia.
Alsmadi, M., Almani, A., & Jerisat, R.	2012	A comparative analysis of Lean practices and performance in the UK manufacturing and service sector firms.
Andersen, H., & Rovik, K. A.	2015	Lost in translation: A case-study of the travel of lean thinking in a hospital.
Andersson, R., Manfredsson, P., & Lantz, B.	2015	Total productive maintenance in support processes: an enabler for operation excellence.
Anisi, S., Marzban, S., Zarei, E., & Sepehri, M. M.	2017	IDENTIFYING PROCESS IMPROVEMENT OPPORTUNITIES IN GYNECOLOGY CLINIC BY VALUE STREAM MAPPING.
Antony, J., Ghadge, A., Ashby, S. A., & Cudney, E. A.	2018	Lean Six Sigma journey in a UK higher education institute: a case study.
Antony, J., Rodgers, B., & Cudney, E. A.	2017	Lean Six Sigma in policing services: case examples, lessons learnt and directions for future research.
Antony, J., Rodgers, B., & Cudney, E. A.	2017	Lean Six Sigma for public sector organizations: is it a myth or reality?
Apte, U. M., & Goh, C. H.	2004	Applying lean manufacturing principles to information intensive services.

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Appendix 3

List of words chosen based on author keywords and frequent words from abstracts.

5S	gap	methodology	quality improvement
acute	health care	model	quantitative
agile	healthcare	National Health Service	Queuing theory
application	higher education	NHS	Radiology
barrier	Hospital	non-value-added	service
Benchmark	HRM	Nursing	Simulation
Call centre	implementation	Operating room	Six Sigma
case stud	initiative	Organizational change	supply chain
challenge	intervention	Patient safety	survey
Change management	interview	patient satisfaction	Takt time
clinic	IT support	performance	technique
Continuous improvement	Kaizen	pharmacy	tool
critical success factor	Laboratory	philosophy	Total Quality Management
CSF	leadership	practice	training
DMAIC	Leagility	primary care	Triage
efficiency	lean	principle	Turnaround time
emergency department	lean thinking	process improvement	value stream map
Empirical	logistics	productivity	VSM
Financial	LSS	public sector	wait time
flow	maintenance	public service	waste
framework	manufacturing	qualitative	

* Words marked with the same color have the same meaning but in different forms, so their numbers of appearance would be combined.

* 'case stud' can index to both 'case study' and 'case studies'.

* Actually the right expression is 'value stream mapping', but some people also use 'value stream map'. Since searching 'value stream map' can also index to 'value stream mapping', 'value stream map' is chosen as the keyword.