Benefits and Difficulties of the Implementation of Lean Construction in the Public Sector: A Systematic Review

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Abstract: Lean philosophy has shown successful results in the manufacturing industry since the eighties regarding efficiency, reducing cost and errors. However, the philosophy originated in the private sector, where the work rules are defined by business owners within the framework of some regulation. In the public sector, however, the picture is different. The way of working and carrying out operations and projects is directly defined by regulation, where the owner's role—as in the private world—is embodied by the entire political system. This article aims to take a comprehensive look at the academic literature on how Lean has been applied in the public sector (LIPS) from a bibliometric perspective and then delve deeper into the concept of lean construction in the public sector (LCPS) through a systematic review. The results give a complete picture of the research in LIPS, revealing that research directions focus on implementing Lean, how it works in the public sector and the human factors involved in its practice and digitalization. Moreover, the advantages and challenges of LCPS have been presented, where again, the human factor is the central concern of researchers.

Keywords: Lean; Lean construction; public sector; Lean implementation; Lean in the public sector

1. Introduction

Lean is a philosophy originated in the 1980s in Japan by Toyota [1], which is based on the practices of the Toyota production system (TPS) that seeks the satisfaction of both internal and external clients, fulfilling their expectations and needs. The Lean philosophy is about the improvement process focused on both the identification and subsequent elimination of waste, as well as the creation of value [2]. The engineer John Krafcik first used the term "Lean" itself in his master's dissertation [3]; after that, the term is used in several texts such as the book "The Machine that Changed the World" [1]. In the above text it is related that after a hesitant moment at Toyota, due to the inability to mass produce, the TPS was conceived, then developed and finally became known as Lean manufacturing.

The Lean philosophy is based on five principles: (1) specify precisely the concept of value for each product, (2) identify the value stream for each product, (3) make the value flow without interruption, (4) allow the client to attract to himself the value that comes from the manufacturer, and (5) seek perfection [1]. The benefits of implementing Lean are associated with the reduction of the eight types of waste or muda, seven of these proposed by Taiichi Ohno, which are: defects, overproduction, waiting, transportation, inventory, movement and over-processing [2]. The eighth consists of not taking advantage of the talents of people in the collaborative space. The Lean philosophy has been applied over time to projects of diverse nature in multiple industries, its diversification allows it to be applied in both the private and public sectors [4,5].

The public sector is the set of entities that, in addition to their general administration, form part of the financial activity of the state and its intervention in the economy. The

sector also includes autonomous agencies, public business entities and state trading companies, foundations, social security management entities and construction consortiums for public assets.

The public sector, when using citizens' resources, is committed to working efficiently. An efficient state provides greater benefits to its citizens without resorting to public debt or tax reforms. To achieve efficiency in the public sector, the use of Lean is proposed, although it has been implemented to a lesser degree, due to current resistance [6,7]. The resistance to organizational culture change is mainly due to doubts about how and where to implement it, what the benefits are and the problems associated with its implementation [5].

Lean in the public sector (LIPS) is a topic that has been discussed for about two decades, and its use is currently related to the dissemination of good practices and experiences [4]. LIPS was born when the Lean approach was used in healthcare and public services, as certain tools and techniques were found to be useful [8]. The transition from services to the public sector has made it a recurrent practice, since through cycles of experimentation and operation it has matured within organizations in terms of diffusion and sophistication, although this has not been without barriers and obstacles. The current state of this philosophy indicates that even for well-reported cases, there are elements of the public sector who do not understand the ideas of this philosophy well [7].

The Lean production approach also has the potential to be applied in planning, design and construction projects. To describe an approach that minimizes waste in materials, time and effort in construction activities, the International Group for Lean Construction coined the term "Lean construction" (LC) in 1993. The ultimate goal of LC is to achieve maximum cost-effective value [9]. The existing literature on LIPS is not specifically focused on the construction sector, so it is complex to evaluate its practicality in such a particular field as construction [10,11].

This research aims to provide an overview of the academic studies of the application of Lean in the public sector—as a whole concept—and Lean construction as a specific topic. This study is conducted through a literature review in two stages. The first stage encompasses a bibliometric review for constructing the panorama of the application of Lean in the public sector (LIPS). The second stage considers a systematic review to identify the experience, benefits and difficulties of using Lean construction in the public sector (LCPS).

A bibliometric analysis is an activity of great relevance at the beginning of a scientific research process, which is related to the need to know the current state of the fields that make up a topic of interest [12]. This knowledge is a crucial requirement for the formulation of works that contribute to the generation of new knowledge and are supported by previous scientific developments [13]. Thus, a bibliometric study can be assumed as a technique of exploration and analysis of large volumes of data that can be used to identify trends, research topics, collaboration patterns and relationships between research approaches, among others [14,15]. Therefore, a bibliometric analysis manages to provide an overview to understand the knowledge structure of a topic of interest, as well as the behavior over time of the research field, which varies due to the inclusion of new complementary research or leads to the development or decline of the topic. In addition, a bibliometric analysis can provide relevant basic information to identify gaps in the field of knowledge that could be explored with the creation of new lines of research [12,13]. Hence, bibliometric studies have become widespread and have become a tool of great importance to evaluate the behavior and current state of the topics of interest in various fields of research [14,15].

The rest of the document is structured as follows. Section two describes the materials and methods used for this research and how the bibliometric and systematic analysis will be developed. Section three encompasses the results and their discussion. Finally, the conclusions are displayed in Section 4.

2. Materials and Methods

To meet the objective of this project a two-stage research method was developed as shown in Figure 1. In the first stage, the trends and research topics associated with LIPS

were identified by applying a bibliometric analysis. The second stage encompassed a study of the benefits and difficulties of implementing LCPS by identifying and analyzing experiences from a systematic literature review; finally, categories related to the common themes were defined.
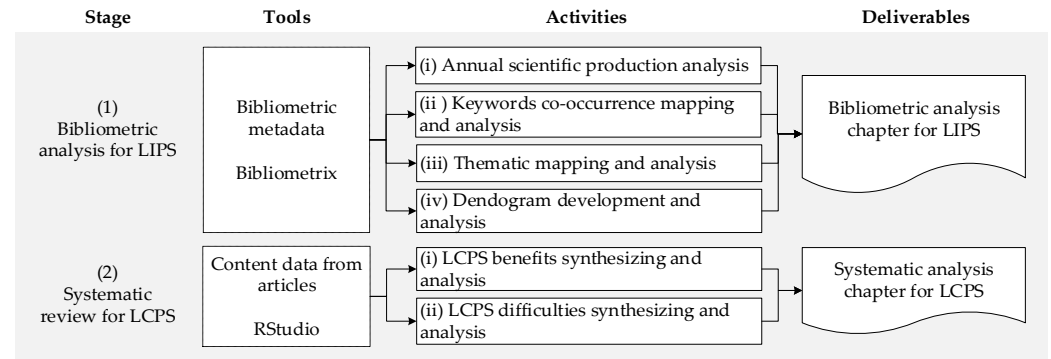
Figure 1. Research method. Source: authors' own work.

In stage 1, a bibliometric analysis was conducted using two libraries, Scopus and Web of Science, combining the terms "lean" and "public sector" together, over a period of time spanning the last 22 years. Since some journals are indexed only in Scopus or only in Web of Science, the use of the two search engines could be considered complementary [16]. In Scopus, documents of the article and conference paper type were considered. For the Web of Science database, documents of the article, early access and review article type were considered, without excluding any sub-areas. The results of both searches totaled 276 documents (considering duplicates). With the obtained articles, an R-studio code was executed for compiling a single list of documents without duplicates. As a result, 76 documents were removed, finally leaving 212 documents to be analyzed using the Bibliometrix package [17]; this tool has been used for bibliometric analysis in the best journals of the construction discipline [18–20]. Using this tool, four analyses were performed (see Figure 1). An annual scientific production analysis (i) was performed by developing a graph based on the count of the year of publication. A co-word analysis (ii) is based on identifying two or more concepts that usually appear together. In this case, two concepts will be co-occurring when they frequently appear together and when they rarely appear separately. To perform this analysis, firstly, a clustering algorithm was chosen based on the results and conclusions of multiple studies involving the performance of multiple clustering algorithms [21–23]: the Lovain algorithm and the InfoMap algorithm. The second step is the network visualization method selection. Here, the strength-based methods were selected with two options, the Kamada and Kawai and the Fruchterman and Reingold methods. The final selection was carried out by combining the options and analyzing the results of each one visually. The Lovain algorithm combined with the Fruchterman and Reingold method was selected due to their good performance, having a smaller amount of crossover, less overlapping of nodes and better uniform distribution. It is important to mention that this analysis was performed based on the keywords plus method. The thematic analysis (iii) was developed by mapping the attraction of groups of keywords and classifying topics. This classification considers the density and centrality of these by dividing them into four quadrants corresponding to four types of topics [24]. The selection of these parameters was based on the comparison after iterating the values between them. In the case of a high number of words and a small amount of minimum cluster frequency a better result was observed in terms of the amount of data presented in the thematic map obtained. Finally, the number of words was chosen as 5000 with five as the minimum cluster frequency. A dendrogram development and analysis (iv) considers an evaluation of the cohesion of the clusters that have been formed and, by means of the representation of vertical and horizontal lines, shows the distance between the merging groups [25,26]. This method was selected by a comparison with the other available methods based on

their performance, for example, the correspondence analysis and multidimensional scaling method, which keeps the number of clusters fixed. The multidimensional correspondence analysis method was chosen due to the more coherent distribution among the topics, allowing subgroups with good relationship to be obtained [26]. The number of clusters was chosen after iterating with different values and comparing the results of all these iterations. Therefore, it was concluded that the best result was achieved with the number five since, if a lower number of clusters was chosen (i.e., cut above the dendrogram) there were lower levels of similarity between the topics. In this case, some topics were united in a single cluster with a large number of observations; in the opposite case, from five clusters upwards, when the number of clusters is increased, we had a large number of clusters with only one observation.

In stage 2 of Figure 1 the benefits and difficulties of LCPS were analyzed. To perform these activities, a systematic review was conducted in two libraries: Scopus and Web of Science using the terms "lean construction" and "public sector" together, for research published in the last 22 years. The documents considered included articles, conference papers, early access and review articles, without excluding any sub-areas. The results added up to a total of 24 documents from which two duplicate documents are eliminated, leaving 22 documents to be read and analyzed. These documents were analyzed and then classified according to their common themes and characteristics. The above was performed by identifying how the lean approach was implemented in projects, in terms of their phase and focus. Finally, the benefits and difficulties that arose at the time of applying Lean in each project were identified. With this classification we expected to be able to formulate an approach and achieve a better understanding of the application of Lean in the public sector with a particular focus on the construction sector.

3. Results

In the following section, the results of the bibliometric and systematic analysis are described.

3.1. Annual Quantitative Distribution of Scientific Production—Lean Manufacturing in the Public Sector

A total of 212 selected documents were distributed in chronological order according to their year of publication, between 2000 and 2022, as shown in Figure 2. The largest number of articles were published in the years 2018 and 2020, with 22 and 24 publications, respectively, followed by the years 2019 and 2014, both with 17 publications. It can be observed that the research related to LIPS topics has become massive over the years, with an annual growth rate equal to 9.37%. This reflects a gradual but constant development of the topic, evidencing a growing interest in the research and development of these topics as a whole.
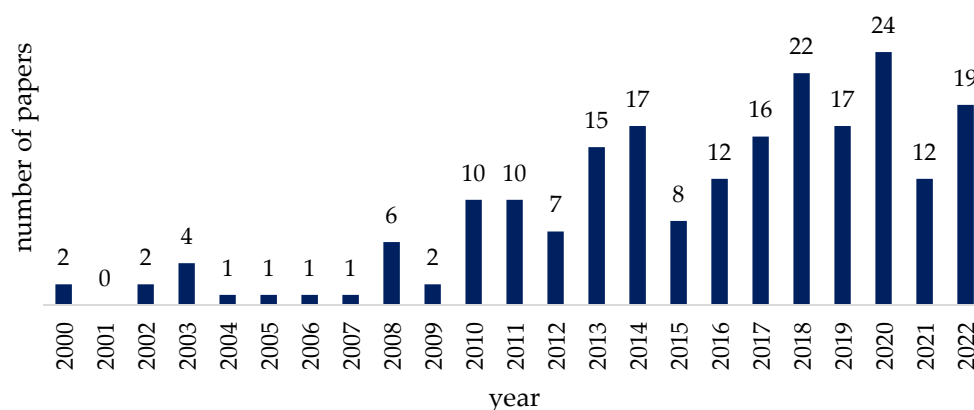

Figure 2. Annual scientific production: number of articles published in the period 2000–2022.

3.2. Keyword Co-Occurrence Analysis—Lean in the Public Sector

A keyword co-occurrence analysis was performed according to the main information of the search results with a total of 730 results. These words were analyzed in the Bibliometrix tool, establishing a minimum number of edges equal to two and removing the nodes that were isolated; with this the keywords were reduced to 40.

With this number, a co-occurrence diagram was generated as shown in Figure 3, in which the words were grouped into four clusters (represented by the colors blue, purple, red, and green). The above is based on the greatest similarity between their concepts and the frequency with which they occur in the documents jointly or separately, the details about their betweenness, closeness and PageRank and the cluster to which they belong. Based on the diagram, the following groups of terms related to different themes are identified: (1) management and implementation (blue); (2) public sector (purple); (3) organization and people (red); and (4) government (green).
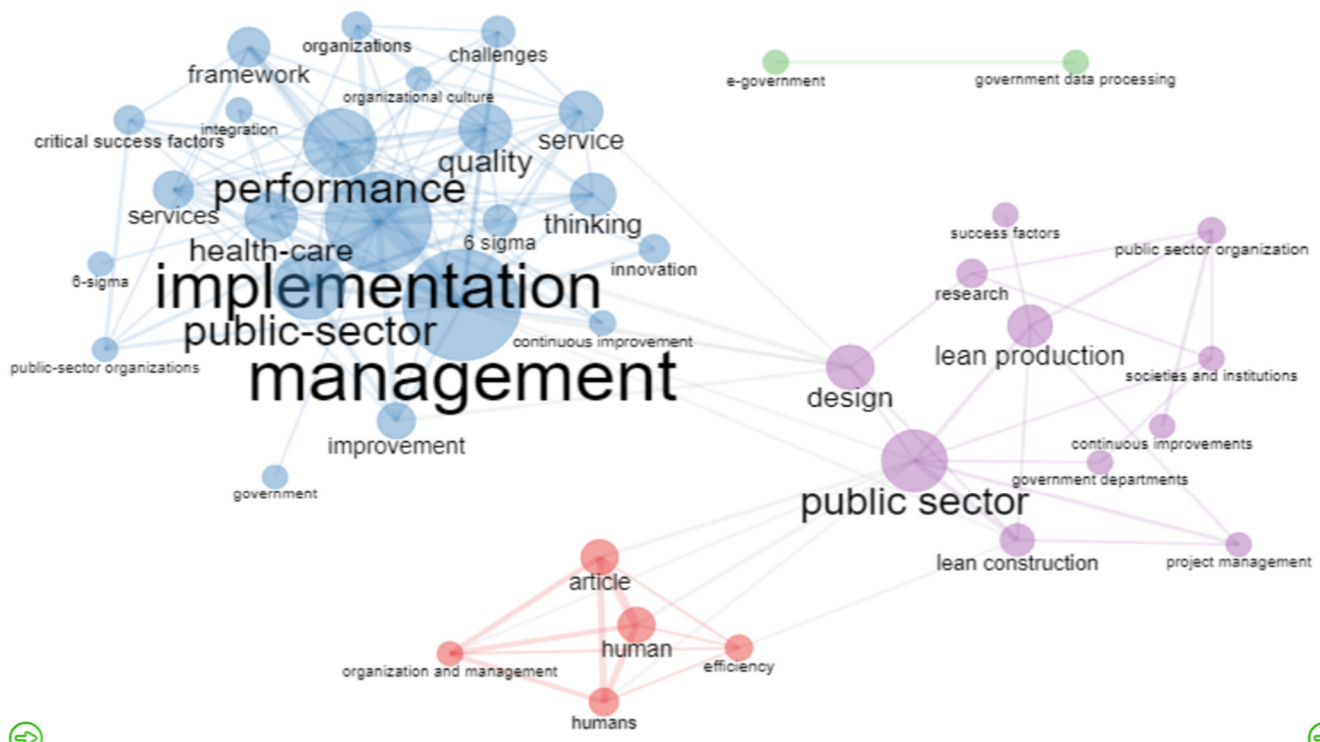
Figure 3. Co-occurrence diagram of the main keywords. Created using the Bibliometrix R package.

3.2.1. Cluster Blue—Management and Implementation

The main keywords in this cluster are implementation, management, performance and quality. This is the main cluster, where the two keywords most cited by the authors in the articles studied are implementation and management. These themes are a response from researchers on how to implement Lean in organizations that make up the public sector. The transition to the organizational culture that fosters Lean requires collaboration among all those involved in the workplace and creating a culture that seeks to solve the problems of the public sector [27]. However, the implementation of the Lean approach often encounters resistance, such as inexperienced employees, difficulties in defining the client [7] and the incapacity to align Lean with the organizational strategy, seeing Lean as a temporary effort and not as a continuous and sustained improvement over time [27]. Therefore, it is imperative to understand what Lean is, what its tools are and how they can be implemented in the public sector [4]. A change to this new organizational culture can be accomplished in a variety of ways, ranging from tentative exploration to systematic approaches [27]. The approach to this implementation can represent the process as a journey in which, during

the course of each stage, the personnel that make up the organization move at different paces, from isolated application through day-to-day problem solving to improvement [27].

Another predominant term in the cluster is management. There is a link between implementation and management since the implementation of Lean in any sector is directly involved with management, from the moment in which traditional ways of working are rethought to when an improvement in performance is sought and stimulated [28]. Performance in public sector environments has improved as a result of suggestions to implement the Lean approach [28]. To obtain this achievement a practical and understood range of performance measures should be used in decision making [5]. As a result, the Lean approach may make management collect statistical information, monitor productivity and challenge performance [29]. In the opposite case, where there is no objective performance measurement, moving to a measurement based on facts becomes a challenge for the organization [29]. Lastly, if there is quality generally in projects, those involved have favorable opinions about quality improvements, with some of them stating that Lean is a fantastic philosophy [28]. In this way, quality improvement can be related to error reduction, increased quality controls with feedback to staff, more structured approaches to problem re-solving and other impacts of implementing the Lean approach [29].

Finally, the main benefits of implementing Lean in the public sector are divided between tangible benefits, such as cost, time, quality and resources; and intangible benefits, such as user perception, motivation and employee satisfaction [29]. Although in most cases Lean implementation is studied in conjunction with management considering important issues such as the definition of value. Value identification should be related to both internal and external clients [29]. This can be complex in the public sector, since simple participation mechanisms must be included for all stakeholders (technical and non-technical), to then have a set of requirements that are integrated, coherent and at the same time satisfy a large number of stakeholders [28].

3.2.2. Cluster Purple—Public Sector

The main keywords of this cluster are public sector, Lean, continuous improvement and success factors. It corresponds to the second largest cluster. These topics are a response from the researchers to study how Lean may help public sector organizations to improving their efficiency in their business processes and the success factors. However, even though the popularity of Lean has contributed to its diffusion in the public sector [6], there is still limited knowledge of this philosophy in the sector [6]. Although Lean asserts that improvement starts with customer focus, this seems to be more possible for companies in the private sector, as opposed to the public sector, where public services are often driven by an efficiency agency [29]. This contrasts the similarities and differences between the two sectors, with the public sector having greater procurement demands. These demands vary from one another, with external and internal demands, contextual and process demands and finally the multiple roles that exist between the two sectors [30]. Because of all this, the public sector should aim to optimize its organizations and processes [30]. It is important to mention that the activities in which Lean is developed in most organizations cover a limited number of processes, in turn, in a limited number of units or departments within the organization [6]. Implementing Lean can be described from two points of view and two levels of the organization, either from a practical point of view, or from a philosophical point of view, at the operational and strategic levels. When these four categories are blended together a toolbox is formed (practical and operational); becoming Lean (practical and strategic); Lean (philosophical and operational); and Lean thinking (philosophical and strategic) [30].

The other terms present in the cluster are continuous improvement and success factors. There is a link between continuous improvement and Lean, as it is one of the five principles of Lean [1], With respect to the success factors that are present throughout the improvement process, we noted the importance of the workers' acceptance. This is because workers represent agents of change and often, in their absence, improvement slows down or even

stops [6]. Another important factor is complexity and importance, Lean-based projects should start on a small scale with problems that show a viable and significant improvement, as quickly visible results help to convince others about the benefits of Lean [6]. The balance of power must be considered; depending on the power relations, the progress of improvement can be tarnished. Rigid or hierarchical organizations tend to present problems with a change of culture. Finally resources and capabilities should be taken into account. Organizations with previous knowledge of management improvement tend to have greater chances of success in implementing Lean as opposed to those who do not have any kind of resource of this type, since they have a common barrier when implementing Lean [6].

One of the main benefits is the visualization of those factors that influence the success of Lean implementation in the public sector. With this, it can be estimated that success and failure are related to organizational factors rather than to the Lean technology itself [6]. In addition, there is a perception on the part of the workers that this implementation is a means of reducing the number of employees, which can lead to a breakdown of the negotiated order [6], and as mentioned above, without these change agents, the system ceases to improve. Finally, there is the complexity of each project. In many cases the customer at the other end is a citizen who is not seen because they are represented by numbers. Therefore, the services involve living, thinking and complex human beings who, not being pieces of hardware, behave, think and act unpredictably. The above makes it difficult to standardize processes, which is why many organizations opt for the use of a Lean back office [28].

3.2.3. Cluster Red—Organization and People

The main keywords of this cluster are related to organizational issues and are efficiency, people, organization and management. It corresponds to the cluster in third place in terms of importance. These themes are a response of the researchers to the whole process of implementing Lean in a public sector organization and the impacts that are produced [29]. Many organizations aim to make efficient use of their available resources, ensure process quality and improve management, for instance [4]. To achieve this, many managers choose to implement Lean in different ways, ranging from a tentative exploration to a systematic approach [27].

The other terms present in the cluster are efficiency and people. There is a close relationship between efficiency and organization and management. Correct efficiency allows a higher percentage of work to be carried out with lower losses, with the same budget, using the same infrastructure, equipment, technology and personnel [27]. The need for greater efficiency and performance is what drives the use of Lean [27]. Although, if there is not a correct specification of value before applying Lean, the service or product delivered will be inefficient [27]. In summary, implementing Lean can lead to impressive efficiency gains but this can stall or fail to materialize into improvements due to a lack of understanding of what represents value and who the customer is [29]. Often in the public sector, where employees work with a stack of papers or with data on a monitor, it is forgotten that at the other end there is a client [29]. This situation occurs if there is no commonly accepted set of activities to achieve a client focus along with service levels that are deemed appropriate. There are elements in the literature that are important, such as knowing who the customer is, what their expectations and needs are and what they want [29]. Therefore, it is imperative to make an effort to define the client, since public organizations cannot be seen only as a business, since the clients are both citizens and workers within the organization [4]. With respect to workers (or internal clients), there is the challenge of ensuring their participation [4]. This implies training them, because if the worker is not properly prepared to evaluate his area of work, he is less likely to identify a possible improvement [31].

Finally, one of the main benefits of implementing LIPS is collaboration, which is the starting point for the identification, reduction and elimination of waste. Collaboration

among workers has been promoted through a suggestion system, inspired by the Toyota system. In this context, workers are able to find potential improvements in their workplace. According to this theory, giving a suggestion and having it received and then implemented gives a sense of importance to the worker, encourages employers to focus on making the work meaningful and creates a space where ideas are valued [31]. However, there is a difficulty related to government entities which have a tendency to promote independent working and dispersed decision making, which makes standardization difficult [31]. This is why the Lean destination must be aligned with the organizational strategy, becoming the way things are done in the organization [27].

3.2.4. Cluster Green—Government

The main keywords in this cluster are related to government and are e-government and government data processing. It corresponds to the cluster of least relevance and with the smallest number of elements. These topics are a response of the researchers to the absence of what can be considered a clear vision of Lean, which makes it difficult to translate the concept correctly. However, as a result of this there is a margin to modify this concept to domains such as e-government [4].

E-government refers to the use of information and communication technologies by government agencies to improve efficiency and effectiveness at the time of operating, meeting the needs of citizens [32]. The realization of all the above implies a crucial change in the structure and operation of a public administration, and for a traditional government it implies the transformation of its function [33].

The other term present in the cluster is government data processing. There is a close relationship between the terms e-government and data processing. E-governance through the digitization of the governmental system provides a tool that allows control over the process(es) while integrating Lean principles [34]. In order to reduce costs while maintaining and/or improving service levels governments seek to streamline processes [4]. The benefits may include building a collaborative platform and inter-organizational workflow formation, facilitating collaboration across networks and improving e-government administrative efficiency [25]. Moreover, the other benefits include encouraging employees to think outside the box and deliver creative solutions [34] and, finally, an increase in the transparency of the system, which is of great importance in countries with a high level of corruption [34].

Finally, one of the main benefits of e-government is the dissemination of information among collaborators. In contrast, in a traditional system each sub-system plays a role, but is independent; due to the different techniques and standards isolated islands of information are produced, leading to new waste and inefficiency [33]. The success of e-government requires strong determination, good leadership, effective coordination and a majority of citizens' participation [33]. In addition, the support of leaders is an important guarantee, since this type of change requires the total and continuous commitment of those involved [33,35]. Implementation in government sectors can prevent corrupt actions, achieve efficiency, save time and reduce unnecessary costs, which is why, if implemented quickly and radically reforming the environment, there will be some resistance to change [34,35].

3.3. *Thematic Map of the Research Field—Lean in the Public Sector*

Thematic mapping is used to study the evolution of a research field, as a result of which the impact of the research field is shown. This includes the topics and thematic areas that were detected, all based on quantitative measures and an impact index, or h-index [36]. The four resulting theme types shown in Figure 3 are: (1) motor themes; (2) basic themes; (3) emerging or declining themes and (4) niche themes.

Regarding Figure 4, the following motor themes are located in the upper right quadrant: efficiency, government, people, research, manufacturing, organizational themes, engineering processes, agile manufacturing systems, public sector, Lean, management themes, supply chains and success factors. These themes are well-developed and important

in the structuring of a research field; they are known as the driving themes because they present both a strong centrality and a high density. The themes located in this quadrant are externally related to concepts that are applicable to other themes with which they have a close conceptual relationship.
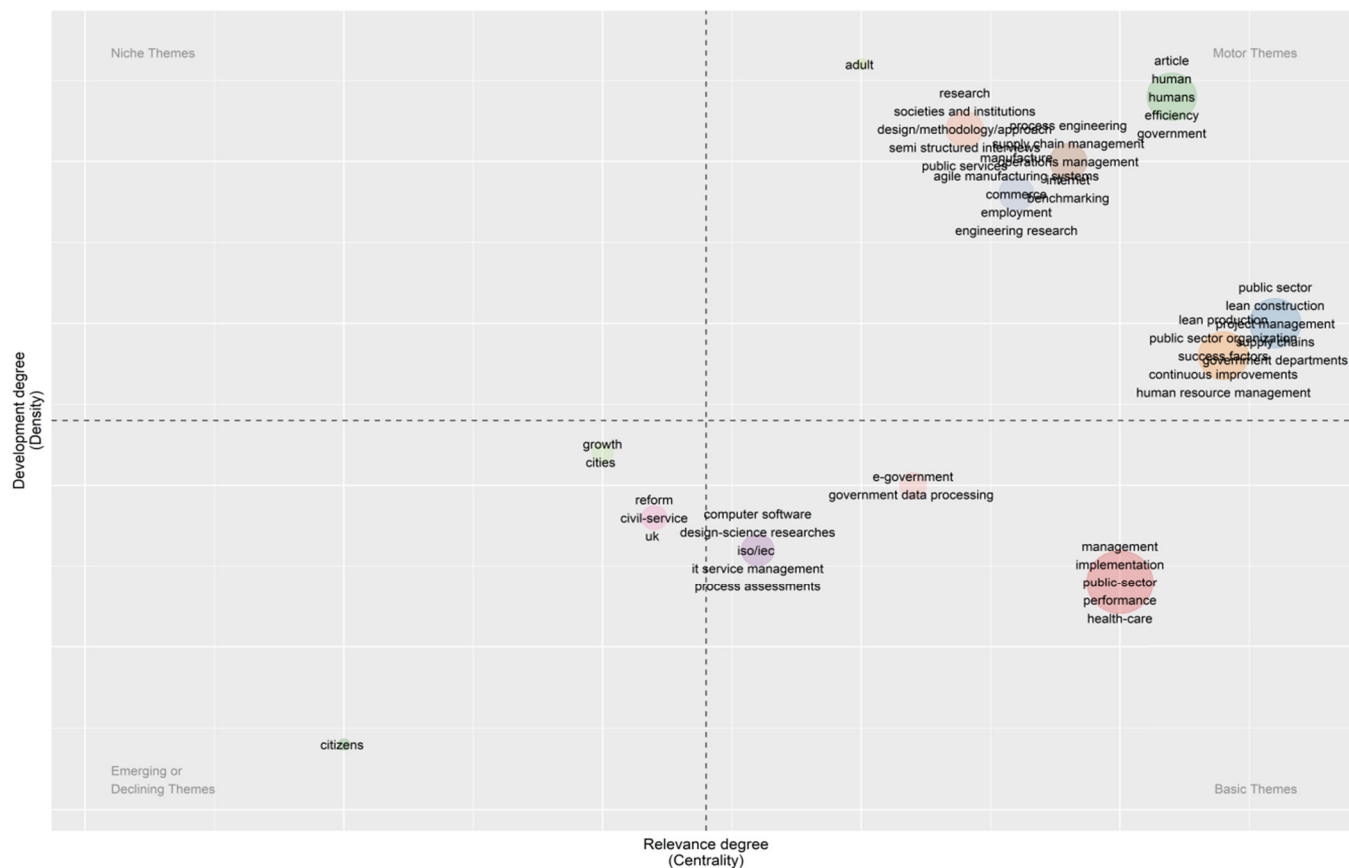
Figure 4. Thematic map on topics in the field of research ordered according to their centrality and density. Created using the Bibliometrix R package.

The basic themes are located in the lower right quadrant and, in this case, are e-government, topics related to data processing, scientific research, iso/iec, IT service management and administrative topics. These topics are important in the field of research, but they are not developed, and the topics in this quadrant are basic, cross-cutting and general.

Emerging or declining themes are in the lower left quadrant and in Figure 4 the themes related to citizen services, growth cities, reform, civil-service and the UK are shown. These themes are underdeveloped, have both low density and low centrality, and are, therefore, marginal and represent mainly emerging or declining themes. The bibliometric analysis did not locate keywords in the niche theme quadrant.

Finally, niche topics are located in the upper left quadrant. In this case, there no specialized topics are found. Regardless of the fact that in this analysis there are no results, it is important to mention the characteristics of the topics in this quadrant. These themes have well-developed internal links, links between those of the same quadrant and, with respect to external links, these lack importance. In the field of research, these themes, due to their peripheral nature, are very specialized.

3.4. Dendrogram Clustering—Lean in the Public Sector

The dendrogram in Figure 5 was created using a final partition of five clusters. The first cluster (far left) is composed of two topics (article and human). The second cluster (second from left to right) is composed of four topics (public management, management,

health and design). The third cluster (middle cluster) is composed of nine topics (quality, improvement implementation, Six Sigma, framework, public sector, service, performance and thinking). The fourth cluster (second from right to left) is composed of one topic (public sector). The fifth cluster (far right) is composed of four topics (Lean construction, Lean production, organization and public sector research).
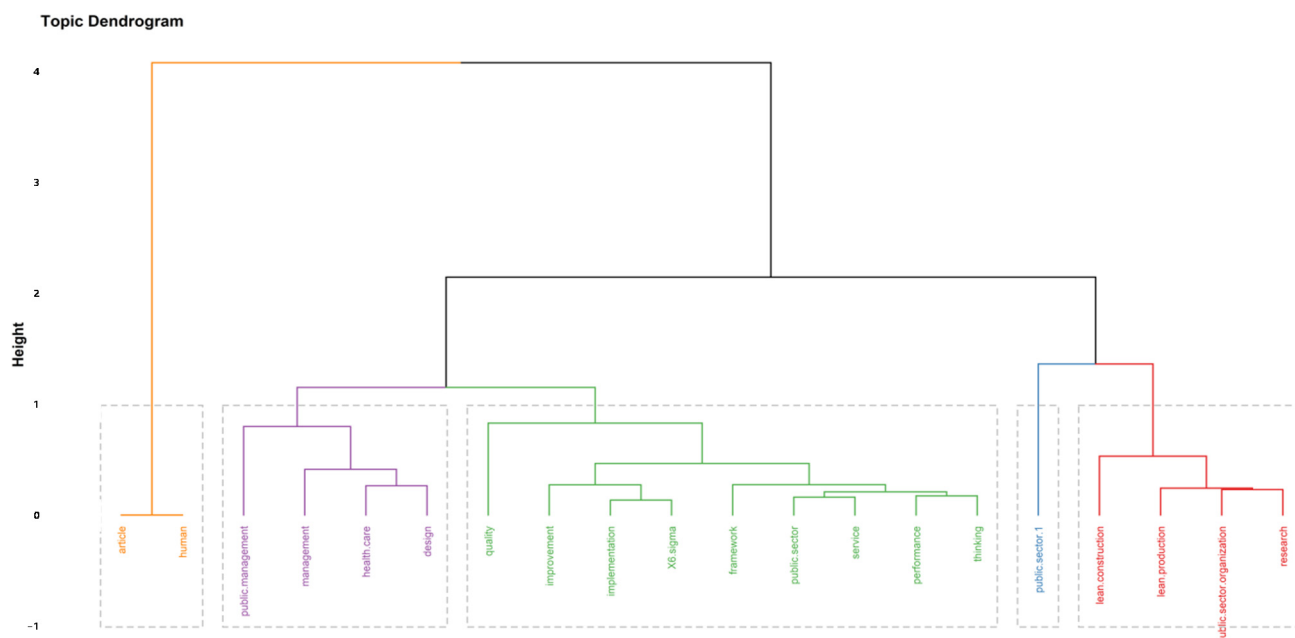
Figure 5. Dendrogram of topics grouped according to the cohesion between them. Created using the Bibliometrix R package.

In the following sub-sections, the clusters found will be analyzed.

3.4.1. Group 1 (Orange)

The topics of this group are articles (referring to research) and human. This group has the second smallest number of topics, but it has the most cohesive topics. These themes are the researchers' response to how the human factor influences the implementation of LIPS. Employment rates in the public sector range from 30% in some Scandinavian countries to as low as 8% in Japan, indicating the significant number of people involved in this sector [37].

The public sector is composed of various organizations at different scales and belonging to different areas. What they all have in common is the need to work efficiently due to external and internal pressures. Therefore, several areas have committed to a systematic and in-depth effort to improve their public services [36,38]. One way to achieve efficiency and productivity is through the workers. Suggesting teamwork leads to generating favorable attitudes among employees while improving their quality of work-life, which can achieve organizational effectiveness [36]. This process must begin with an understanding of the needs of those parties involved and interested in the public sector (for example, internal clients, executives, organization managers and citizens) [36]. Then, there must be personnel training. By achieving a trained personnel, the teams can be divided into centralized and specific ones, with the centralized teams being responsible for disseminating best practices [38].

In addition to managing personnel within the organization, the strategic and operational objectives of the organization must be considered, and there must be an evaluation of effectiveness. Measuring the real social impact of services that add public value for everyone involved through public organization processes and services, evaluating them from the perspective of social value and management, translates to an impact on the human factor and internal clients [36].

3.4.2. Group 2 (Purple)

The topics of this group are public management, management, healthcare and design. This group has the second highest number of topics and in this case, the topics scale towards the left. These themes are the researchers' response to how the implementation of Lean has evolved in the public sector. Starting with design, Lean is based on the assumption that organizations are made up of activities linked to processes, which have a defined order and space, and are delimited by a start, an end and established inputs and outputs [27].

There is a trend generated by successful case study results where Lean has been implemented for the rapid spread of this philosophy in public sector environments, causing a rethinking of traditional work methods [28]. The need to improve efficiency and performance leads managers to improvement methodologies such as Lean. In the case of healthcare, implementation ranges from tentative exploration to a systematic approach, aligning the organizational strategy with implementation [27]. The adoption of Lean in hospital services should follow the policies of the health department, with events and talks, although seldom with the necessary training [28]. The complexity of this implementation lies in the fact that patients are not inanimate objects; they think, act and behave in an almost unpredictable manner, which is why personnel differ in their effectiveness in complex medical practice [28].

Moving on to the terms management and public management, it can be observed that, recently, Lean has been mobilized to sectors other than manufacturing and production, encompassing various public sector organizations [30], from healthcare to other public services. One point on which some documents agree is that services should operate in a somewhat similar way to their manufacturing counterparts, transforming inputs into outputs through serial processes [36].

In the healthcare area, Lean includes philosophical aspects and improvement processes where some of the vast variety of Lean tools previously experimented with by healthcare professionals and managers are used. The aforementioned is done to improve incentives, efficiency, clinical outcomes, the perception of satisfaction and safety for internal clients (employees) and external clients (patients) [39].

3.4.3. Group 3 (Green)

The topics covered in this group are quality, improvement, implementation, Six Sigma, framework, public sector, service, performance and thinking. This group has the highest number of topics, and these themes are the response of researchers to work towards continuous improvement. Starting from the first subgroup from right to left, the topics related to work in the public sector using Lean are found. Regarding Lean thinking, there is limited knowledge of its use and impacts, which is significant since introducing this thinking without a strategic plan adapted to the public sector's context can result in inappropriate performance and unexpected results [6]. Service and performance are limited by multiple variables mentioned in the results of other analyses, and implementing Lean generates conflicts with daily work [6]. Most projects are carried out on a smaller scale and are far from being organizations fully aligned with Lean principles [6]. Despite the small scale at which Lean techniques or tools are implemented, services in the public sector must be efficient, have good performance and be evaluated from an economic perspective for efficiency, social value and management [36].

The need to increase efficiency and effectiveness highlights the concept of continuous improvement [40]. The middle subgroup's topics are related to the implementation of improvements in the public sector. Some public sector organizations have committed to making efforts towards improving and innovating the services they offer [36]. It is recommended that implementation should start on a small scale with visible and significant problems to solve [6]. To achieve success, some level of training for the workforce is necessary [41], and unrealistic expectations should be avoided as they may result in disappointment and a sense of failure [40]. Instead, the process should be considered as

continuous improvement, increasing learning through continuous interaction between operations [40].

Finally, it is observed that Lean provides a more structured approach based on problem-solving, which can be learned from, fostering a positive perception among staff members [29].

3.4.4. Group 4 (Blue)

This group encompass one single topic: the public sector. This theme is the researchers' response to how the implementation of Lean has evolved in the public sector. Starting with the attention that Lean has received in recent times, which has contributed to its diffusion in the public sector [6]. The Lean approach has been adapted and subsequently implemented in public services, leading several organizations to experiment to a certain extent with Lean [5]. In the public sector, it has been implemented in areas such as healthcare, the military, higher education, criminal justice and local government [5,42].

Some factors that condition the implementation of Lean are: (1) goals and values—quick results lead to workers' acceptance; (2) complexity and importance—starting a project on a smaller scale that has simple problems is a good start; (3) balanced power relations—workers who have power, either formally or informally, and openly oppose the implementation of Lean make the process difficult and (4) resources and capabilities—past experience in management improvement contributes to the possibility of benefiting from Lean [6].

Despite Lean's fame, its application to projects is limited to a certain number of departments encompassing few processes due to the complexity of the work environment and Lean's susceptibility to personnel change, according to Rahbek Gjerdrum Pedersen and Huniche (2011) [6]. Nevertheless, it is imperative to implement a methodology of continuous improvement in the public sector, thus ensuring a quality service [37].

3.4.5. Group 5 (Red)

The topics covered by this group are research, public sector organizations, Lean production and Lean construction. This is the group with the second-highest number of topics, just like the purple group, and in this case, the topics scale and cluster to the left. These themes reflect researchers' responses to how implementing Lean has fared in public sector organizations. Starting with research, the Lean concept emerged over two decades ago, but its appeal has not waned; instead, it has evolved over time [43]. In recent years, Lean management research has explored numerous topics, questions and issues in various settings [43].

Budget cuts experienced by any government lead to the need to scrutinize the services offered to debate whether to withdraw or reduce them [42]. Cutting services, as well as reducing them, is a crucial issue in any public sector organization because they work with citizens. The alternative to cutting services is to make them as efficient as possible [42]. However, service in the public sector must not only be efficient, it is essential that it is the right service and meets the customer's needs by delivering what they require [42]. When talking about the customer, the question often arises as to who the customer really is. Defining the customer is a common problem in the sector because the customer is diverse and has needs that are difficult to fit into just one category. Therefore, managers seek to encompass a greater number of objectives corresponding to their organization's different stakeholders [5].

There is a reengineering axis, and the customer, whether the citizen, entrepreneur or professional, has been the focus of this axis, which is related to the moment when the customer and the public administration have real contact. The Lean reform creates a window of opportunity for a wide range of innovations [44].

3.5. Characterization of the Application of Lean Construction in the Public Sector

Once the results were obtained, a literature review was carried out. This review began by categorizing each project in which one or more Lean tools were applied according

to the type of project, phase of application and focus. For each document, the type of project in which one or more Lean tools were applied was identified (in the 22 documents found mentioned in Section 2), with four results: (1) management, applied in nine documents; (2) construction, eight papers; (3) roadway, four articles and (4) transportation, one document.

The management sector (1) was the one where one or more Lean tools were most commonly applied. Its use was applied from the application of Lean Six Sigma [45] to the proposal of its use to improve practices in government organizations [46]. The construction sector (2) was second in terms of Lean application. Its use in this sector is present in projects such as off-site construction using building information modeling [47] and the implementation of formal and informal mechanisms in construction projects [48].

The highway sector (3) was third in terms of Lean application, although it was a percentage below the sectors mentioned above. Its use was presented, for example, in a study on the adoption of Lean principles for highway projects [49], as well as on the application of competitive dialogue [50].

The transportation sector (4) was the fourth in terms of Lean application, with the lowest percentage of application in the classification, being used in only one document. It was used in a project that deals with transportation in infrastructure deliveries [51].

Continuing with the characterization, for each of the 22 selected articles, the phase or phases in which one or more Lean tools were applied in some ways were identified. The phases classified were those proposed by the Project Management Institute (PMI) described in the Project Management Body of Knowledge (PMBOK). As a result, there were five phases: (1) initiation, which applied in 12 of the 22 documents, representing a 55% occurrence; (2) planning, which applied in all 22 documents, representing a 100% occurrence; (3) execution, which applied in 18 of the 22 documents, representing an 82% occurrence; (4) monitoring and control, which applied in 20 of the 22 documents, representing a 91% occurrence; and (5) closing, which applied in 8 of the 22 documents, representing a 36% occurrence.

The initial phase was the fourth one when applying Lean tools, but it had a percentage greater than 50%, and it was used to exemplify some of the Lean techniques and methodology applied to road schemes in the UK [52]. The planning phase is the first when applying Lean tools, being applied in all the documents studied, it is used to reduce waste in the construction of urban infrastructure [53]. The execution phase is the third when applying Lean tools, and its uses include the application of Kanban in the UK construction industry [54]. The monitoring and control phase is the second when applying Lean tools, and its use in one of the documents is related to monitoring the Lean proposal in South Africa, specifically in public sector management [37]. The closing phase is the fifth when applying Lean tools, with a percentage lower than 50%. Its use in one of the documents is associated with the development of a framework using various tools for public procurement planning [55].

Concluding the characterization, it was identified for each document whether the focus was on the public sector or a combination of the public and private sector. As a result, (1) the public sector was the focus in 19 of the 22 documents, equivalent to an 86% occurrence, and (2) a combination of the public and private sector was the focus in 3 of the 22 documents, equivalent to a 14% occurrence.

The focus on the public sector was the main approach, and different projects were developed under this, such as evaluating a collaborative cost management framework [56] or studying the success factors of target value design (TVD) [57]. The combined focus on the public and private sectors was the approach with the lowest percentage, and some projects were developed under this, such as defining non-value-adding activities in the construction sector in South Africa [58].

3.6. Lean Construction Tools Applied in the Public Sector

For each document, the implementation of one or more Lean tools was identified. The tools were divided into three categories from the selected 22 articles: (1) tools, which

applied in 19 papers, representing an 86% occurrence; (2) technology which applied in five documents (23%) and (3) Six Sigma which applied in two articles (9%).

The implementation of one or more tools (1) was first in terms of its application, and its use varies, such as implementing the Last Planner System in infrastructure projects [59]. The implementation of technology (2) was second in terms of its application, and its use can occur in different project stages, such as off-site construction projects using BIM. It is important to mention that the use of technology can occur in different phases [38]. The implementation of Six Sigma (3) along with the Green strategy is third in terms of its application, and its use in one of the documents was related to a survey aimed at developing models for public sectors, based on Green Lean Six Sigma (GLSS) [60]. The list of tools and techniques presented is shown below, along with their definitions.

- 5S: A method used for process improvement; it is the basis for the implementation of Lean manufacturing. Its name comes from the first letter of each of the Japanese words—seiri, seiton, seiso, seiketsu, shitsuke—which represent the five stages of work organization, namely sorting or selecting, systematic arrangement, cleaning, standardizing and discipline, respectively [61].
- BIM: Building information modeling (BIM) is a comprehensive digital representation of a constructed facility with a high level of information depth. It includes the three-dimensional geometry of building components at a defined level of detail, as well as non-physical objects and a hierarchical project structure or schedules. The term BIM describes both the process of creating such digital building models and the process of maintaining, using and exchanging them throughout the life of the built facility [62].
- Standardized work: Standardization is used in Lean for work improvement and process sustainability. Standardized work is the best method of operation because it allows for the execution of all steps in the same way, in the same order and time, at a fixed cost [63].
- Continuous flow: Continuous flow aims to make work in the execution process flow through the production stages, minimizing the buffer. Thus, waste or activities that do not add value in the form of inventories, waiting times and transportation are eliminated [64].
- Visual management: Visual management arises from the need for updated and real information, which is sought to be transmitted quickly, clearly and simply so that the receiver or receivers receive it in the best possible way. This allows for an accurate and timely understanding of the current situation of the workplace, processes and management, providing a window of time that facilitates the correction of possible deviations. Visual control should be basic to achieve the better transmission and reception of information, a reduction in misinterpretation and the availability of information in time [65].
- Green Lean Six Sigma (GLSS): GLSS is a comprehensive methodology that focuses on helping to optimize resources, minimize waste and provide a path for sustainable development. Progressive manufacturing sectors are in search of approaches that validate them to be sustainable along with competitive performance assistance. Green, Lean and Six Sigma strategies are widely used tools that help organizations work towards sustainability [60].
- Integrated project delivery (IPD): The American Institute of Architects (AIA) defines IPD as a project delivery method that harmoniously integrates individuals, systems, structures and business practices into a collaborative process. This approach leverages the diverse perspectives and talents of all project participants to achieve optimal project outcomes, enhance customer value, minimize waste and maximize efficiency across the design, fabrication and construction phases [66].
- Just in time (JIT): JIT is a production-oriented approach that relies on other Lean tools and has as its main idea the reduction or elimination of inventories, which, in turn, reduces the need for space, improves cash flow and eliminates waste. Just in time works based on the pull system and, in a broader sense, aims to build customer

relationships by correctly fulfilling the quality, deadlines and costs of the delivered product [61].

- Kaizen: Kaizen is the concept of continuous improvement, assuming a constant search for ideas to improve all areas of the organization. This is achieved by involving all the employees of the company, collecting ideas and then implementing them to improve work organization or improve the production process. Kaizen aims to replace activities that do not add value with activities that do add value [36].
- Kanban: Kanban is a Japanese method of production control that assumes control that is not based on the production program but rather on the events that occur in production directly. Kanban allows for the almost complete elimination of pre-reviews, interoperable and finished products. Finally, due to the reserves generated, the production capacity and the flexibility in the production process, it is possible to produce almost any product at any time [54].
- Pull System: This is a production control system in which each activity signals its needs for materials or components to the activities preceding it in the value chain, specifying what is needed, in what quantity, when and where. In other words, the upstream supplier process does not produce anything until the downstream customer process signals it. The customer pulls the demand, rather than the manufacturer pushing the materials or semi-finished parts [67].
- Takt time: Takt time is the time required to complete a task in the manufacturing process. Takt is the German word for rhythm, which means that takt time sets the pace for what the customer requires, to whom the company must deliver the product in order to satisfy them. When used in production, it implies that both production and sales rhythms must be synchronized [68].
- Target value design: Target value design (TVD) is one of the Lean management approaches. It involves identifying what creates value for the customer and directing the goals of integrated teams to design a product that meets the customer requirements while also meeting the project limitations. There are five main components of TVD: (1) target costing; (2) defined work structure; (3) collaboration; (4) set-based design and finally (5) co-location [69].

3.7. Benefits and Difficulties of Implementing Lean Construction in the Public Sector

Based on the reading of each document, the benefits of applying one or more Lean tools and the type of difficulties that arise from implementation were identified. In the identification of benefits, six were identified from the 22 selected articles, as shown in Figure 6: (1) cost, which applied in 15 of the 22 documents, representing a 68% occurrence; (2) schedule, which applied in 14 of the 22 documents, representing a 64% occurrence; (3) quality, which applied in 7 of the 22 documents, representing a 32% occurrence; (4) ecological, which applied in 3 of the 22 documents, representing a 14% occurrence; (5) work, which applied in 4 of the 22 documents, representing an 18% occurrence; and (6) user perception, which applied in 4 of the 22 documents, representing an 18% occurrence.

(1) Cost-benefit refers to generating lower project development costs, an important benefit as it is part of the triple constraint of all projects. Cost reduction is associated with proper planning and efficient work, achieved through the implementation of tools and technology throughout all project phases [34,46,49,50,52,54–57,70–75].

(2) Schedule-benefit refers to staying within the stipulated project development timeline, an important benefit as it is part of the triple constraint of projects. Schedule reduction is associated with proper planning, minimizing valueless activities and efficiently completing the project, achieved through the implementation of tools or technology [34,46,49–52,54,55,70–75].

(3) Quality-benefit refers to achieving the project scope and objectives, such as cost and schedule, an important benefit as it is part of the triple constraint. The concept of meeting quality suggests that the goals and requirements of both internal and external customers have been fulfilled. This advantage is evident throughout the different project

stages, starting from the definition of the scope in the first phase, and continuing with the monitoring of objective attainment in the subsequent phases. Ensuring quality implies customer and user satisfaction, achieved through tools, technologies and performance indicators [46,52,54,57,72,74,75].

(4) Ecology-benefit refers to Lean projects being performed more optimally than projects where the philosophy is not used. Thus, lower waste of materials and debris resulting from rework are generated, by improving the flow between processes and reducing losses in them [52,53,60].

(5) Work-benefit refers to the elimination of valueless activities in the process flow by analyzing process groups and proposing implementation plans when implementing Lean, thereby reducing waste such as rework, product defects and other losses [34,46,73,75].

(6) User-perception benefit refers to both internal and external customers being satisfied with the results of implementing Lean in the project, and with the new way of working creating a positive feeling that motivates workers and affects their morale [45,47,48,58].
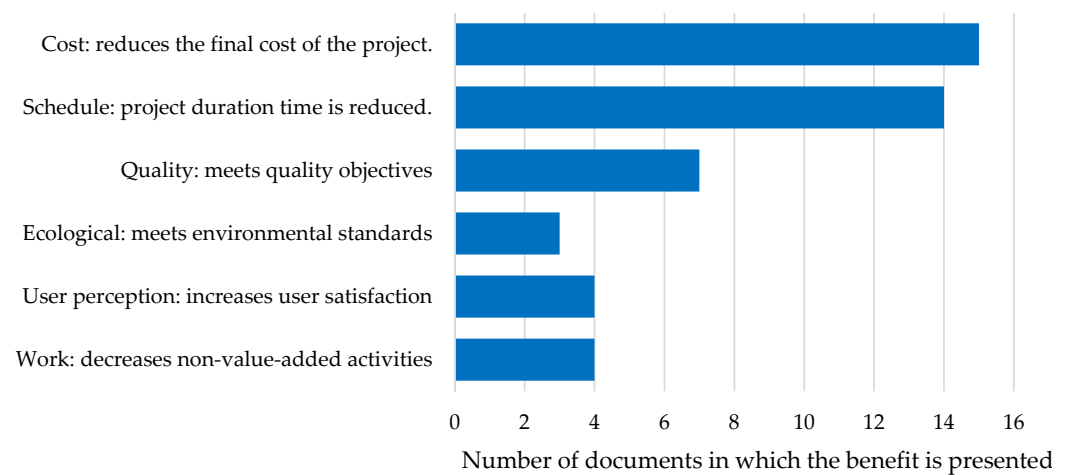
Figure 6. Graphical representation based on the benefits present in projects in which Lean was implemented and a brief definition of the benefit.

From the selected articles, the difficulties encountered (eight in total) when implementing any of the Lean tools were diverse and are grouped and described in Figure 7.
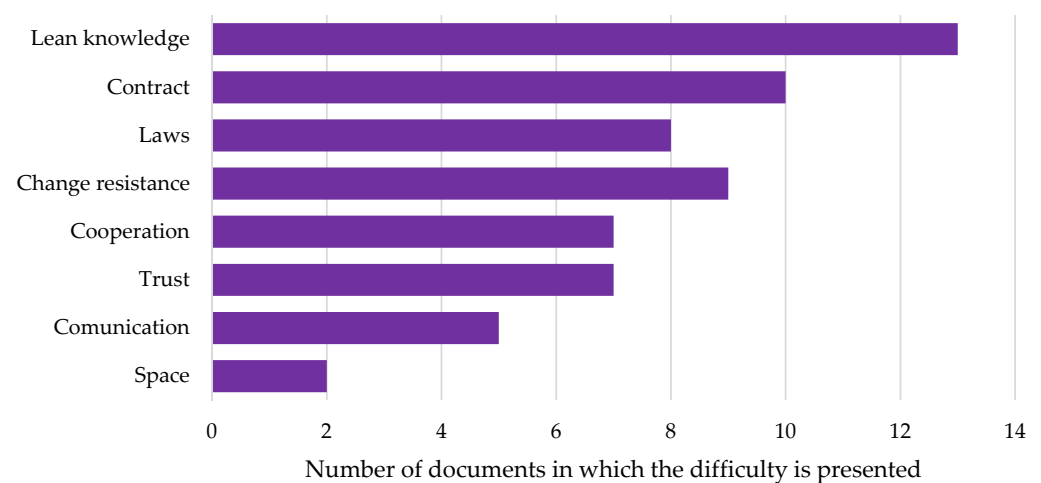
Figure 7. Graphical representation based on the difficulties present in projects in which Lean was implemented.

(1) Lack of knowledge or understanding of Lean appeared in 13 out of the 22 studied documents, representing a 59% occurrence and being the most frequent difficulty. This is associated with a limited understanding of the Lean philosophy and how its practices are managed. In some studies, it was presented as a complicated obstacle to overcome when implementing Lean efficiently in a project [47,49–52,54,55,58,70–72,74,75].

(2) Contracts appeared in 10 out of the 22 studied documents, representing a 45% occurrence and being the second most frequently encountered difficulty. The difficulty of contracts lies in the type of project, which, depending on its nature, can hinder the implementation of Lean. Additionally, the deadlines stipulated in contracts can be restrictive when attempting to generate a Lean solution. There were occasions where the problem was identified, but traditional solutions were maintained, and no resolution was reached. Finally, implementing a Lean-focused project requires hiring personnel with knowledge of Lean practices and some Lean-specific tools, otherwise confusion among workers may arise [48–52,54,57,58,72,73].

(3) Laws appeared in 8 out of the 22 studied documents, representing a 36% occurrence and being one of the moderately frequent difficulties. Although laws differ from country to country, in some projects, they can restrict innovation, limiting its potential application. There are cases where implementing Lean is out of place in countries with a high corruption index, and it is necessary to reflect on how its potential use could bring varied benefits [34,48,51,53,58,60,73,76].

(4) Fear of change appeared in 9 out of the 22 studied documents, representing a 41% occurrence and being one of the moderately frequent difficulties. Fear of change is generated by the change in culture and work processes that comes with implementing Lean. Although it may be an intrinsic factor of human nature, its consideration is essential because it impedes progress [34,46,48,49,51,53,60,70,75].

(5) Cooperation appeared in 7 out of the 22 studied documents, representing a 32% occurrence and being one of the moderately frequent difficulties. In some studies, a lack of cooperation was detected both among different specialties and among stakeholders. This resulted in multiple errors throughout the project, leading to rework, increased costs and delays [34,53–56,60,72].

(6) Trust appeared in 7 out of the 22 studied documents, representing a 32% occurrence and being one of the moderately frequent difficulties. In some studies, a lack of trust was related to doubts about the potential benefits of implementing Lean in a project. Team members may feel insecure due to the novelty of this work process and the fact that not everyone has been present in projects where it has been implemented, leading to uncertainty about the results. A lack of trust leads to a lack of sincerity, which is related to the feeling, often collective, that a solution is not generated once a problem is presented, so it tends to be hidden [34,46,49,56,57,60,73].

(7) Communication appeared in 5 out of the 22 studied documents, representing a 23% occurrence and being one of the less frequently encountered difficulties. Communication, or rather the lack of it, arises from the same lack of interaction among specialties and/or stakeholders that causes a lack of cooperation. There are occasions where a lack of communication hinders the fulfillment of what both internal and external customers need [48,53,56,60,70].

(8) Space appeared in 2 out of the 22 studied documents, representing a 9% occurrence and being one of the less frequently encountered difficulties. The space where activities are carried out, when not well-distributed, brings difficulties in performing activities efficiently. Poor spatial organization results in poor communication and cooperation among team members [48,70].

4. Discussion and Future Research

The present study aimed to analyze the research trends in Lean and public sector topics published between 2000 and 2022, and to identify the main themes, clusters and trends. A total of 212 documents were selected from different databases and, based on the

results obtained, it was possible to conclude that the interest in this area has been growing over the years, with an annual growth rate of 9.37%, indicating a constant and gradual development of this research field.

The co-occurrence diagram helped to identify four clusters, each representing a set of themes: management and implementation, public sector, organization and people and government. The driving themes located in the upper right quadrant were efficiency, government, people, research, manufacturing, organizational themes, engineering processes, agile manufacturing systems, public sector, Lean, management themes, supply chains and success factors. These themes are well developed and important in structuring a research field, and they present strong centrality and high density.

The lower right quadrant comprised basic topics, such as e-government, data processing, scientific research, iso/iec, IT service management and administrative topics. Although important in the field of research, these topics are not yet well-developed. The lower left quadrant represented emerging or declining themes related to citizen services. These themes are underdeveloped, have both low density and low centrality and are therefore marginal and represent mainly emerging or disappearing themes. Finally, the upper left quadrant was composed of very specialized niche topics. These themes have well-developed internal links, links between those of the same quadrant and lack importance concerning external links.

The dendrogram analysis allowed us to identify five clusters: (1) article and human, (2) public management, management, health and design, (3) quality, improvement implementation, Six Sigma, framework, public sector, service, performance and thinking, (4) public sector and (5) Lean construction, Lean production, organization and public sector research. In addition, based on the classification of the projects in which one or more Lean tools were applied, it was possible to identify four types: (1) management, (2) construction, (3) roadway and (4) transportation. The management sector was where one or more Lean tools were most applied, followed by the construction sector.

Regarding LCPS, the benefits are directly related to the main constraint of project management: cost, schedule and quality. This fact shows how the Lean approach has benefited not only the manufacturing industry and operations, but also temporary organizations, such as projects. The challenges of LCPS come from external and internal factors. Regarding external factors, particularly laws, the only thing left to do in this regard is to seek the best adaptation, especially in the public sector, which is constantly audited and regulated. To adopt a Lean perspective, an adjustment to working conditions should come formally in the form of legal provisions and will take time. This is different in the public sector, where there is greater flexibility.

Regarding contracts, although by definition, contracts are consensual, it is often the case that contracts with public entities follow a standardized and, therefore, rigid format. Therefore, the possibility of implementing new work methods is discouraged since the risk would be assumed mainly by the contractor (who works for the public entity). Regarding internal factors, Lean implementation ultimately comes down to empowering people. Knowledge and resistance to change are the most recurrent challenges in the literature to achieve such empowerment. So are collaboration, trust and the right space. This shows that LCPS implementation requires a transversal adoption in the organization at the strategic, process, people, technology and infrastructure levels.

There is a correspondence between Lean construction and bibliometric analysis. Some connections between the main keywords of the clusters in Figure 3 and Lean construction were identified: a blue cluster of implementation was related to how the Lean principles are followed in construction projects. The purple cluster related to Lean production and the green cluster related to digitalization and modernization in terms of Lean Construction project management practices and how this may be improved through Lean. Finally, the red cluster referred to the individual concerns of Lean in the public sector and at the project level.

Adopting Lean in the public sector, as in construction, can be considered a lever for a sustainable industrial transition. On the one hand, Lean, by definition, seeks to reduce waste and make production processes more efficient [1]. In this context, Lean potentially reduce environmental, economic and social impacts [2]. On the other hand, between Lean and sustainability, a two-way relationship can be observed when focusing on people. The present study has shown how the main difficulties in its implementation lie directly in the individual aspects such as: Lean training, resistance to change, trust, communication, workspace and the regulatory framework. Overcoming these difficulties—and as a consequence, a complete application of Lean—could also benefit workers, as adopting Lean has shown greater empowerment, collaboration and well-being in workers [3]. All these concerns are considered sustainable goals, such as health and well-being, education and decent work [4].

5. Conclusions

In the present article, the implications of LIPS and the LCPS industry have been studied through a literature review. This review has been addressed through (1) a bibliometric analysis of LIPS and (2) a systematic analysis of LCPS. The first approach allowed us to identify how the field's knowledge is displayed in four clusters. We considered the main concerns of each cluster: the research directions related to the implementation of Lean, how this philosophy may work in the public sector, people's challenges in its adoption and how Lean facilities the establishment of e-government and digitalization. The systematic analysis delved into the construction industry and allowed an understanding of the Lean-related tools and techniques addressed in the literature and the benefits and challenges of implementing LCPS. The bibliometric and systematic approach provides an updated panorama with academic and practical benefits. On the one hand, from the academic point of view, this paper is the first review that studies the application of LIPS and provides a perspective of Lean for construction projects in the public sector context. On the other hand, in terms of practical use, this paper may be used as a guideline for developing a Lean implementation project, as well as presenting the main key success factors and difficulties to be faced.

The limitations of this study are related to the focus of the study and mainly lie in the systematic analysis, addressing the specific concerns of tools, techniques, benefits and challenges. Other concerns, such as the Lean level of maturity in the identified cases, the relationship with the digitalization of the AEC industry or the technologies that could facilitate Lean implementation, may be considered as future research. This study has been focused on methodological issues. Moreover, other sources—not referenced in this article—could be considered for this study, such as government studies and reports. Articles that explicitly mentioned the use of LIPS were also considered.

Finally, the identified themes and trends can serve as a basis for further research. The results can help policymakers and practitioners in the public sector identify improvement opportunities and implement Lean practices more effectively. This study is expected to contribute to developing new approaches and tools to help organizations in the public sector achieve their goals more efficiently and effectively while also improving the quality of the services they provide to citizens.

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