Trend Analysis in Lean Management: A Bibliometric Analysis

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Abstract

Lean Management is a system comprising specific practices and techniques aimed at reducing both internal and external process variability. It encompasses a set of principles, methods, and procedures for business organisation and management. Implementing Lean Management necessitates changes in organisational culture and workforce dynamics, wherein all employees, from operator level to senior management, assume responsibilities and are empowered to make rapid decisions at all levels. This study aims to elucidate the intellectual structure of the Lean Manufacturing research field through a bibliometric analysis combining productivity and co-word analyses. This approach facilitates the identification and analysis of relationships between key topics that have significantly influenced the discipline's knowledge base. Furthermore, the evolution of keywords over time is examined, and potential future trends are identified. A search for "Lean Management" was conducted in the Web of Science (WoS), and the resulting data were processed using Bibliometrix, enabling the analysis of indices, article volume, and productivity by country, authors, and journals. Additionally, the nodes (themes) and clusters (trends) within the field of study were identified, highlighting the principal research areas.

Keywords: *Lean management, WoS, Bibliometric, Co-work, Future tendencies analysis.*

Introduction

The confluence of rapid globalisation, accelerated technological development, and growing concerns regarding their potential adverse effects (Umar et al., 2020; Sharif et al., 2021) has precipitated a continuously evolving economic landscape in recent decades. Consequently, organisations are compelled to seek tools that enable them to adapt to this dynamic environment (Smith & Besharov, 2019) and achieve favourable outcomes by enhancing production and process efficiency, as well as the conditions, relations, and satisfaction of both employees and customers (Mourtzis, 2016; Hernández et al., 2020).

Lean tools and philosophy facilitate the attainment of organisational objectives, including cost reduction, elimination of non-value-adding activities, waste minimisation and eradication, inventory reduction, timely delivery of products in precise quantities, and simultaneous quality improvement (Jasti and Kodali, 2015; Alves et al., 2019; Alahyari et al., 2019).

This philosophy was applied to business management under the paradigm of "Lean Management," a framework that provides a customer-centric overview of processes. It is predicated on the elimination of non-value-adding activities, ensuring production aligns with effective demand, and minimising or eradicating warehousing, thereby reducing resource requirements for inventory management and mitigating the risk of product and material obsolescence. These practices contribute to enhanced operational efficiency without necessitating significant investment, facilitate inter-period comparisons, foster collaborative teamwork, and drive quality improvement in the pursuit of operational excellence (Florescu and Barabas, 2020). Various techniques can be used within the context of Lean Management to help businesses toward continuous improvement (Marin-García et al., 2019).

According to Petrillo et al. (2018), businesses which shy away from implementing these tools and techniques may become obsolete compared to their competition and therefore run the risk of folding. These factors underscore the imperative to further explore this field of studyIn this context, conducting a a bibliometric analysis could play an important role in research concerning "Lean Management" and its associated tools,

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as well as in understanding the growth and development of research and scientific output in recent years, which has necessitated the development of indicators to analyse this concept..

Bibliometric analysis is a methodology that facilitates the examination of scientific production, guiding the scientific community towards key areas of focus and advancements within a specific domain of knowledge. It also analyzes elements such as author collaboration, scientific activity by country or region, citations, and the impact factor of publications and journals (Vogel and Güttel, 2013; Donthu et al., 2020).The objective of this study is to delineate and illustrate the intellectual structure of the Lean Manufacturing research field through a bibliometric analysis that integrates productivity and co-word analyses. This approach aims to identify and analyse the relationships between the topics that have exerted the most significant influence on the construction of the discipline's knowledge base. Furthermore, the evolution of the keywords over time is examined to identify potential future trends. Notably, a comprehensive bibliometric analysis providing a holistic overview of Lean Management, and specifically identifying and analysing the relationships between core topics influencing the discipline's knowledge base, is currently absent from the existing literature.

This bibliometric analysis commenced with a search on the theme of "Lean Manufacturing" within the Web of Science (WoS) database. The retrieved references were exported and subsequently processed using the Bibliometrix software, enabling the analysis of key indicators such as article count, prolific authors, country and journal productivity, and journals with the highest article volume and citation impact . Moreover, it facilitates the identification of nodes (different topics) and clusters (trends) within the field of study, highlighting the main research themes, their evolution, and emerging trends that may inform future research directions (Bai et al., 2021).

The structure of this paper is as follows: a theoretical framework outlining Lean Management and bibliometric analysis, a detailed methodological description, the presentation of results, and a discussion of findings leading to the study's conclusions.

Theoretical Framework

Lean Management

Lean Management is a system that encompasses specific practices and techniques designed to mitigate both internal and external process variability. It comprises a set of principles, methods and procedures for business organization and management, focusing on reducing or eliminating waste within the value chain of processes through the identification of critical system points The overarching objective of Lean Management is to enhance processes, products, and services which provide added value to customer.

Employees are empowered to utilise new knowledge and skills, working collaboratively to augment company productivity. This facilitates comprehensive control over production and inventory, enhances effective manufacturing lead times, and reduces auxiliary times, thereby accelerating the manufacturing cycle (Bortolotti et al., 2014).

Bibliometric Analysis

Bibliometrics is a widely employed quantitative methodology, utilized as a technique to comprehensively elucidate the mobility and interaction of knowledge (Aman, 2018; Zhang et al., 2022). Its main objective is to identify, organize, and analyze the key components within a specific field of research (De la Hoz et al., 2018; Muñoz-Leiva et al., 2020) by extracting pertinent information from databases encompassing journals, citations, authors, institutions, countries, and keywords (Van Raan, 2005).

The core aim of this study is to analyze the trend of co-occurrence (Callon et al., 1983), a form of content analysis that enables the mapping of the simultaneous presence of terms within academic documents, thereby identifying patterns and relationships between them. This approach seeks to interconnect the most significant concepts (Muñoz-Leiva, et al., 2012) to "reduce the distance between descriptors (or

keywords) to a set of network diagrams which effectively illustrate the strongest association between descriptors" (Viedma-del-Jesús et al., 2011). This analysis includes the co-occurrence of keywords in articles within a specific research area, facilitating the identification of common themes or emerging trends, and the co-occurrence of authors in article citations, revealing frequent collaborations or research networks (Kumar et al., 2021; Baker et al., 2020). In this case, the focus is on keywords, to generate an overview of the most relevant keywords, their interconnections and their temporal evolution, thereby discerning areas of increasing or decreasing significance.

Secondly, a performance analysis will be conducted to ascertain, both quantitatively and qualitatively, the relative contribution of a theme to the research field, identifying the most prominent, productive, and impactful sub-fields. Key metrics include publication count, citations per year or per publication, h-index, institutional affiliation, and area of knowledge, among others (Donthu et al., 2020).

Method

This study employs a bibliometric methodology (Moreno-Guerrero et al., 2020a, 2020b). The Web of Science (WoS) database was selected due to its extensive coverage of articles, authors, and journals, and its adherence to peer-review standards for scientific quality (Hodge and Lacasse, 2011). To ensure a comprehensive analysis, a search equation was formulated to encompass all terms associated with the concept under investigation (Montero-Díaz et al., 2018). Specifically, the search equation (Theme ("Lean Management")) was defined and applied to the primary collections of the Science Citation Index Expanded and the Social Sciences Citation Index.

The retrieved references were subsequently processed using the Bibliometrix software, which facilitated the analysis of key indicators, including article count, prolific authors, country and journal productivity, and journals with the highest article volume and citation impact. Moreover, this software enabled the identification of nodes (different topics) and clusters (trends) within the research field, highlighting the main research themes, their evolution, and emerging trends that may inform future research directions.

For subsequent analysis, the complete records and references of the retrieved articles were downloaded in .txt or BibTex formats. Detailed publication characteristics were extracted from WoS, encompassing source, country, institution, author, title, abstract, keywords, citation count, and cited literature. An initial retrieval yielded 504 documents. Documents published in 2023 were excluded due to their incompleteness, as were those deemed irrelevant to the study's focus, resulting in a final dataset of 468 documents. The study period was segmented into five distinct intervals: 1993–2000, 2001–2007, 2008–2014, 2015–2020, and 2021–present. The procedural overview is illustrated in Figure 1.
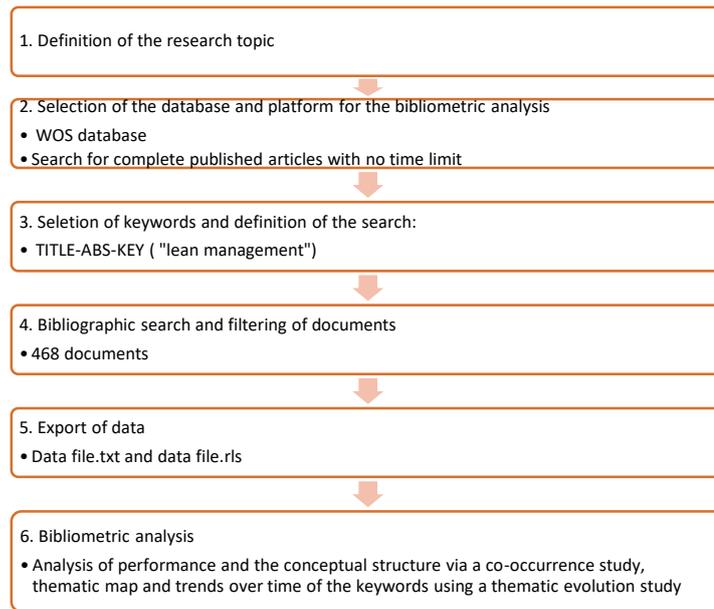
1. Definition of the research topic

2. Selection of the database and platform for the bibliometric analysis
• WOS database
• Search for complete published articles with no time limit

3. Seletion of keywords and definition of the search:
• TITLE-ABS-KEY ("lean management")

4. Bibliographic search and filtering of documents
• 468 documents

5. Export of data
• Data file.txt and data file.rls

6. Bibliometric analysis
• Analysis of performance and the conceptual structure via a co-occurrence study, thematic map and trends over time of the keywords using a thematic evolution study

Figure 1: Steps for a bibliometric

Source: León-Castro et al., 2021

Results

Productivity Analysis

This section presents a bibliometric analysis of "Lean Management" from its inception, including scientific production and examining productivity by country, the most influential authors in terms of publication output and citations, and the leading journals within the field.

Figure 2 illustrates the annual publication trend of scientific articles related to Lean Management in the WoS database, spanning from 1993 to 2022, with a total of 468 documents. Despite the extended study period of 30 years, the majority of publications are concentrated in recent years. Until 2013, the annual publication count remained below twelve, followed by a gradual increase until 2018, which marked a significant surge. The period from 2018 to 2022 witnessed the highest volume of scientific output, accounting for 59.61% of the total publications, as evidenced by the trend line, thereby reflecting the growing interest of the scientific community in this knowledge domain. Notably, 2021 recorded 68 publications, representing approximately 14.53% of the total output.
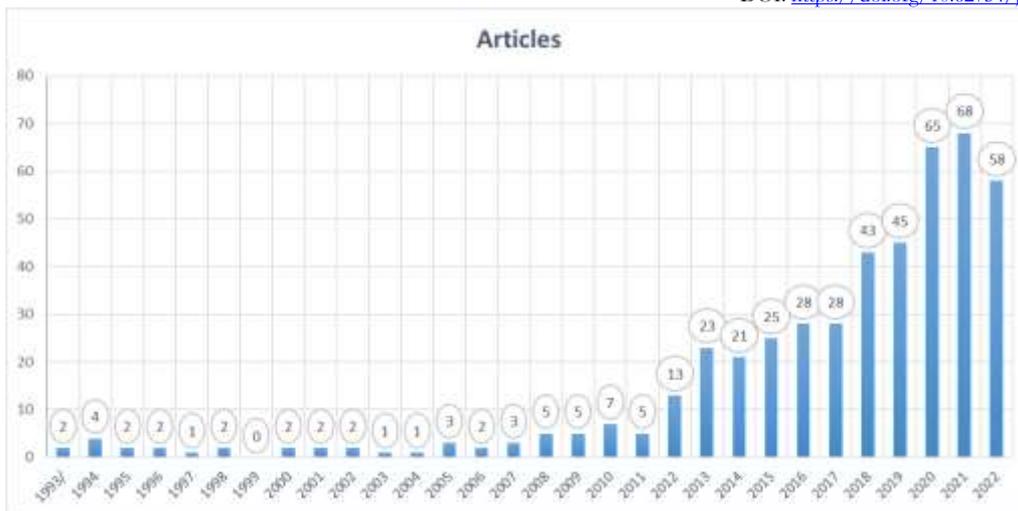
Figure 2. Annual scientific production of articles related to Lean Management

Figure 3 analyzes scientific production by country, detailing the fifteen nations leading global academic output on Lean Management within the WoS database. The United States of America (USA) exhibits the highest publication count with 85 articles, followed by China with 53. In terms of citation volume per country (see Figure 4), the USA maintains its leading position with 1858 citations, while China ranks fourth with 424.
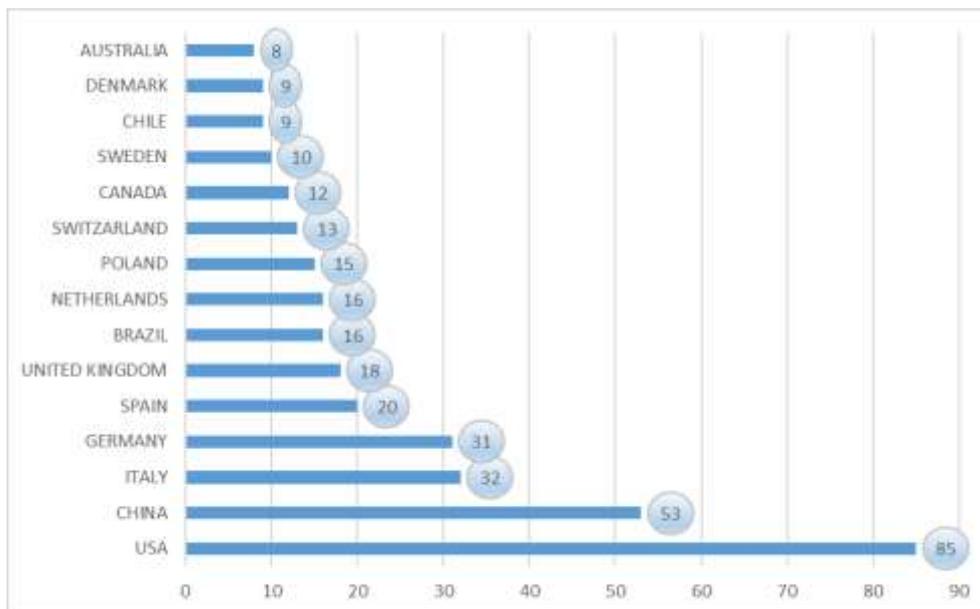

Figure 3. Annual scientific production of articles related to Lean Management, per country
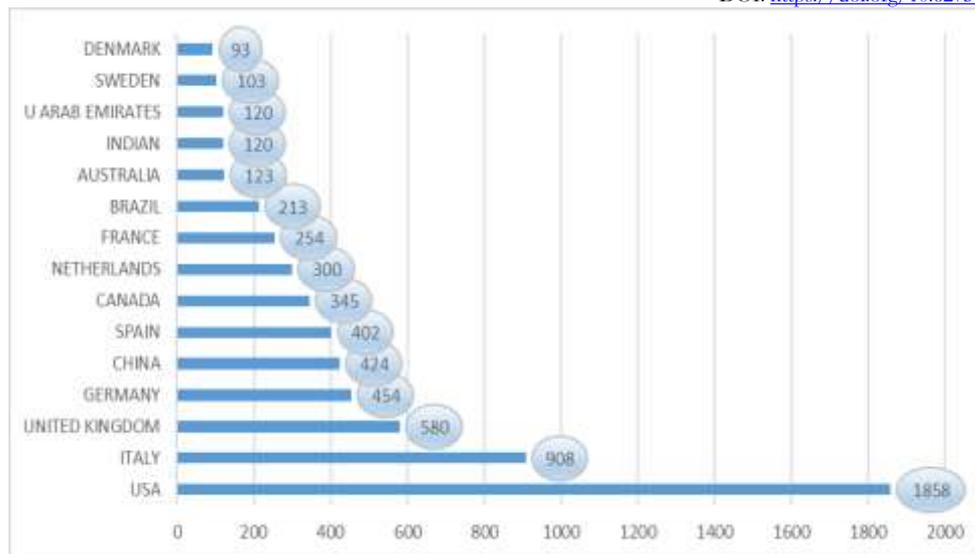
Figure 4. Number of citations concerning Lean Management, per country

The data shows that, among the 468 analyzed works, 1245 authors contributed, but 89.06% only published an only work. Table 1 lists the most prominent authors, categorized by their publication count and h-index. Alarcon, Rundall, and Shortell lead the production, each with a total of 8 published articles. Alarcon also exhibits the highest h-index of 6, while the other two leading authors possess an h-index of 4, despite not having the highest total citation count (TC). Bortolotti has the highest TC (450) in 4 published articles and an h-index of 4.

Table 2. The most relevant authors based on production

Author	h_index	Total Citations	Articles
ALARCON LF	6	84	8
RUNDALL TG	4	30	8
SHORTELL SM	4	30	8
BLODGETT JC	4	30	7
CREMA M	5	68	6
VERBANO C	5	68	6
JING SW	3	43	6
MOYANO-FUENTES J	4	140	5
TORTORELLA GL	4	126	5
BORTOLOTTI T	4	450	4
HUSSAIN M	4	120	4
MOURGUES C	4	36	4
PELLICER E	4	48	4
VAN HARTEN WH	4	85	4
HERRERA RF	3	30	4
KLEIN LL	2	17	4
NIU ZW	2	33	4
REPONEN E	1	4	4

Table 2 analyzes the documents with the highest impact on WoS and the highlights are as follows: "Lean, green, and the quest for superior environmental performance" (Rothenberg, Pil and Maxwell, 2001) with 321 citations, and "Successful Lean implementation: Organizational culture and soft Lean practices" (Bortolotti, Boscari and Danese, 2015) which is cited 294 times. In terms of the most cited article, it is notable that the authors have collectively received 321 citations, with each author having a single publication in this field. The second most cited document is attributed to Bortolotti, the author with the highest citation count (450), who has produced 4 articles.

Table 3. The most relevant article based on Global citations

Document	Article	Global Citations
[45]	Lean, green, and the quest for superior environmental performance. *Production and operations Management*, *10*(3), 228-243.	321
[46]	Successful Lean implementation: Organizational culture and soft Lean practices. *International Journal of Production Economics*, *160*, 182-201	294
[47]	The promise of Lean in health care. In *Mayo clinic proceedings* (Vol. 88, No. 1, pp. 74-82). Elsevier.	200
[48]	Lean manufacturing and firm performance: The incremental contribution of Lean Management accounting practices. *Journal of Operations Management*, *32*(7-8), 414-428.	185
[49]	Lean Management and supply Management: their role in green practices and performance. *Journal of Cleaner Production*, *39*, 312-320.	157
[50]	Lean Management in academic surgery. *Journal of the American College of Surgeons*, *214*(6), 928-936.	117
[51]	Impacts of Industry 4.0 technologies on Lean principles. *International Journal of Production Research*, *58*(6), 1644-1661	106
[52]	Lean/Green integration focused on waste reduction techniques. *Journal of Cleaner Production*, *137*, 567-578.	97
[53]	Translating Management ideas. *Organization studies*, *27*(2), 207-233.	90
[54]	Implementing 5S within a Japanese context: an integrated Management system. *Management Decision*.	90
[55]	Analysing supply chain performance using a balanced measurement method. *International Journal of Production Research*, *40*(15), 3533-3543.	89
[56]	Lean Management and supply Management: their role in green practices and performance. *Journal of Cleaner Production*, *39*, 312-320.	78
[57]	Development of Lean supply chains: a case study of the Catalan pork sector. *Supply Chain Management: An International Journal*, *15*(1), 55-68.	76
[58]	The relative merits of Lean, enriched, and empowered offices: An experimental examination of the impact of workspace Management strategies on well-being and productivity. Journal of Experimental Psychology: Applied, 16(2), 158.	76
Rydenfält et al. (2017).	Organizing for teamwork in healthcare: an alternative to team training? *Journal of health organization and Management*.	70
McCann et al. (2015).	Casting the Lean spell: The promotion, dilution and erosion of Lean Management in the NHS. *Human relations*, *68*(10), 1557-1577.	70

The document with the highest citation count, "Lean, green, and the quest for superior environmental performance", was published in 2001 in "Production and Operations Management", ranked fifth in terms of citations (321). Among the 15 most cited documents listed in Table 2, three were published in the Journal of Cleaner Production. The International Journal of Production Research, the third most cited journal overall (508 citations), featured two of the most relevant articles, collectively receiving 195 citations (see Figure 5).

Figure 5. Number of citations concerning Lean Management, per journal

Figure 6 shows the distribution of articles across 204 journals. Sustainability leads with 26 articles, despite ranking ninth in citation relevance and having no publications on this theme within the 15 most cited. It is followed by Production Planning and Control, which published 23 works and ranks fourth in citation count.

Figure 6. Number of publications on Lean Management, per journal

Figure 6 delineates the research domains in which "Lean Management" is prominent. Notably, Management emerges as the most significant field with 23.07%, followed by Industrial Engineering with 21.3%.

Manufacturing Engineering and Operations Research Management Science occupy the third and fourth positions, respectively, with negligible differences between them.

Conceptual Structure

Studies on Lean Management can be grouped into thematic clusters, reflecting dynamic and varying levels of significance within the broader scientific domain. The analysis of term co-occurrence, based on a comparative study of authors' keywords, was conducted utilizing the Bibliometrix software. For the clustering of the 468 articles, 1491 authors' keywords were considered, with only those appearing a minimum of two times being mapped.

Figure 7: Co-word mapping

Figure 7 shows the distribution of keywords across five distinct clusters. The links represent co-occurrence relationships between e keyword pairs, while node colors denote the semantic group of each keyword. In naming the five clusters, the keyword with the highest frequency was used. The interpretation of the map considered the number of keywords within each thematic cluster, the frequency of their occurrence, their interrelationships, and their spatial location. The various clusters elucidated the actual content and

research themes of the documents, with central conglomerations indicating thematic areas of heightened scientific activity.

- Cluster 1: Lean Management. This term appears in 200 articles, serving as the cluster's central nodeand exhibiting the strongest relationships with terms from other clusters. Among the 26 keywords within this cluster, *Lean Manufacturing, continuous improvement, case study, sustainability,* and *Lean healthcare* are particularly noteworthy, each with over 10 occurrences. The terms comprising this cluster predominantly fall within the domains of management, production organisation, and engineering. They feature in studies that analyse methods and tools within this field, aiming to achieve continuous improvement in production processes across diverse areas.

- Cluster 2: Lean. This node encompasses the highest article count (38) and comprises three key terms: *Lean Production* (22), *quality improvement* (15) and *efficiency* (12). The articles within this cluster focus on research into strategies, grounded in Lean philosophy, that enhance product quality and production process efficiency.

- Cluster 3: Industry 4.0. This cluster comprises two terms with equal occurrences: *0* (14) and *Industry 4.0* (14). Analysis of the publications containing these terms reveals that the software interprets '0' as an independent term, whereas the publications consistently refer to 'Industry 4.0'. The cluster also includes 'digital transformation'. The publications within this cluster emphasise the role of Lean in Industry 4.0 and its potential to benefit companies or facilitate their digital transformation

- Cluster 4: Value Stream Mapping. This cluster consists of four keywords: *Value Stream Mapping* (14), *sustainability* (12), *supply chain management* (7), and *improvement* (5). It is interconnected primarily through publications focusing on strategies related to the Value Stream Mapping Lean tool, enhance business sustainability through the improvement and optimization of a company's value chain.

- Cluster 5: Six Sigma. This node is formed of the following terms: *Six Sigma* (8), *healthcare* (7), and *Lean Six Sigma* (6). It pertains to the Six Sigma methodology, which seeks to improve business processes using Lean principles and tools to achieve rapid and efficient enhancements.

Figure 8 illustrates the main clusters and identify their relative roles within the literature, showing strategic themes map (Cobo et al., 2011).
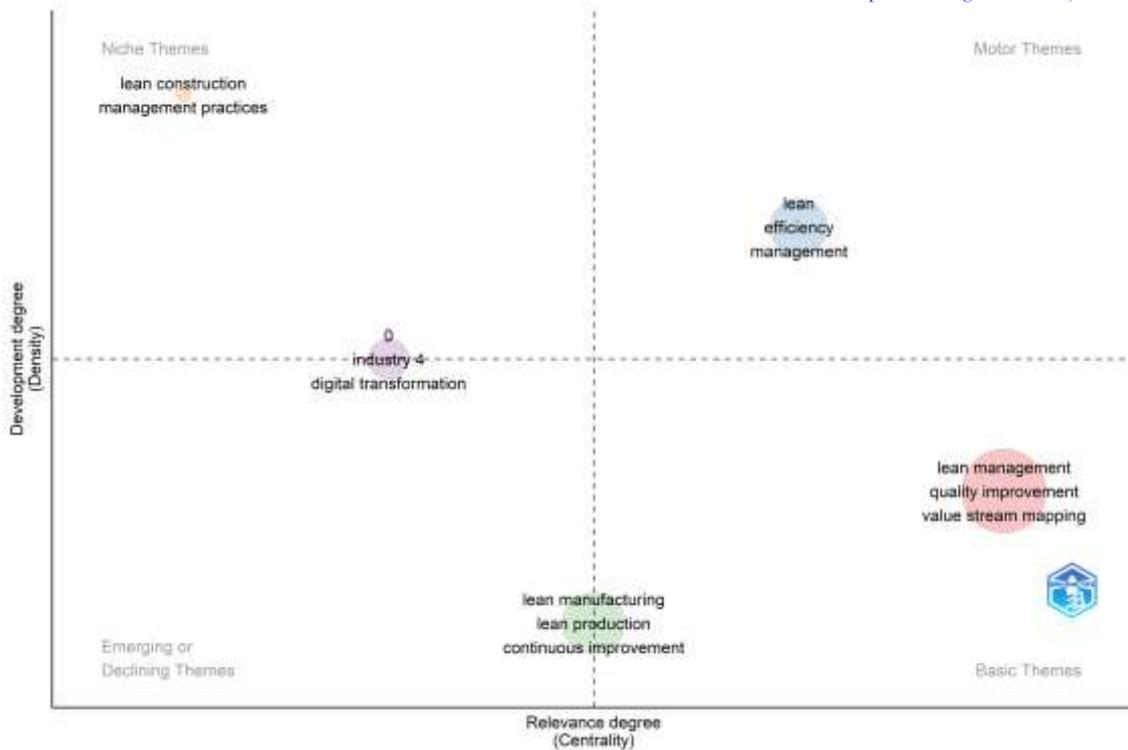
Figure 8: Thematic map of Lean Management topic distribution

This thematic map facilitates the categorization the clusters into four quadrants, thereby delineating the conceptual structure of the theme. This is achieved through an analysis of word co-occurrence networks, which defines the discourse of the scientific community within a specific field, identifies the core themes, and anticipates future trends. The thematic map for Lean management obtains the following results:

Motor themes. This quadrant contains themes that have transitioned from niche to motor themes, including Lean, *efficiency,* and *management*. These are consolidated into a single cluster, comprising 9 keywords, with: *Lean* (38 works), *efficiency* (12), and *Management* (7) as the most prominent. They are included in 47 publications across 36 journals. The journals with the highest number of publications are Sustainability (5) and the International Journal of Production Research (3). The journals with the highest number of citations are The Journal of Production Economics (294), the International Journal of Production Research (96), and the Journal of Cleaner Production (83). These publications collectively explore production management and feature articles that aim to analyse potential enhancements in quality and production efficiency through the implementation and development of Lean principles. Basic themes. This quadrant is formed of two clusters. The first consists of 24 keywords, with *Lean Management* (200 works), *quality improvement* (15), *Value Stream Mapping* (14), *case study* (12), *sustainability* (12), and *Lean Healthcare* (10) being the most prominent.. The themes address the application of Lean Management for quality enhancement and business sustainability, employing tools such as Value Stream Mapping or Six Sigma. A total of 203 articles feature various case studies, not only focusing on the implementation of Lean Management but also on related philosophies suh as Lean Healthcare, Lean Six Sigma, Lean Practices, and Lean Leadership. The articles are published across 51 journals. The journals with the highest number of publications are Production Planning and Control (18) and Sustainability (11). The journals with the greatest number of citations are the Journal of Cleaner Production (328) and Production Planning and Control (295).

The second cluster, situated between the basic themes and emerging or declining themes quadrants, comprises 9 keywords. The most frequently occurring keywords are *Lean Manufacturing* (26), *Lean Production* (22), *continuous improvement* (18), *productivity* (7) and *project management* (7). These keywords appear in publications that analyse the implementation and development of Lean Manufacturing or Lean Production (both terms are used indistinctly), aiming for continuous improvement and increased productivity in

production and project management.. These publications are featured in 57 works across 43 journals. The journals with the most works published are The Journal of Manufacturing Technology Management (5), the International Journal of Operations and Production Management (3), the International Journal of Production Research (3) and Applied Sciences (3). The two journals with the highest number of citations, each featuring a single work in this área, are Production and Operations Management (321) and the Journal of Operations Management (185).

Basic themes. This quadrant is formed of two clusters. The first and biggest, as seen in Figure 8, is composed of 24 keywords with the most noteworthy being: *Lean Management* (200 works), *quality improvement* (15), *Value Stream Mapping* (14), *case study* (12), *sustainability* (12) and *Lean Healthcare* (10). The themes they address are Lean Management for the improvement of quality and business sustainability with tools such as Value Stream Mapping or Six Sigma. 203 articles feature various case studies that are not only about the application of Lean Management but also about other philosophies which are based on it, such as Lean Healthcare, Lean Six Sigma, Lean Practices and Lean Leadership. The articles are published in a total of 51 journals. The journals with the greatest number of publications are: Production Planning & Control (18), Sustainability (11), The International Journal of Lean Six Sigma (9), The Journal of Cleaner Production (9), Quality Management in Health Care (7) and The International Journal of Production Research (6). The journals with the greatest number of citations are: The Journal of Cleaner Production (328), Production Planning & Control (295), The International Journal of Production Research (154), Safety Science (132) and Human Relations (102), with the latter 3 having published less than 6 papers on this theme

Niche themes. These represent themes of importance within the research field but with limited development, bridging transversal and basic themes, indicating areas with some relevance yet substantial potential. The cluster is formed of 2 terms, *Lean construction* (4) and *management practices* (4), as featured in publications which analysing specific tools applied to project execution and the implementation of production system that eliminate or minimizes waste. These publications appear in seven journals, with Buildings (23), the Journal of Management in Engineering (21), and the Journal of Construction Engineering and Management (12) receiving the most citations. Each of the seven journals contains a single publication on this theme, all published between 2018 and 2022.

Emerging or declining themes. This quadrant is distinct in that its cluster overlaps with the niche themes in quadrant 3, encompassing both undeveloped themes and those transitioning into niche themes with enhanced relevance to the research field. The cluster's primary keywords are *Industry 4.0* (14), *digital transformation* (4) and *optimization* (4). The publications analyse the evolution of the Industry 4.0 concept and the significance of digital transformation in production, appearing in 12 journals. The journals with the highest number of citations are The International Journal of Production Research (106) and Production Planning and Control (26).

Thematic Evolution

The literature on Lean Management has undergone significant evolution, employing a diverse array of keywords to characterise study content, with certain themes emerging and others diminishing. Furthermore, a subset of keywords has maintained consistent usage across consecutive sub-periods. Figure 9 shows this evolution in the keywords related to this field of study.
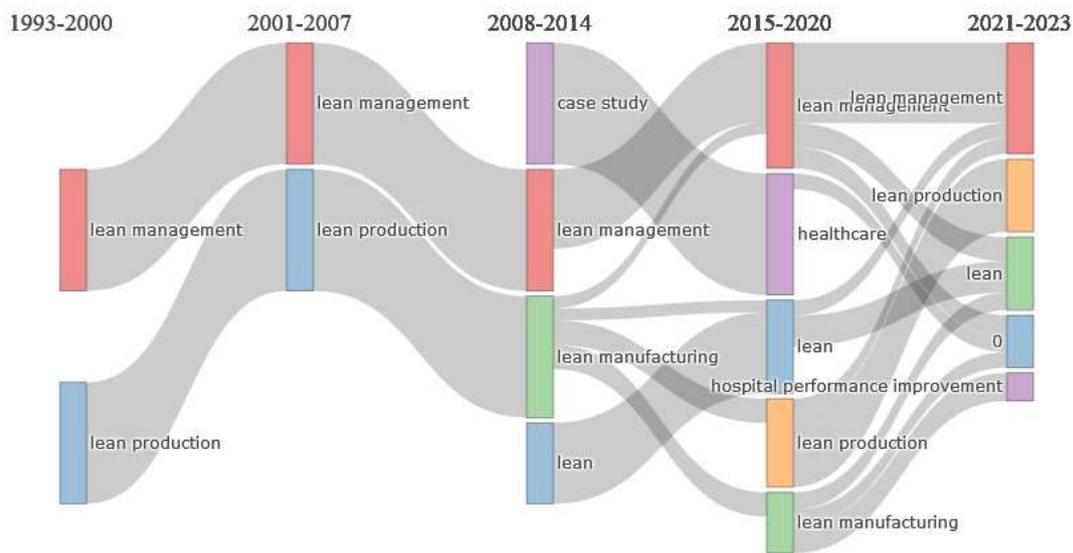
Figure 9: Thematic evolution of Lean Management, 1993-2022

Following the network keyword analysis presented in Figure 8, a longitudinal analysis was conducted to map the evolution of research themes across the five distinct stages within the study period (Figure 9). For this analysis, articles were labelled using their most significant keyword.

During the initial period, spanning 1993 to 2000, only two clusters were identified. The first, Lean Management, has a single keyword with two occurrences, and the second, Lean Production, has a single word with two occurrences.

The pattern repeated in the 2001 to 2007 period, with two initial clusters: "Lean Management" and "Lean Production" , each have two occurrences. These synonymous terms refer to the same underlying concept.

The next period analysed (2008–2014) reveals four distinct clusters. Two of these clusters are novel, emerging independently rather than evolving from previous keyword sets. The first clustercomprises a single keyword with two occurrences. The second, Lean, contains two keywords, Lean and efficiency, with six published articles. The third cluster, Lean Management, is inherited from the two previous periods and it is a constant throughout the entire study period. In this iteration, it incorporates 'Value Stream Mapping' (3 occurrences), 'Lean Management', 'Lean Six Sigma', and 'Process Improvement' (38 occurrences), 'continuous improvement' (3 occurrences), and 'benchmarking' (2 occurrences). The 'Lean Manufacturing' cluster derived from the 'Lean Production' cluster features 'Lean Production' and 'Lean Manufacturing' (4 occurrences each) alongside 'management' and 'Toyota Production System' (2 occurrences each).

During the 2015 to 2020 period, the 'Case Study' cluster transitioned into the 'Healthcare' cluster, comprising 'case study' and 'management' (8 occurrences each), and subsequently evolved towards terms related to Industry 4.0 research. The 'Lean Management' cluster remained constant throughout the study period, as shown in Figure 9, incorporating keyword such as 'Industry 4.0' (4 occurrences), 'quality improvement' and 'human factors' (9 occurrences each), and 'Lean Management', 'Lean Leadership', and 'sustainability' (93 occurrences).. In the last period, this cluster further evolved into the 'Lean Management', 'Lean', and 'Industry 4.0' clusters.

During the 2015-2020 period, the 'Lean Manufacturing' cluster diverged into two distinct clusters: 'Lean Management' (previously analysed)) and 'Lean'. The 'Lean' cluster comprises 'healthcare' and 'Value Stream Mapping' (4 occurrences each), and 'efficiency' (5 occurrences). This evolved into a focus on 'Lean' in the final period, as evidenced by 22 published articles. The publications primarily address themes related to Lean Management and Lean in this concluding period. The 'Lean Production' cluster persisted as 'Lean Production' in the final period, featuring 'Lean Production' (9 occurrences), 'Lean Healthcare' (5 occurrences), and 'leadership' (3 occurrences). Subsequently, it transitioned into the 'Lean Manufacturing' cluster, with 'Lean Manufacturing' (16 articles), 'continuous improvement' (9 articles), and 'patient satisfaction' (3 articles) being the prominent keywords.The keyword analysis illustrates the research's temporal evolution, emphasising the growing significance of applying concepts and tools associated with Lean Management, Lean Manufacturing, and Lean Production, all of which are employed to achieve continuous improvement, business leadership, and enhanced quality in corporate production management. The strategic diagram analysis theme positions across each period (see Figure 10) reveals that the first period (1993–2000) comprises two overlapping clusters, similar in size, position, and form, situated centrally within the diagram across the four quadrants. Each cluster features a single respective keyword: Lean Management and Lean Production.
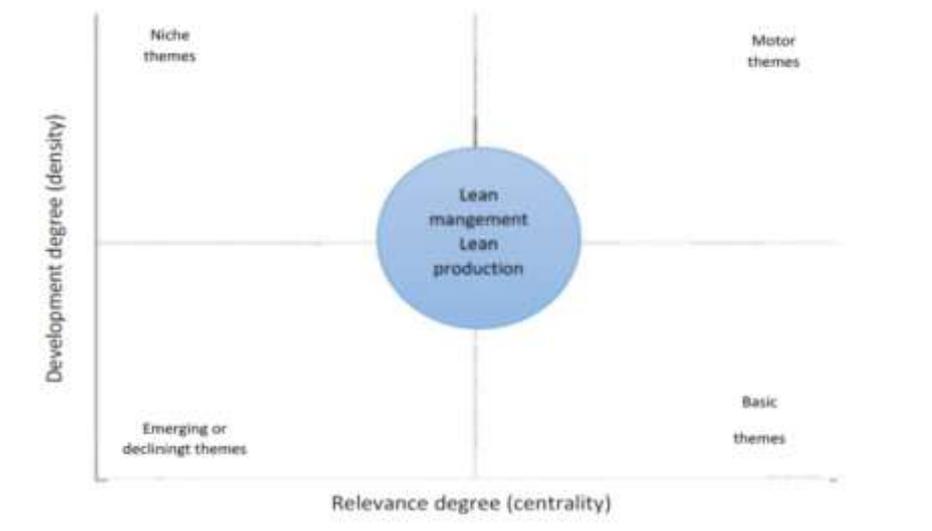

Figure 10: Time slice 1 (1993-2000)

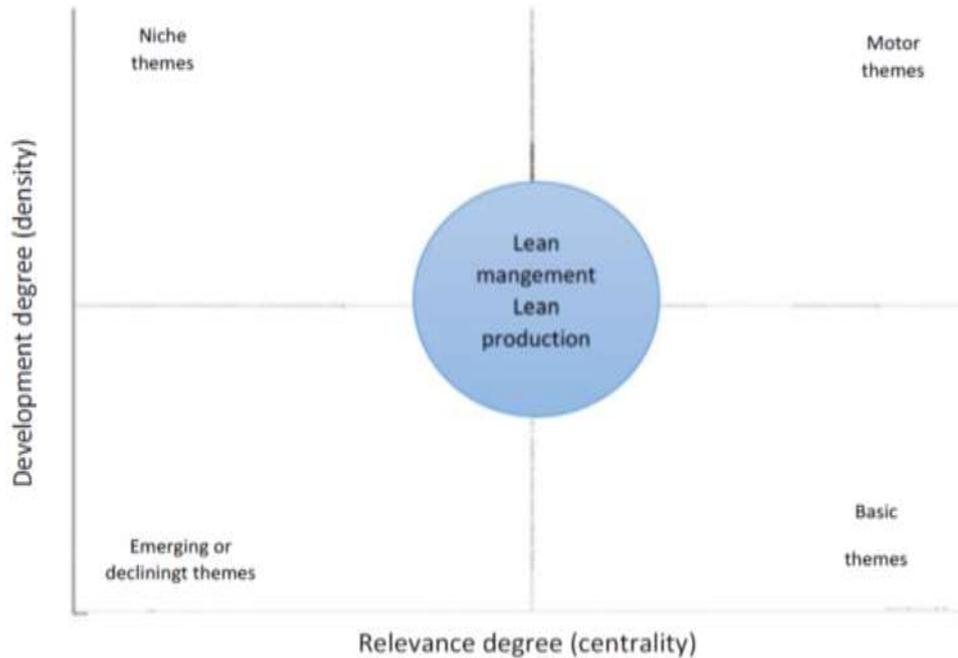The previous situation is repeated in the 2001–2007 period (see Figure 11).

Figure 11: Time slice 2 (2001-2007).

Figure 12, which illustrates the third period (2008–2014), reveals the emergence of five clusters, indicating a significant surge in research within this field. In the first quadrant, representing motor themes or the most relevant topics, are 'Lean Manufacturing' (4), 'Lean Production' (4), and 'innovation' (3).   The second quadrant, basic themes, features a cluster overlapping with the first quadrant (motor themes), signifying a highly relevant theme with stable development. This cluster includes 'Lean Management' (38), 'continuous improvement' (3), and 'Lean Six Sigma' (3). The third quadrant (niche themes), comprises topics relevant to the research but still in developmental stages, such as 'cytologic interpretation', 'fine needle aspiration', 'head and neck masses', 'Six Sigma methodology', and 'ultrasound', all tools employed within the Six Sigma philosophy for continuous improvement and organisational quality. Finally, the emerging or declining themes quadrant contains two clusters: the first with 'case study' and the second with 'Lean' (2), 'efficiency' (2), and 'Lean Thinking' (2). Consequently, the analysis during this period primarily focuses on the various iterations of Lean Manufacturing, Production, and Six Sigma, which are associated with manufacturing processes, and Lean Management and Thinking, which are linked to strategic business management for improvement and efficiency enhancement.
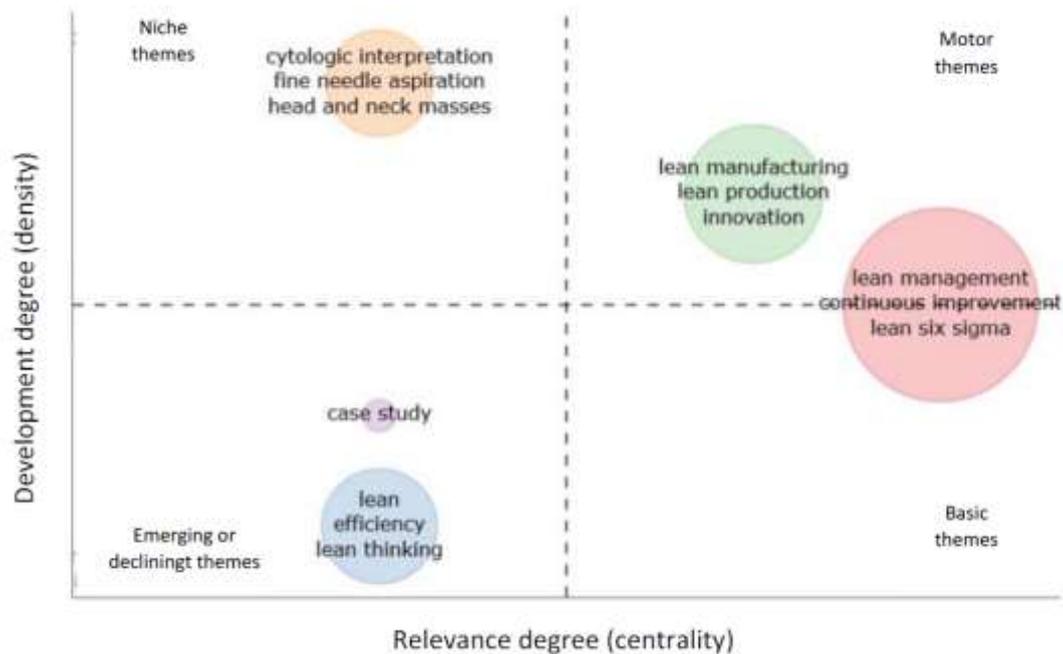
Figure 12: Time slice 3 (2008-2014).

Subsequently, the 2015 to 2020 period features five clusters (see Figure 13). Within the basic themes quadrant, representing developed and highly relevant themes, two clusters are observed. The smaller one contains 'Lean Manufacturing' (16), 'Continuous Improvement' (9), and 'Patient Satisfaction' (3), keywords previously identified in motor themes. No cluster is exclusively situated within the emerging or declining themes quadrant; however, a cluster positioned on the axis separating these themes from the niche themes quadrant includes notable keywords such as 'Lean' (22), 'Efficiency' (5), and 'Management' (5). The second cluster within the niche themes quadrant has the terms 'Lean Production' (9), 'Lean Healthcare' (5), and 'Organizational Change' (4). The final cluster is located on the boundary between the fourth (emerging/declining) and first (motor themes) quadrants, incorporating concepts such as 'healthcare' (9), 'case study' (8), and 'Clinical Risk Management' (3). During this period, research predominantly focused on analyzing Lean practices and their impact on healthcare, as evidenced by the presence of healthcare-related terms across multiple quadrants.
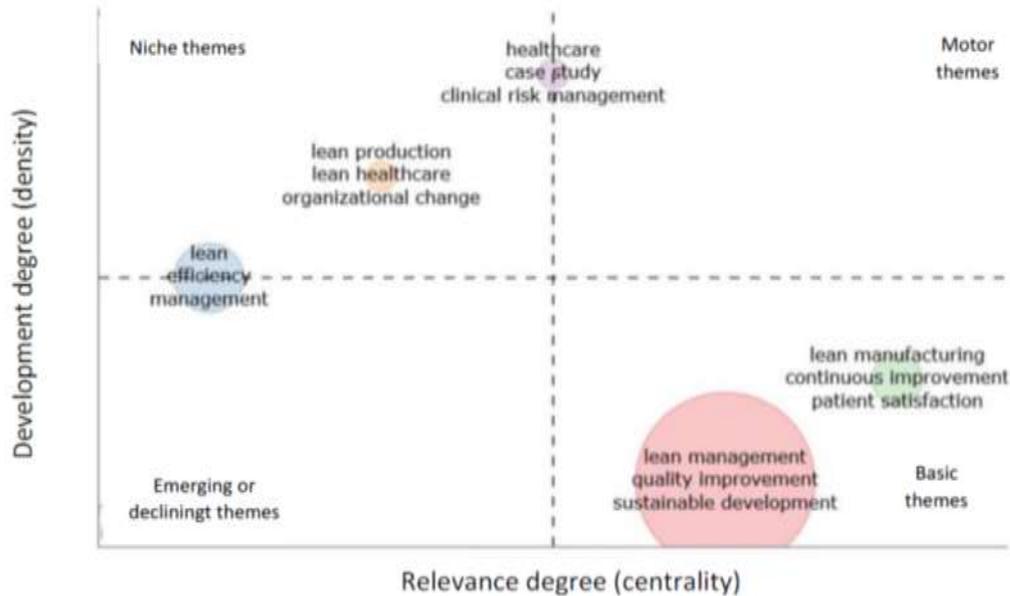
Figure 13: Time slice 4 clusters (2015-2020).

As depicted in Figure 14, representing the final period, motor themes feature a cluster transitioning towards the basic themes quadrant, comprising 'Lean' (9), 'continuous improvement' (5), and 'quality improvement' (5), indicating a shift towards grounding Lean themes in process optimisation and quality enhancement. Basic themes continue to contain 'Lean Management' (57), alongside t 'sustainability' (6) and 'Value Stream Mapping' (6), with a secondary cluster highlighting 'Industry 4.0' (14) and 'Lean Manufacturing' (5). The keyword 'Lean Production' has shifted from a niche to a declining theme. Conversely, developing but not yet consolidated themes include 'Lean Design' and 'Management Practices' in one cluster, and 'hospital performance improvement', 'patient satisfaction', and 'quality of care' in another. Consequently, recent research has shifted its focus from the study of Lean tools for corporate improvement to the optimisation of management processes and leveraging management decisions to enhance the organisational environment.
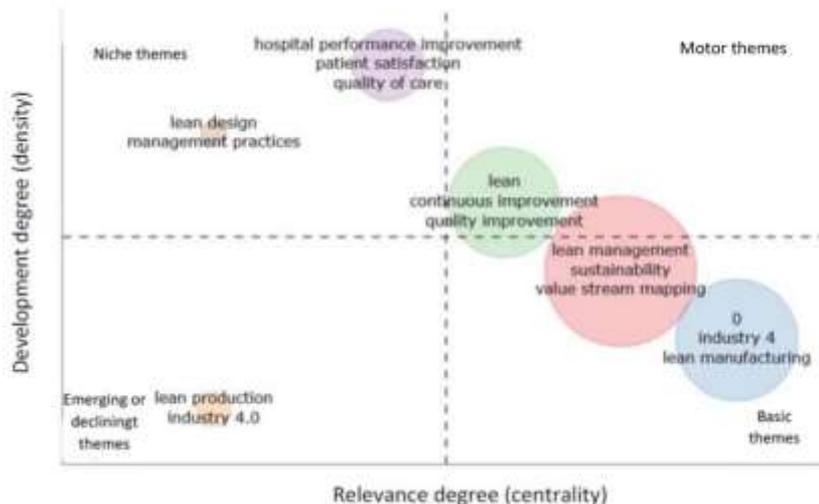

Figure 14: Time Slice 5. From 2021

Discussion

This study has analyzed the evolution of the Lean Management field across various periods from 1993 and 2022. Following an initial assessment   of the most relevant publications, authors, countries, and keywords, the analysis extended to a longitudinal examination of keyword and thematic evolution within each period. This longitudinal analysis yielded a bibliometric map, illustrating the temporal shifts in research focus within the Lean Management domain.

Over recent decades, Lean philosophy has proliferated across diverse global sectors, with the Lean Management model establishing itself as an innovative managerial system, significantly complementing automation and digital transformation processes in the global economy (Buer et., 2018; Kämpf, 2018; Cardoso, 2019; Rosin et al., 2019; Srnicek, 2019).

In this context, the study has demonstrated a temporal pattern in Lean Management keyword usage. The initial 15 years of research primarily concentrated on Lean Management and Lean Production studies, with limited explicit reference to constituent tools or the organisational benefits of their implementation at production or decision-making levels (De Oliveira and Sousa, 2019; Redeker, 2019; Taddeo et al., 2019; Akmal and Greatbanks, 2020; Apoustu 2021; Furstenau, 2021; Teixeira, 2021). However, with time, keywords such as 'continuous improvement', 'innovation', 'efficiency', and 'quality improvement', pertaining to production management, gained increasing prominence within the field. Furthermore, tools like Six Sigma and Value Stream Mapping began to be extensively addressed (Farrukh et al., 2020; Hernandez-Lara et al., 2021; Niñerola erl., 2021a; Niñerola et al., 2021b; Puram et al., 2021; Prakash et al., 2022; Sá et al., 2022; da Silva et al, 2022).

While the literature includes bibliometric studies on Lean Management, (Uriola et al., 2020; Birgün and Kulakli, 2020; Barud et al., 2021; Lalmi et al., 2022; Nedjwa et al., 2022), these have not proliferated to the same extent as those conducting bibliometric analyses of Lean in general. Moreover, a comprehensive analysis of thematic trends within Lean Management, and consequently, the evolution and trends of Lean Management research as a managerial tool, remains absent.Over time, research themes have diversified, incorporating a broader spectrum of Lean-related keywords specific to sectors such as healthcare, leading to the emergence of 'Lean Healthcare'. Post-2008, this became a recurrent theme, integrating concepts like 'improved hospital performance', 'patient satisfaction', and 'quality of care'. These themes have consistently remained niche, failing to consolidate as motor themes, yet also avoiding decline.Within the motor and basic themes, the evolution of keywords in Lean Management exhibited limited significant changes, with the most relevant terms transitioning between quadrants 1 and 2 while remaining within these core areas. Prominent keywords included 'Lean Manufacturing', 'Lean Management', 'continuous improvement', and 'quality improvement'

Conversely, the emerging or declining themes demonstrated notable evolution over the analyzed periods, especially after 2008 when the emerging or declining themes of Lean, efficiency, Lean Thinking, and case study became niche themes in the subsequent periods without ever becoming basic or motor themes.

Therefore, keyword evolution across the analysed period was characterised by stabilisation rather than significant change. 'Lean Manufacturing', 'Lean Production', and 'Lean Management' emerged as central or basic themes, eventually solidifying as motor and stable themes. Conversely, themes like 'efficiency' and 'Lean Thinking' became emerging themes. Notably, niche themes primarily focused on healthcare-related keywords, such as 'Lean Healthcare', and the associated benefits of its application.

Conclusions

The keyword evolution underscores the increasing significance of Lean Management concept and tools in business particularly in enhancing efficiency and decision-making processes. . It also reflects the expansion of the research themes to address broader aspects related to production process management through the application of Lean Manufacturing and Lean Production. The thematic evolution demonstrates a

progression from a central focus on Lean Management to a more diversified exploration of specific aspects within this domain. This includes not only the core principles of Lean but also various tools and methodologies such as Six Sigma and Value Stream Mapping. These shifts reflect the dynamic adaptation of research within the field, responding to the evolving concerns of researchers and stakeholders.

This study delivers valuable insights into the current state of Lean Management research and offers a strategic framework for researchers aiming to contribute to this field. Moreover, it facilitates the comparative evaluation of terminology, thereby suggesting potential avenues for future research and contributing to scientific advancement. Moreover, this study provides future researchers with a valuable overview of key authors and institutions within the discipline, highlighting pertinent topics for review. For both current and prospective authors, it serves as a guide regarding content and areas of interest, offering information to facilitate their publication endeavours.

Limitations of this study must be acknowledged. Firstly, the reliance on the Web of Science Core Collection as the sole data source may introduce bias into the results. Secondly, the topic-specific keyword search ('Lean Management') may limit the final dataset and potentially exclude relevant studies. Thirdly, language preferences may have led to the exclusion of certain keywords from the search formula, potentially affecting the comprehensiveness of the search results.

Contribution: Both authors Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Roles/Writing - original draft; and Writing - review & editing.

Author contribution

Substantial contributions to the conception or design of the work, or the acquisition,analysis or interpretation of data for the work: All authors have participated in the conceptualization and methodology: (software: machine learning, data acquisition, formal analysis, data curation data and validation. All authors have participated in drafting the work or revising it critically to shape the intellectual content (writing, preparation of the original draft, writing, review and editing, as well as visualization. All authors have participated in the final approval of the version to be published (project administration and supervision). All authors agree to be accountable for all aspects of the work in ensuring that questions regarding the accuracy or integrity of any part of the work is appropriately investigated and resolved.

Competing interests

The authors declare no competing interests.

Ethical approval

This article does not contain any studies with human participants performed by any the authors.

Informed consent

This article does not contain any studies with human participants performed by any of the authors.

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