LEAN MANAGEMENT: BIBLIOMETRIC ANALYSIS AND VISUALIZATION ANALYSIS

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ABSTRACT
Lean management increases efficiency by reducing waste and maximizes customer value. Therefore, studies on lean management can indirectly positively affect the performance of businesses. Examining these studies, creating clear and consistent new research routes can contribute to the formation of studies that have a strong impact on the future of businesses. The aim of this study is to apply bibliometric analysis to studies on the concept of lean management. The Bibliometrix application in the R package was used to perform the bibliometric analysis. According to the analysis results, it was found that the number of studies on the subject has increased since 2007, the journal with the most published studies is Sustainability, the author who has done the most studies is Thomas Rundall, the organization that has done the most studies is the University System of Ohio, the country that has done the most studies in terms of the number of authors is the USA, the keywords lean management, lean production, lean leadership, continuous improvement, and quality development are mentioned the most in the articles.
Keywords: Lean Management, Bibliometric Analysis, Visualization Analysis

INTRODUCTION

Lean management is a comprehensive approach to eliminate waste and increase efficiency in various sectors such as manufacturing, healthcare, and construction (D'Andreamatteo et al., 2015). It is an integrated socio-technical system that reduces or minimizes variability in supplier, customer, and internal processes (Soliman et al., 2018). Lean Management is a management system that integrates specific practices and techniques to reduce internal and external variability of processes (Rebelo et al., 2014). It is a set of principles, methods, and procedures for the organization and management of companies that focus on reducing or eliminating waste in value chain processes through the identification of critical points of the system aimed at improving processes, products, or services that provide added value to the customer (Manzouri et al., 2014). Lean management is widely perceived as a way to reduce waste without additional resources, making it an attractive strategy for industries seeking operational efficiency (Lewis, 2000). The benefits of Lean management implementation are divided into economic, environmental and social, so the use of Lean management can have a good effect on sustainable project delivery (Carvajal-Arongo et al., 2019). From an economic perspective, Lean management can help reduce project costs and duration, increase productivity and quality, minimize errors and rework (Al-Aomar, 2012). From an environmental perspective, Lean management can reduce waste materials, energy consumption, and help conserve water (King & Lenox, 2001). From a social perspective, Lean management can provide customer and employee satisfaction, minimize conflicts, enhance teamwork, and improve decision making (Goshime et al., 2019). Lean culture places special emphasis on teamwork, collaborative work, and good communication skills (Alves et al., 2012). Multidisciplinary teamwork can encourage improvements in business performance and a more efficient and effective business system by allowing professionals to learn from each other (Sales-Coll et al., 2023). Lean aims to help public sector organizations become more efficient and effective in their service delivery and policy implementation, and has not been given much due attention by managers and employees from organizations due to unsuccessful Lean implementations (Radnor & Osborne, 2013). Part of the problem may lie in the functionalist perspective on Lean management (Johansson & Osterman, 2017). This perspective views Lean as a largely linear and hierarchical process (Lyons et al., 2013). Adopted as a global concept, Lean is specifically designed at a specific organizational level and then implemented. Here, implementation is considered a top-down process that spreads the concept from the center to the periphery throughout an organization. If the concept fails to achieve its predetermined goals, it is considered a failure. Such a perspective underestimates the dynamics involved in Lean (Secchi & Camuffo, 2019).

The aim of this study is to apply bibliometric analysis to studies on the concept of lean management. Thus, it is aimed to guide future research topics on lean management.

METHODOLOGY

Bibliometric Analysis

Bibliometric analysis, as a quantitative analysis of literature, serves as a methodological tool to identify development trends in specific academic fields and emphasizes the achievement of measurable, reproducible, and objective results (Azarian et al., 2023). This methodology allows the research field to be structured as it develops and guides future research areas (Mukherjee et al., 2022). Therefore, bibliometric methods have become important in the evaluation of institutional research and the positioning of future academic research (Jappe, 2020). A bibliometric analysis can present an analysis by referring to, among others, the number of publications, the most influential authors, the countries where the topic is most researched, or journals that focus their publications on topics related to the object of analysis (Ellegaard, 2018).

VOSviewer is a software tool developed by the Centre for Science and Technology Studies at Leiden University that facilitates the creation and evaluation of bibliometric networks (Kuzior & Sira, 2022). This application demonstrates the ability to create bibliographic networks, especially co-authorship, co-creation and citation-based relationships in bibliographic data (Maltseva & Batagelj, 2024).

Bibliometrix in R software is a robust software package specifically designed for quantitative research in the fields of bibliometrics and scientometrics (Aria & Cuccurullo, 2017). It has been used to create maps representing various countries, analyze trends in journal publications, enhance the intuitiveness of findings with a more scientific touch, and perform scientific keyword analysis (Lim et al., 2024).

In this study, the Web of Science database was used to ensure scientific validity. The keywords "Lean Management", "Lean Leadership", and "Lean Culture" were used in the Web of Science article search engine. The results were then filtered. These filters were in English and articles, and a total of 1054 articles were reached.

FINDINGS

General characteristics of the articles used for bibliometric analysis are given in Table 1. The first article was accessed in 1993, a total of 1054 articles, 2706 keywords, 3053 authors, 36782 references were accessed, and the average age of the articles was found to be 5.34 years.

Table 1. Descriptive Information

Definition	Conclusion
Time period	1993:2024
Number of Articles	1054
Average Age of Articles	5.39
Average Number of Citations of Articles	14.95
Number of References	36782
Number of Keywords	2706
Number of Authors	3053
Number of Single Author Articles	98

Figure 1 shows the distribution of studies on lean management by year. Accordingly, it has been determined that the articles generally show an increasing trend by year. It is observed that the studies on the subject have increased especially since 2007.

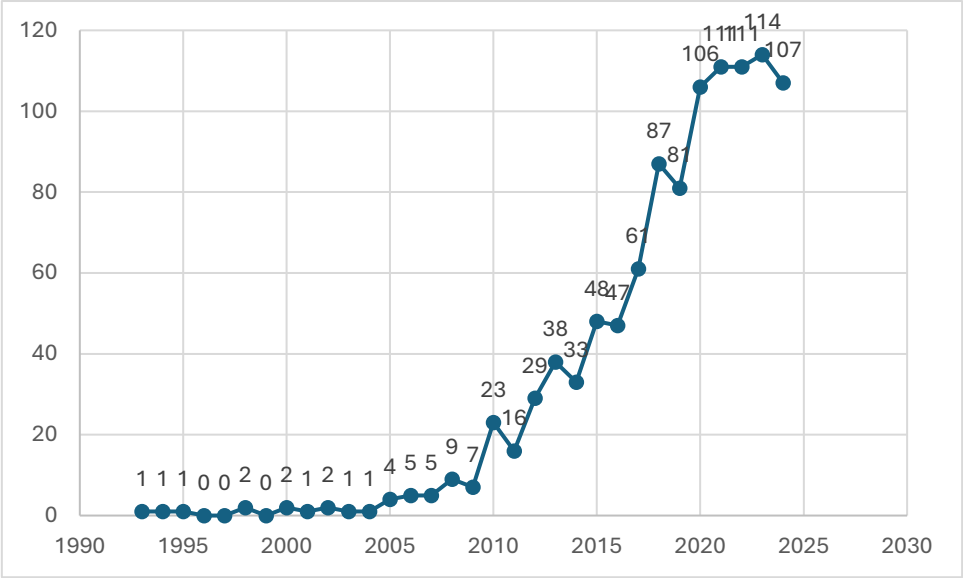

Figure 1. Distribution of Articles by Year

Figure 2 shows the journals that include studies on lean management. Accordingly, it was determined that the journals with the most studies on lean management were Sustainability (38 articles), International Journal of Lean Six Sigma (34 articles), Production Planning & Control (32 articles), International Journal of Production Research (20 articles), and BMJ Open Quality (20 articles).

Figure 2. Journals in which the Studies Appeared (Top Ten)

Figure 3 shows the authors of studies on lean management. Accordingly, the authors who have done the most studies on lean management are Thomas Rundall (12 articles), Shortell (12 articles), Stadlmann (11 articles), Pramreiter (11 articles), and Mann (11 articles), respectively. In his studies, Thomas Rundall examined the relationship between lean management and hospital performance (Shortell et al., 2021), the relationship between lean management and the performance of US public hospitals (Po et al., 2019), the relationship between the

adoption of lean management and hospital performance (Rundall et al., 2021), the relationship between lean management and groundbreaking performance improvement in healthcare (Ahn et al., 2021), the relationships between the functions of Human Resources, Finance and Information Technologies and general Lean Implementation and self-reported performance improvements of hospitals implementing Lean (Shortell A et al., 2021).

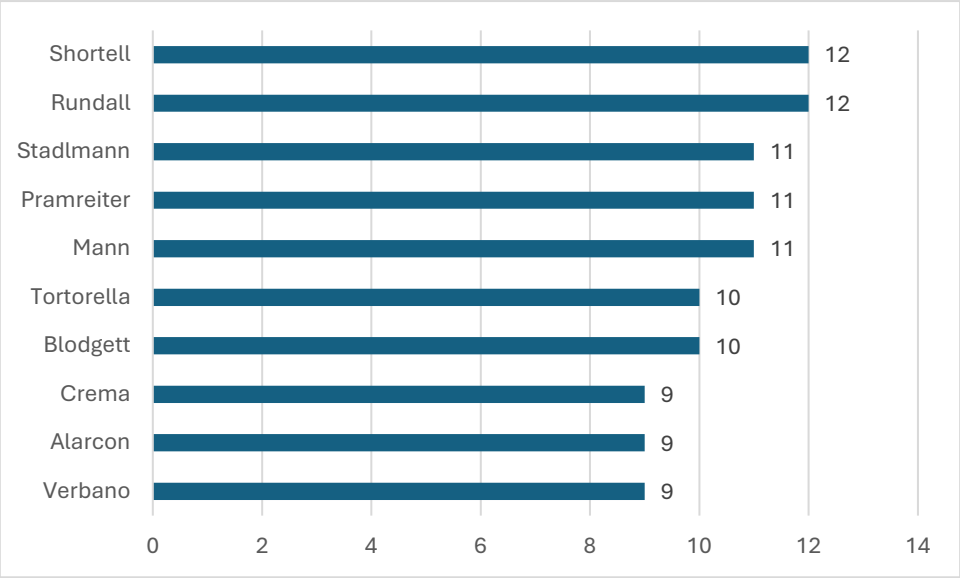

Figure 3. Authors (Top Ten)

Figure 4 shows the organizations that have conducted studies on lean management. Accordingly, the organizations that have conducted the most studies on the subject are University System of Ohio (34 articles), University of California System (34 articles), Ohio State University (24 articles), Veterans Health Administration (21 articles), University of California Berkeley (21 articles). When examined, it is seen that all of these organizations are in the USA.

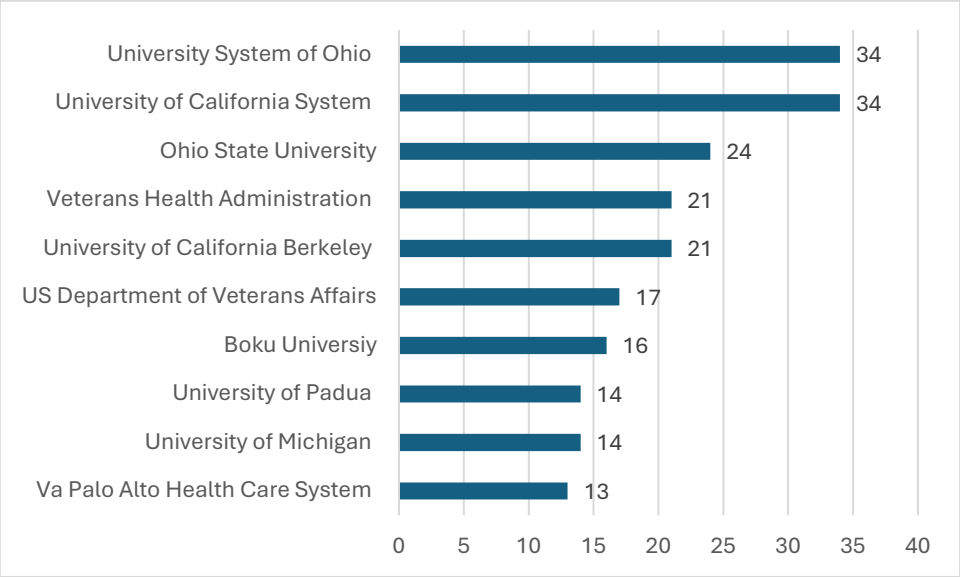

Figure 4. Organizations (Top Ten)

Figure 5 shows the countries of the authors of studies on lean management. Accordingly, the countries with the highest number of studies on lean management are the USA (439 authors), China (209 authors), the United Kingdom (174 authors), Italy (116 authors), and Poland (107 authors), respectively. It is seen that studies on lean management, which is a concept on productivity, are mostly concentrated in developed countries.

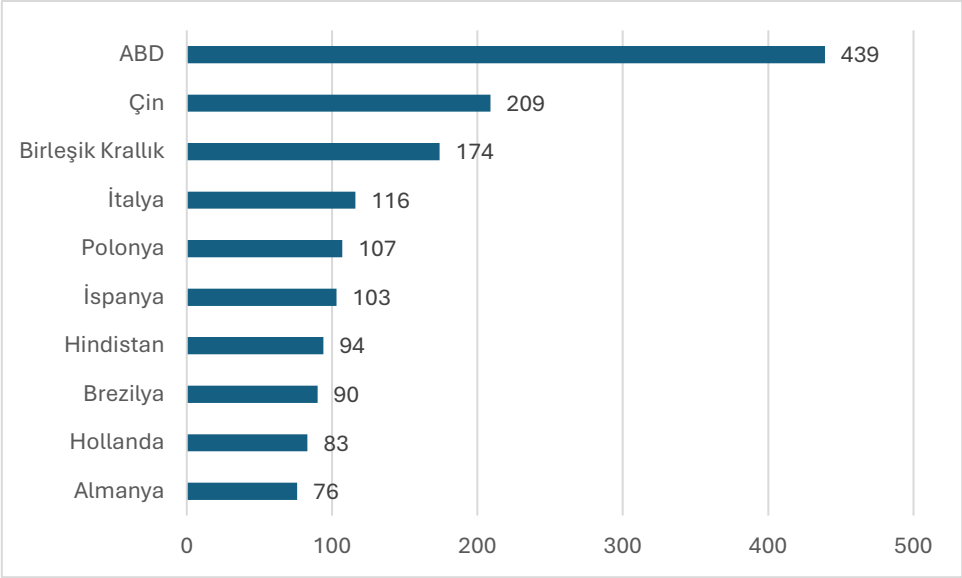

Figure 5. Countries (Top Ten)

Table 2 shows the most cited articles on lean management. Accordingly, the most cited article is the study by Bortolotti et al. (2015) with 375 citations. This study examines whether facilities that successfully implement Lean Management have a certain organizational culture profile and whether they widely adopt soft Lean Management practices (Bortolotti et al., 2015). The second most cited study is by Rothenberg et al. (2001) with 354 citations. This study examines the relationship between Lean production practices and environmental performance measured in terms of air emissions and resource use (Rothenberg et al., 2001). The third most cited study is by Fullerton et al. (2014) with 219 citations. This study examined the mediating effect of lean management accounting practices on the relationship between lean production and firm performance (Fullerton et al., 2014). The fourth most cited study was the article by Toussaint & Berry (2013) with 216 citations. This study defines Lean and presents the 6 principles that constitute the basic dynamics of Lean management (Toussaint & Berry, 2013). The fifth most cited study was the article by Rosin et al. (2020) with 213 citations. This article examined the effects of Industry 4.0 technologies on Lean principles (Rosin et al. 2020).

Table 2. Most Cited Articles (Top Ten)

R	Magazine	TR	Average Quote	Article	Writer	Year
1	Int J Prod Econ	375	37.5	Successful lean implementation: Organizational culture and soft lean practices.	Bortolotti et al.	2015
2	Prod Opera Manag	354	14.75	Lean, green, and the quest for superior environmental performance.	Rothenberg et al.	2001
3	J Opera Manag	219	19,909	Lean manufacturing and firm performance: The incremental contribution of lean management accounting practices.	Fullerton et al.	2014
4	Mayo Clinic Proc	216	18	The promise of Lean in health care	Toussaint & Berry	2013
5	Int J Prod Res	213	42.6	Impacts of Industry 4.0 technologies on Lean principles	Rosin et al.	2020
6	J Clean Prod	174	14.5	Lean management and supply management: their role in green practices and performance	Hajmohammad et al.	2013
7	Bus Process Management J	174	14.5	A methodology for effective implementation of lean strategies and its performance evaluation in manufacturing organizations	My wife & Arif-Uz-Zaman	2013
8	Prod Manuf Res	169	24.14	Industry 4.0 and lean management: a proposed integration model and research propositions.	Sony	2018
9	J Clean Prod	141	15.67	Lean/Green integration focused on waste reduction techniques.	Fercoq et al.	2016

10	Brit J Manage	138	27.6	The impact of lean management practices and sustainably-oriented innovation on sustainability performance of small and medium-sized enterprises: empirical evidence from the UK.	Dey	2020

Table 3 shows the keywords frequently mentioned in lean management studies. Accordingly, in articles related to lean management, the keywords lean management were mentioned 420 times, lean production 124 times, lean leadership 116 times, continuous improvement 45 times, and quality development 37 times.

Table 3. Most Frequently Mentioned Keywords (Top Ten)

Words	Frequency
Lean Management	420
Lean Production	124
Lean Leadership	116
continuous improvement	45
quality improvement	37
value stream mapping	29
health services	25
productivity	22
simple thinking	21
case study	19

Figure 6 shows the keyword visual map of lean management. The keyword visual map consists of 10 clusters. The leader of the red cluster is lean manufacturing, which consists of 17 keywords. The leader of the green cluster is lean leadership, which consists of 16 keywords. The blue cluster consists of 10 keywords, and the leader of lean management. The leader of the yellow cluster, which consists of 8 keywords, is quality management. The leader of the purple cluster, which consists of 7 keywords, is value stream mapping. The leader of the light blue cluster, which consists of 6 keywords, is industry 4.0. The leader of the orange cluster, which consists of 6 keywords, is healthcare. The leader of the brown cluster, which consists of 6 keywords, is productivity. The leader of the pink cluster, which consists of 3 keywords, is project management. The light pink cluster, which has a single keyword, consists of the word occupational safety.

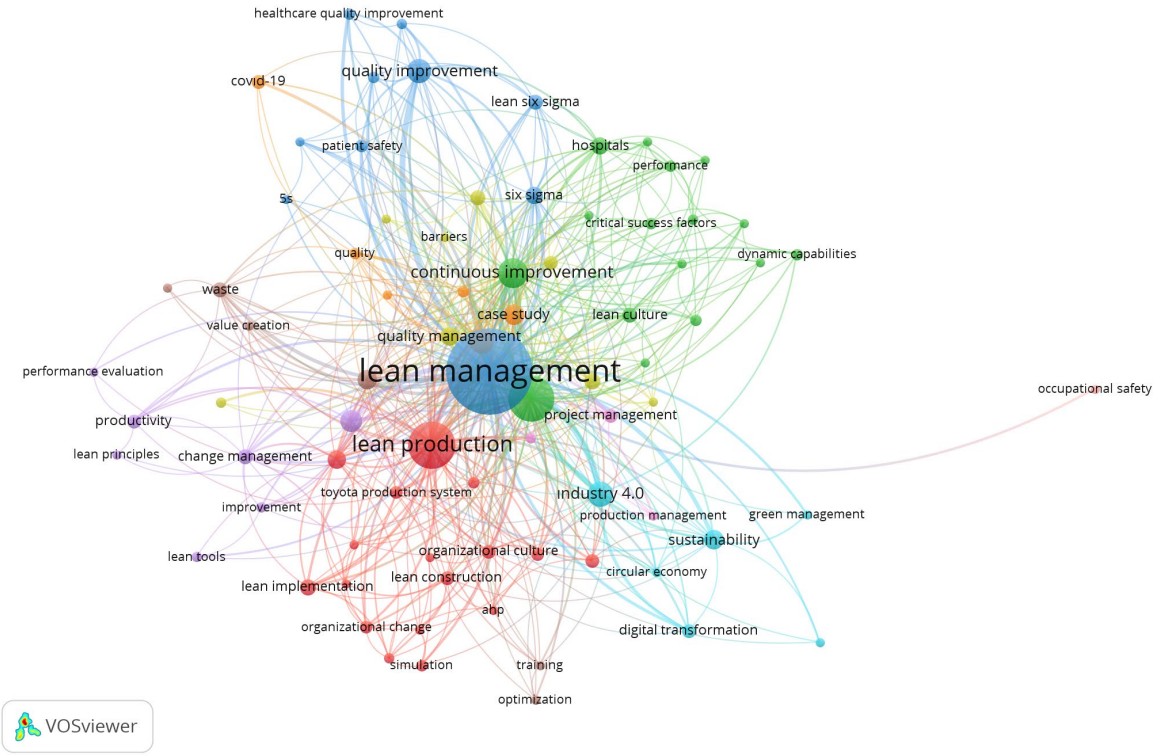

Figure 6. Keywords

Figure 7 shows the visual map of references according to the co-citation analysis of lean management. This visual map consists of 90 references and 5 clusters. Accordingly, the reference with the highest number of co-citations was Womack et al. (1990) with 209 co-citations and 1316 total link strength (ranked 1st). This reference is the leader of the blue cluster. The reference with the second highest number of co-citations was Shah & Ward (2003) with 143 co-citations and 1241 total link strength (ranked 2nd). This reference is the leader of the red cluster. The reference with the third highest number of co-citations was Shah & Ward (2007) with 136 co-citations and 1241 total link strength (ranked 2nd). This reference is the second leader of the red cluster. The fourth most co-cited reference is Womack & Jones (1996) with 109 co-citations and a total link strength of 598 (ranked 7). This reference is the second leader of the blue cluster. The fifth most co-cited reference is Hines et al. (2004) with 99 co-citations and a total link strength of 882 (ranked 4). This reference is the third leader of the blue cluster.

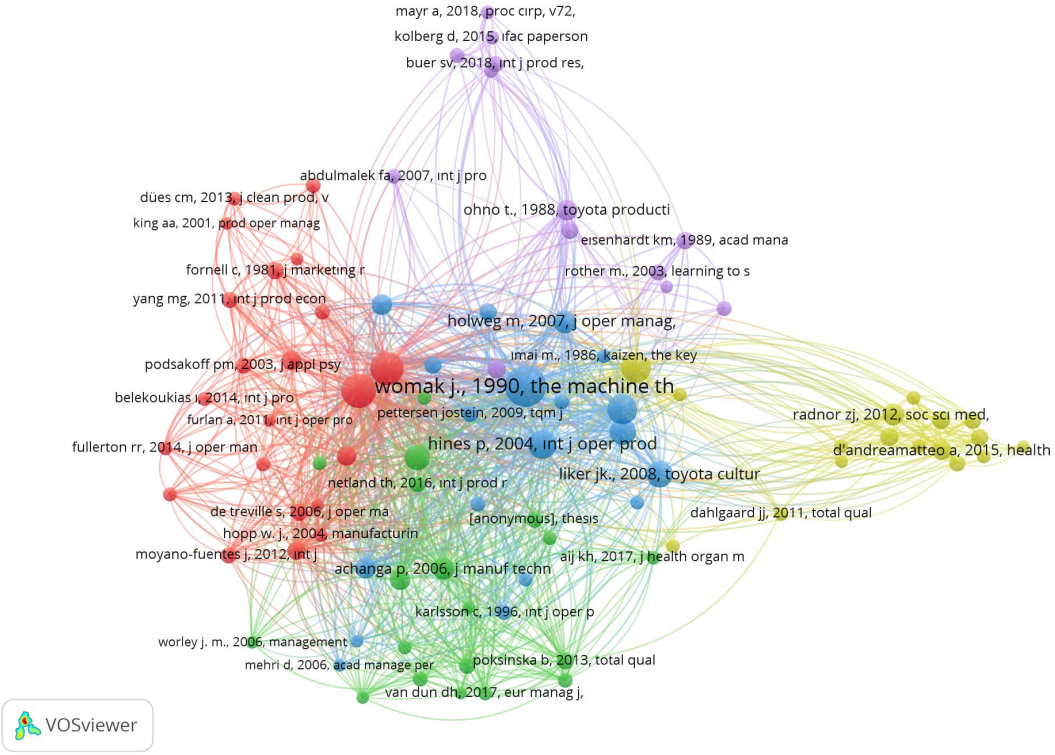

Figure 7. Co-Citation Analysis by Reference

Figure 8 shows the visual map of journals according to the co-citation analysis of lean management. The visual map of journals is divided into 315 journals and 6 clusters. The red cluster consists of 83 journals and Journal of Cleaner Production is the leader of the red cluster with 908 co-citations and 35235 total link power (ranked 5th). The second leader of the red cluster is Procedia CIRP with 339 co-citations and 13095 total link power (ranked 15th). The third leader of the red cluster is Sustainability with 316 co-citations and 11892 total link power (ranked 16th). These journals focus on research topics such as sustainable production, innovative technologies and environmentally friendly applications.

The leader of the green cluster consisting of 80 journals is International Journal of Lean Six Sigma with 531 co-citations and 24541 total link power (ranked 8th). The second leader of the green cluster is International Journal for Quality Research with 288 co-citations and 14800 total link power (ranked 13th). The third leader of the green cluster is Business Process Management Journal with 195 co-citations and 9160 total link power (ranked 19th). These journals focus on research topics such as process improvement and quality management.

The leader of the blue cluster consisting of 71 journals is Total Quality Management and Business Excellence with 432 co-citations and 20173 total link power (ranked 9th). The second leader of the blue cluster is Harvard Business Review with 379 co-citations and 15655 total link power (ranked 10th). The third leader of the blue cluster is The Academy of Management Journal with 277 co-citations and 15354 total link power (ranked 11th). This journal focuses on research topics such as business, management, strategy and quality.

The leader of the yellow cluster consisting of 52 journals is International Journal of Operations & Production Management with 1334 co-citations and 68819 total link power (Rank 1). The second leader of the yellow cluster is International Journal of Production Research with 1170 co-citations and 55481 total link power (Rank 3). The third leader of the yellow cluster is Journal of Operations Management with 1169 co-citations and 61545 total link power (Rank 2). These journals focus on research topics such as operational efficiency, process optimization, and manufacturing systems management.

The leader of the purple cluster consisting of 28 journals is Strategic Management Journal, with 187 co-citations and 11174 total link power (ranked 17th). The second leader of the purple cluster is Journal of Business Research, with 121 co-citations and 6754 total link power (ranked 32nd). The third leader of the purple cluster is California Management Review, with 80 co-citations and 4019 total link power (ranked 60th). These journals focus on research topics such as strategy and business management. The light blue cluster consisting of one journal is Production Planning & Control.

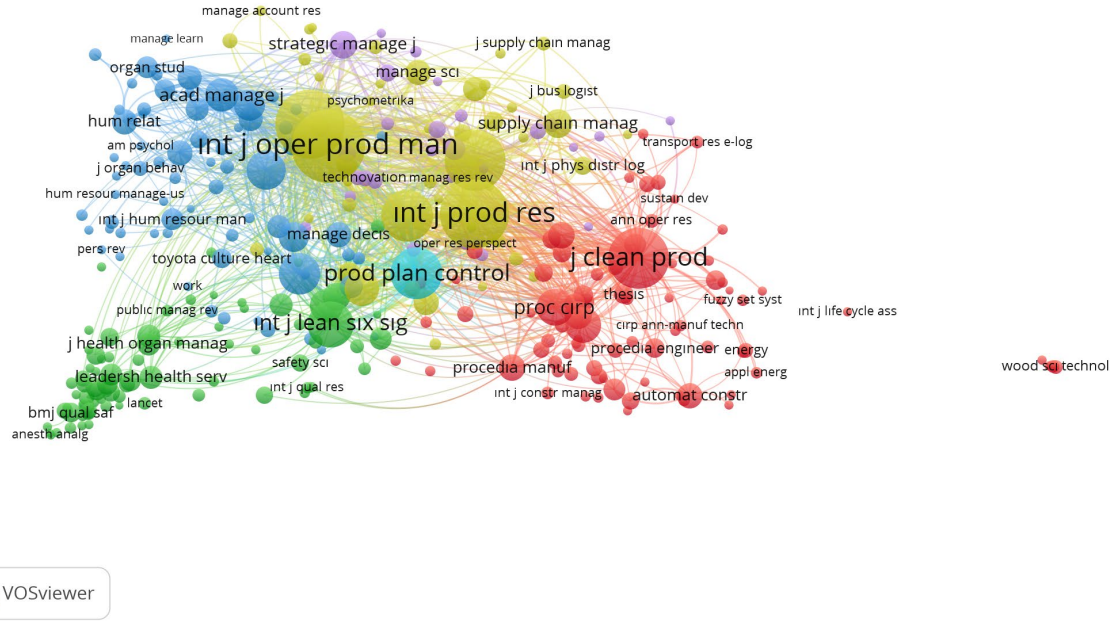

Figure 8. Co-Citation Analysis by Journal

Figure 9 shows the visual map of authors according to the co-citation analysis of lean management. This visual map consists of 206 authors and 6 clusters. The leader of the red cluster consisting of 49 authors, Shah & Ward (2003), has 301 co-citations and 6226 total link power (Rank 1). The second leader of the red cluster, Hair et al. (2011), has 97 co-citations and 1814 total link power (Rank 14). The third leader of the red cluster, Chiarini & Kumar (2021), has 67 co-citations and 1089 total link power (Rank 36). This cluster is a cluster that provides methods for improving operational processes and increasing business performance. Shah & Ward (2003) examines the effects of plant size, plant age, and unionization status on the probability of implementing 22 production practices, which are the basic elements of lean manufacturing systems. Hair et al. (2011) conducted a study on the conditions under which PLS-SEM models should be used. Chiarini & Kumar (2021) investigates a possible integration between Lean Six Sigma (LSS) tools and principles and Industry 4.0 technologies.

The leader of the green cluster consisting of 44 authors is Womack & Jones (1996), who has 267 co-citations and a total link power of 3730 (ranked 3rd). The second leader of the green cluster is Womack & Jones (1994), who has 209 co-citations and a total link power of 3159 (ranked 6th). The third leader of the green cluster is Radnor et al. (2012), who has 108 co-citations and a total link power of 1854 (ranked 13th). This cluster focuses on the application of Lean principles. Womack & Jones (1996) discusses the Lean approach in detail to increase the efficiency of business management and production processes. Womack & Jones (1994) examined the efficiency and success management of Toyota. Radnor et al. (2012) examines four multi-level case studies on the implementation of Lean in the British National Health Service.

Liker & Choi (2004), the leader of the blue cluster consisting of 39 authors, has 232 co-citations and 3907 total link power (ranked 2nd). Hines et al. (2004), the second leader of the blue cluster, has 194 co-citations and 3593 total link power (ranked 4th). Bhasin (2012), the third leader of the blue cluster, has 141 co-citations and 3213 total link power (ranked 5th). This cluster covers topics such as supply chain, collaboration, continuous improvement, innovation, and value creation of lean manufacturing philosophy. Liker & Choi (2004) examines the practices of leading companies such as Toyota and Honda on how to do successful supplier management. Hines et al. (2004) examines approaches that attempt to address some of the gaps that emerged earlier in lean thinking. Bhasin (2012) examines the significant barriers that prevent organizations from adopting the concept of lean or implementing it more broadly.

The leader of the yellow cluster consisting of 38 authors, Tortorella et al. (2017), has 133 co-citations and 2921 total link power (ranked 7th). The second leader of the yellow cluster, Rother (2010), has 116 co-citations and 1552 total link power (ranked 19th). The third leader of the yellow cluster, Ballard & Howell (2003), has 63 co-citations and 427 total link power (ranked 140th). This cluster focuses on the principles of Lean Thinking and discusses how these principles can be applied to improve organizational processes. Tortorella et al. (2017) provide

a framework to define the precise practices to be considered in relation to Lean Supply Chain Management in their study. Rother (2010) aims to strategically structure Lean processes in his study. Ballard & Howell (2003) present a lean project management model and compare lean and traditional approaches.

The leader of the purple cluster consisting of 20 authors, Emiliani (1998), has 126 co-citations and 2673 total link power (ranked 8th). The second leader of the purple cluster, Netland (2017), has 102 co-citations and 2555 total link power (ranked 9th). The third leader of the purple cluster, Anthony & Banuleas (2002), has 101 co-citations and 1743 total link power (ranked 16th). This cluster focuses on organizational excellence, lean thinking, and process improvement strategies. Emiliani (1998) examined the real-life impact of lean practices. Netland (2017) investigates how contingency variables affect what practitioners see as success factors in lean implementation. Anthony & Banuleas (2002) presents the basic components required for Six Sigma implementation.

The leader of the light blue cluster consisting of 16 authors is Womack et al. (1990), who has 209 co-citations and a total link power of 3159 (Rank 6). The second leader of the light blue cluster is Ohno (2019), who has 167 co-citations and a total link power of 2442 (Rank 11). The third leader of the light blue cluster is Monden & Minagawa (2015), who has 52 co-citations and a total link power of 997 (Rank 40). This cluster focuses on the Toyota Production System (TPS) and Lean Thinking philosophies. Womack et al. (1990) examined the birth and evolution of the Lean production system, and how it revolutionized the industrial world. Ohno (2019) describes the basic principles and applications of the Toyota Production System (TPS) . Monden & Minagawa (2015) focus on the Toyota Production System and lean manufacturing.

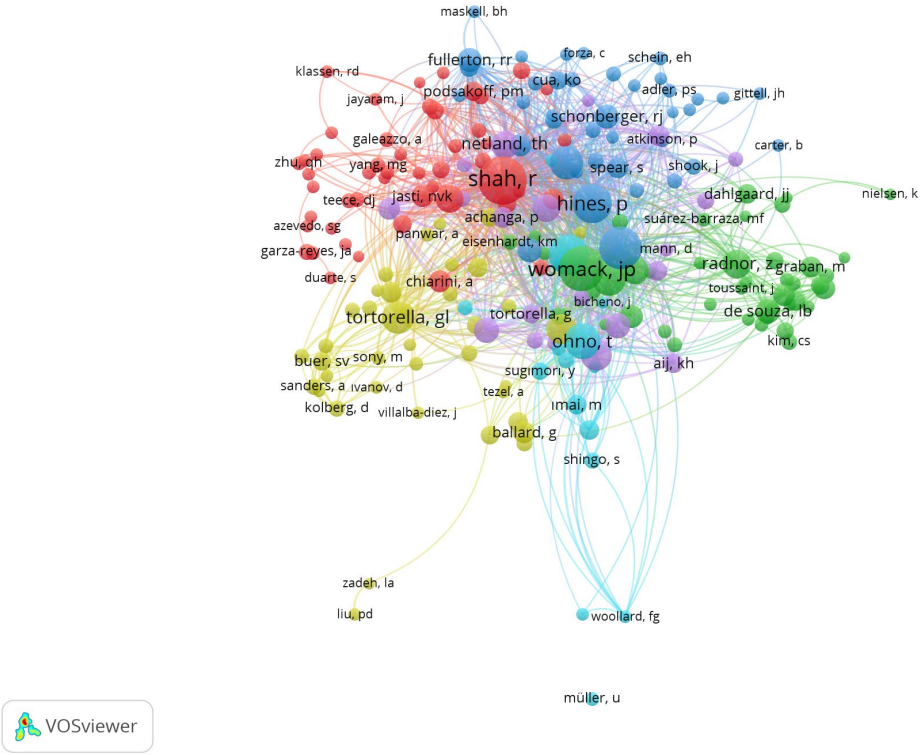

Figure 9. Co-Citation Analysis by Author

CONCLUSION

In this study, lean management articles were examined by applying bibliometric analysis. These articles were accessed from the Web of Science database. After selecting the keywords related to the subject and performing the necessary filtering process, a total of 1054 articles, 2706 keywords, 3053 authors, 36782 references were accessed, and the average age of the articles was determined to be 5.34. Accordingly, it was determined that the number of studies on the subject increased since 2007, the journal with the most studies was Sustainability, the author who did the most studies was Thomas Rundall, the institution that did the most studies was the University System of Ohio, and the country with the most studies according to the number of authors was the USA,

It was found that the most cited article was Bortolotti et al. (2015) and that the keywords lean management, lean production, lean leadership, continuous improvement and quality development were mentioned the most in the articles.

According to the results of co-citation analysis by reference, it was determined that the reference with the highest number of co-citations was Womack et al. (1990), the second highest number of co-citations was Shah & Ward (2003), and the third highest number of co-citations was Shah & Ward (2007). According to the results of co-citation analysis by journals, the journals were divided into 6 clusters, the leader of the red cluster was Journal of Cleaner Production, the leader of the green cluster was International Journal of Lean Six Sigma , the leader of the blue cluster was Total Quality Management and Business Excellence. It was determined that the leader of the yellow cluster is the International Journal of Operations & Production Management , and the leader of the purple cluster is the Strategic Management Journal. According to the co-citation analysis results according to the authors, the authors are divided into 6 clusters. The red cluster, led by Shah & Ward (2003), is a cluster that offers methods for improving operational processes and increasing business performance. The cluster, led by Womack & Jones (1996), The green cluster focuses on the application of Lean principles, led by Liker & Choi (2004) The blue cluster covers topics such as supply chain, collaboration, continuous improvement, innovation and value creation of lean production philosophy. The yellow cluster, led by Tortorella et al. (2017), focuses on the principles of lean thinking and discusses how these principles can be applied to improve organizational processes. The purple cluster, led by Emiliani (1998), focuses on organizational excellence, lean thinking and process improvement strategies. The light blue cluster, led by Womack et al. (1990), focuses on the philosophies of the Toyota Production System (TPS) and lean thinking.

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