Lean in pharma: through the lenses of bibliometrics

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Abstract:

Given the success of lean management practices in both manufacturing and service contexts and the increasing awareness of its relevance in process industries, the purpose of this study is to investigate the extent of research on lean implementation in the pharmaceutical industry. The research reveals the most influential journals and authors, the collaborative networks in the field, the structure of the research community, and how the concept of lean in pharma has evolved throughout the main themes in the literature body. The Study finds a fragmented research landscape with no strong network of authors consistently studying lean in the pharmaceutical sector. It also revealed a diverging body of knowledge related to the implementation of lean in the pharmaceutical industry and a broad spectrum of themes with no specific focus on a specific tool, method, or concept of lean management. Research was conducted through a bibliometric analysis using the Bibliometrix package in R.

Type of paper: Bibliometric literature review

1 Introduction

Since the publication of The Machine That Changed the World (Womack et al., 1990) Lean has become the way many manufacturing companies around the world streamline their operations. Lean originates from the Japanese way of managing the shop floor, specifically, the Toyota Production System (Holweg, 2007). However, over

the years, lean has spread to many other regions and industries, including the service sector (Jiang et al., 2021).

One of the areas that is significantly different from the mass production in which lean originated, and in which lean is very well implemented, is medicine. Various studies have been conducted regarding the use of lean in medical institutions. Lean has been implemented successfully, from the surgeries (Mahmoud et al., 2021; Sales-Coll et al., 2023) to the distribution of medication in hospitals (Hammoudeh et al., 2021; Trakulsunti et al., 2022). However, when taking a closer look at the other key part of the world health system, the pharmaceutical industry, the situation is dramatically different; the existing literature is surprisingly sparse on research on lean management practices in the pharmaceutical industry.

The pharmaceutical industry is a part of the process industry, which is significantly different from discrete mass production, from which lean stems. Many authors have stressed that the pharmaceutical industry has been slower than other industries in embracing the lean theory (Greene & O'Rourke, 2006; Pavlović & Božanić, 2012).

As lean has proven itself as one of the most successful management approaches, this study aims to explore the existing literature on lean in the pharmaceutical industry in hopes of helping both researchers and practitioners understand the overview of implementation of Lean in the pharmaceutical industry better. This becomes even more relevant bearing in mind the recent COVID-19 pandemic, which showed us how important the efficiency of the global health system is.

2 Methodology

This paper carries out a bibliometric analysis on Lean implementation in pharmaceutical industry. As there is no generally accepted framework according to which a bibliometric analysis should be conducted, the procedure defined by Tranfield et al., (2003) of systematic literature review was followed. The difference in the methodological approach in this research is that instead of full-text analysis, a series of analyzes in the field of bibliometrics was performed.

2.1. Research questions

To guide this research, inspired by Ingale & Paluri, (2022) the following research questions were defined:

(1) How does the structure of the research community look like – what are the most important journals and authors in the lean in pharma research?
(2) What are the collaborative networks in lean in pharma research?
(3) How has the literature on lean in pharma changed through time, and what are the most addressed topics in the recent work?

Research questions inform the objective of the research:

To understand trends, patterns and knowledge structure regarding the use of lean in the pharmaceutical industry.

2.2. Gathering the literature

Scopus database was used to gather data and conduct research. Scopus was used in order to collect all the relevant publications and to prevent the search from excluding any specific publishers. Search was restricted to the English language, and data base was searched through based on title, abstract, and keywords. Publishing period was not restricted.

The search for the articles was complex due to the diversity of both lean and pharma literature. Two sets of keywords were used and three iterations of exclusion were applied to the raw data in order to generate an appropriate database. The first

keyword combination was “Lean pharmaceutical” (lean AND pharmaceutical) and the second one was “lean drugs manufacturing” (lean AND drugs AND manufacturing). The association rule for combining keyword sets was ‘OR’ and 381 publications were found. Exclusion criteria were then applied to a subject area. Subject areas not related to business aspects of the pharmaceutical industry were excluded (e.g. chemistry, biochemistry, molecular biology). This way number of articles has decreased to 167 articles. Then, another exclusion criterion to the search was applied, this time to the keywords. Articles with keywords related to medicine and drug research were excluded (e.g. obesity, controlled study, glucose, protein etc.). This resulted in a database containing 108 articles. After reading the abstracts, 7 more papers were excluded, most (5/7) of them were focused on hospital pharmacies and/or drug distribution in hospitals. The final article database consisted of 101 articles.

2.3. Conducting the analysis

In order to perform analysis, one of the R packages, Bibliometrix (Aria & Cuccurullo, 2017) was utilized. Bibliometrix provides tools for gathering and evaluating bibliographic information, such as co-authorship, citation, and co-citation networks (Aria & Cuccurullo, 2017). Bibliometrix provided tools for creating network diagrams and citation histograms.

3 Findings and discussion

3.1 Data sample characteristics

The first result output generated via Bibliometrix is the distribution of research papers throughout the years and Journals. Figure 1 shows the Annual scientific production. Even though publication period was not restricted, first article regarding lean in pharma was published in 2004, more than 15 years after lean was introduced to the manufacturing literature and practice. Throughout the years, the number of published articles has fluctuated; the increase and decrease in the number of published works

alternated. It is not surprising that the years 2020 and 2022 have the highest number of published papers, it can be explained by the growing interest in the pharmaceutical industry due to the COVID-19 crisis. However, the sudden drop in 2021 is puzzling. Figure 1 clearly depicts the lack of any trend, implying the ad hoc nature of research in this field, which is based on individual attempts rather than the growing popularity of the research domain.

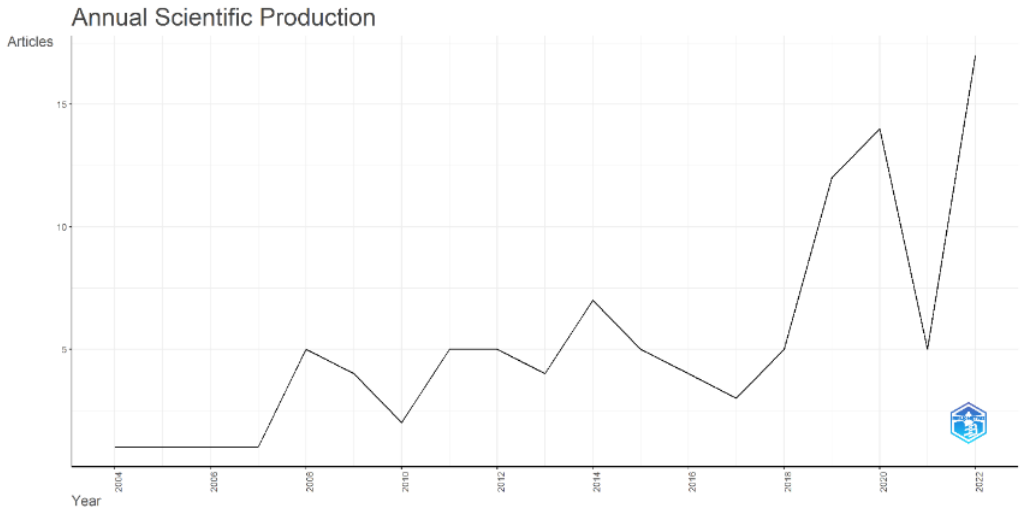

Figure 1: Annual Scientific Production of Literature

Regional scientific production is shown throughout corresponding author's countries (Figure 2). The number of publications is somewhat related to pharmaceutical sales in the given regions. According to the research (González Peña et al., 2021), US tops the list of pharma sales values, and it's followed by EU, South East Asia, Japan Latin America and India, respectively. Similarly, when it comes to research publications, the USA tops the list, and Europe closely follows, but looking at the rest of the list and Figure 2, we can see that India produces large quantities of publications, but ranks in the middle of the sales values list. China, on the contrary, drives the sales in the South Asia region but falls on the lower part of the spectrum when it comes to research.

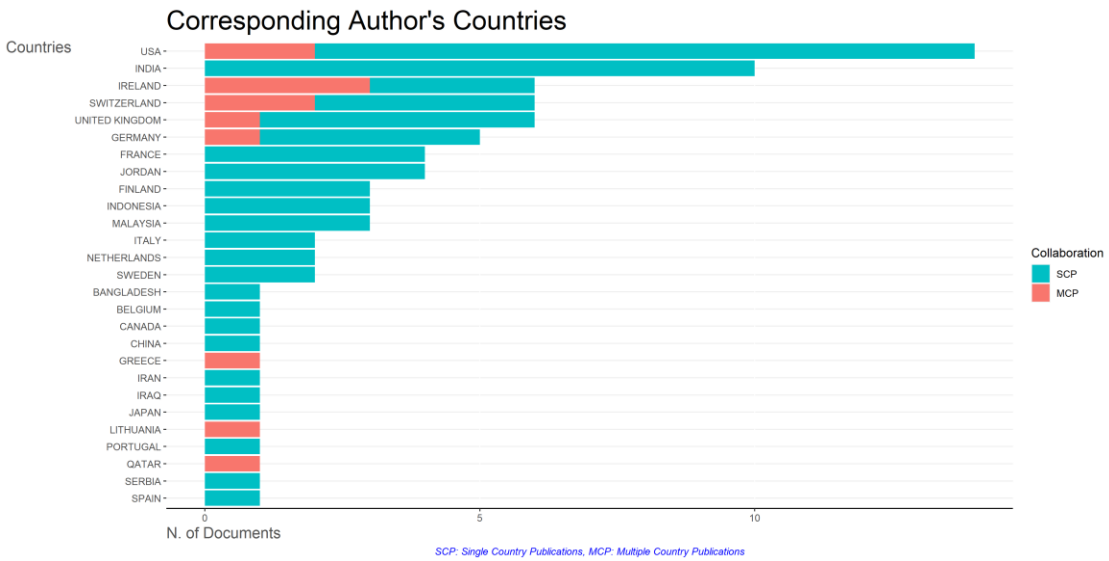

Figure 2: Scientific Production of Countries

There are noticeable differences in the sources that are cited in the papers from the data sample and those in which the papers are published. Journals in which sample articles are published in, are mostly literature oriented towards the pharmaceutical industry (Figure 3), only 3 out of 10 journals are oriented primarily towards Lean, processes, and industrial engineering. Journal of Pharmaceutical Innovation tops the list with 8 published articles.

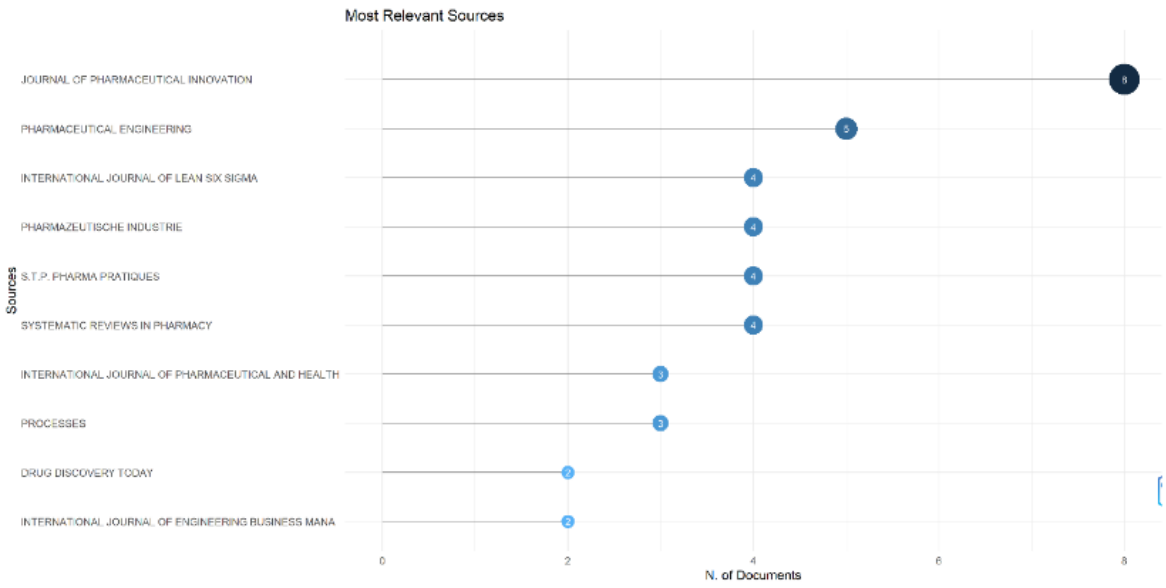

Figure 3: Key publication outlets

On the other hand, the most frequently cited papers (Figure 4) are entirely focused on the business side. All 10 most cited sources concern production, operations management and the lean itself, and count a significantly higher number of citations in papers.

Looking at Figures 3 and 4, it can be noticed that there are two bodies of knowledge related to the implementation of lean in the pharmaceutical industry. The first knowledge base relates to the direct application of lean in the pharmaceutical industry and can be found in journals oriented directly to the pharmaceutical industry. The second, which is used when creating the first, contains a wider range of knowledge in the field of lean. However, there is no overlap between these knowledge bases, which confirms that lean in the pharmaceutical industry is still an underdeveloped and young field of research and that the authors are forced to use another, general, knowledge base when researching specific phenomena in the pharmaceutical industry. As a consequence of this, the general scientific public, interested in the topic of lean in the process industry, or specifically in the pharmaceutical industry, may have difficulties when searching for literature, which potentially slows down the development of literature, but also the application of lean in the pharmaceutical industry.

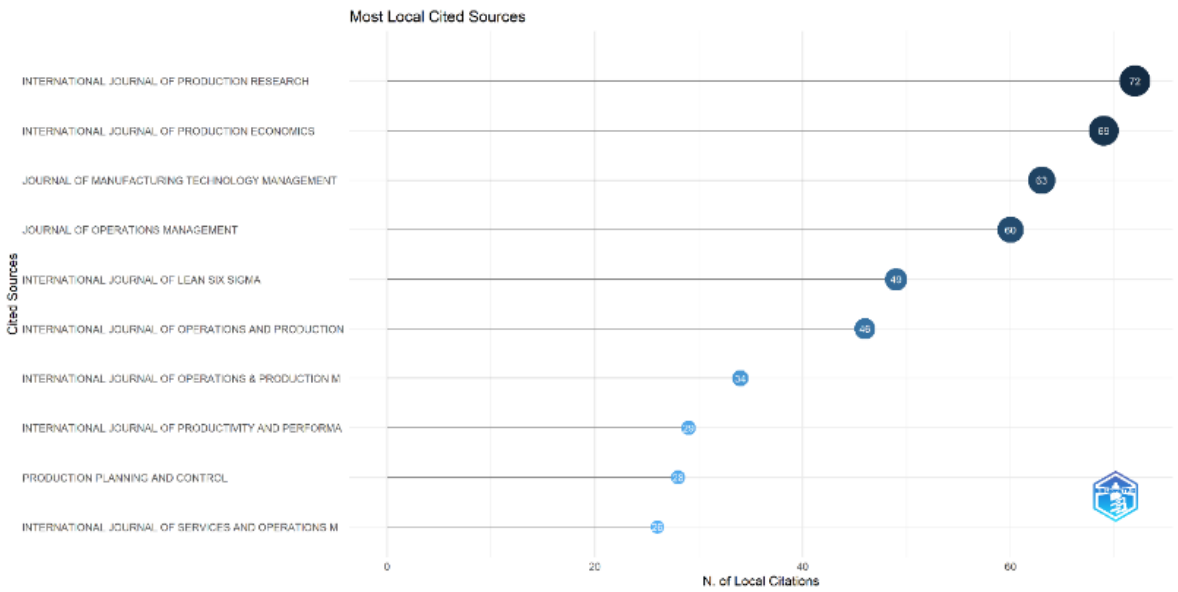

Figure 4: Cited Sources

3.2 Scientific Comunity

One of the most common bibliometric analyses is the citation analysis. Each color in the co-citation network structure (Figure 5) represents a cluster. The node size demonstrates the number of times publications of the corresponding author has been co-cited, the distance between two nodes indicates the strength of the co-authorship between the corresponding authors (Abideen et al., 2021).

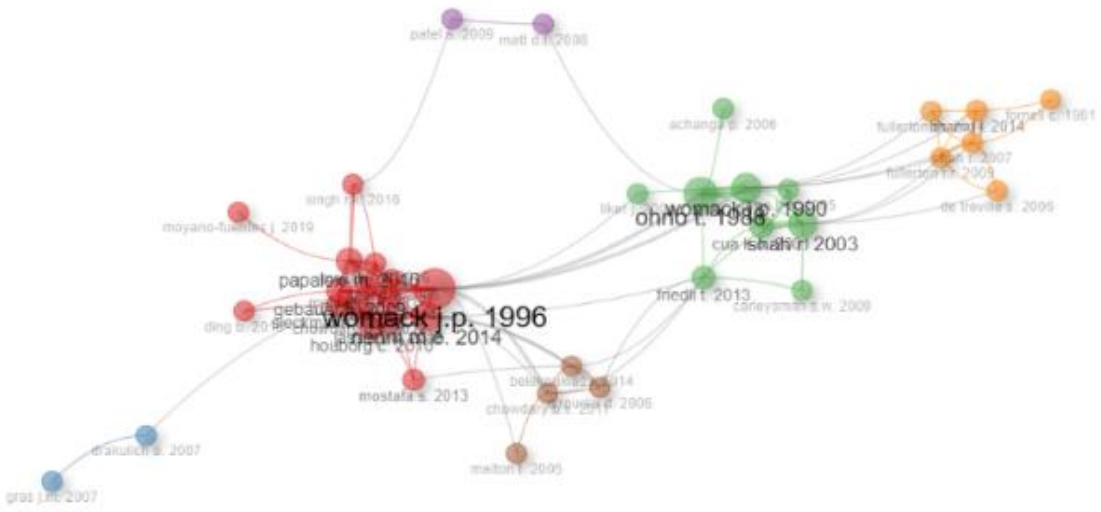

Figure 5: Co-citation network

Co-citation network reveals that the most cited authors are Womack & Jones (1996)and Ohno (1988). Having in mind that Womack pioneered lean in academic literature, and the importance of Ohno's literature on Toyota Production System, this doesn't come as a surprise. What is surprising, though, is the fact that there isn't a cluster formed around a source focused on lean in the pharmaceutical industry, pharmaceutical industry itself or at least the process industry.

Figure 6 displays the Scientific collaboration network. In a Scientific collaboration network, nodes represent authors and connecting lines represent co-authorships. Since the article sample consists of only 101 papers, and there are 14 clusters in this network, the analysis suggests that the co-authorship network is wide.

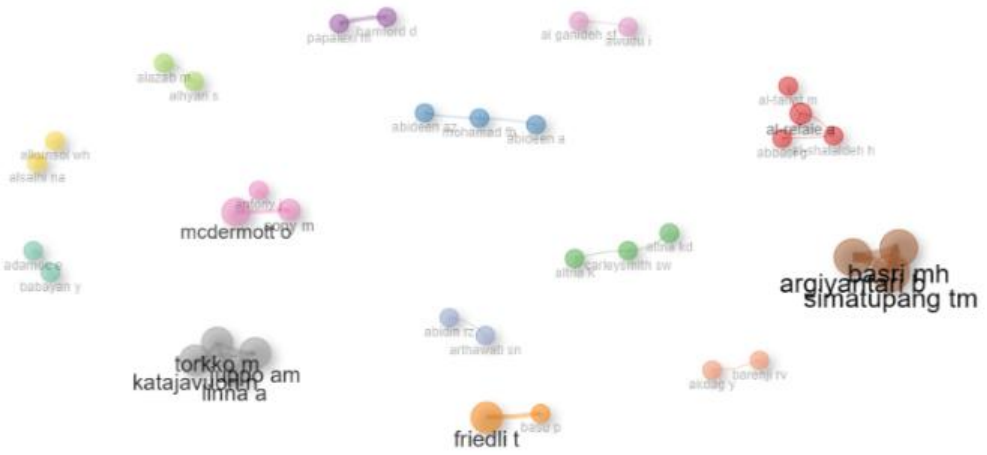

Figure 6: Collaboration network

Noticeably, although there is a large number of clusters, they contain a small number of articles. When examined closely, three clusters are constituted of repeating authors. Looking at authors' productivity represented by Lotka's law (Lotka, 1926) (Figure 7), it is apparent that most authors publish only one paper on this topic, which additionally explains this constellation of the co-author network.

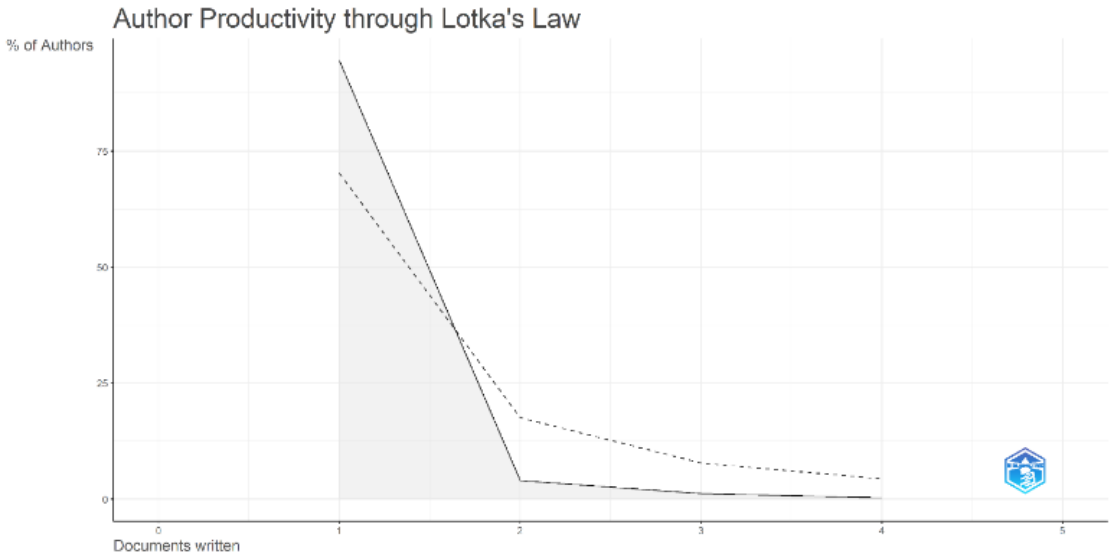

Figure 7: Author Productivity

4.3 Research focus

To fully understand the literature regarding Lean in pharma, progression of themes in the literature should be observed. Figure 8 represents thematic evolution and is based on author keywords in the form of a Sankey diagram (Schmidt, 2008). This diagram explains the shift in the research focus of Lean in pharma during the given periods. Sankey diagrams include directed arrows with a width proportional to the flow quantity that is being visualized.

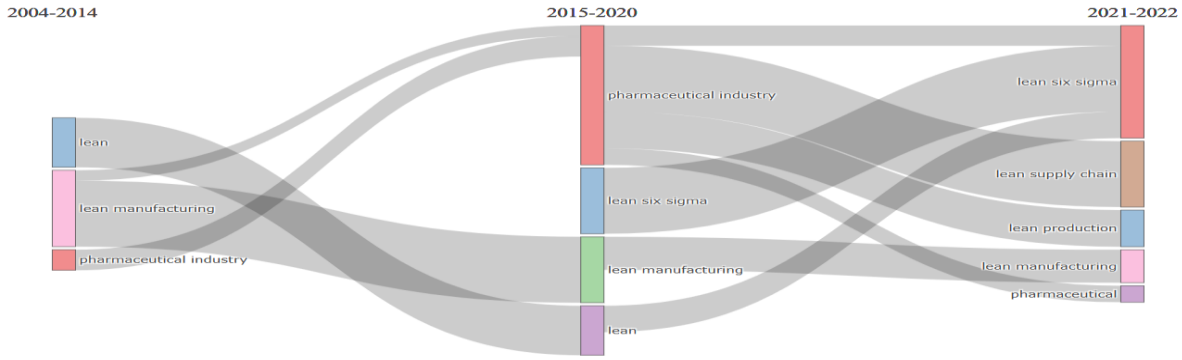

Figure 8: Thematic evolution

The main keywords used, and therefore the focus of research on lean in pharma in the period of 2004 - 2014, were Lean and Lean Manufacturing. In the following period, 2015 - 2020, the focus changes. In addition to the typical keywords Lean, and Lean Production, the research focus shifts to Lean Supply Chains, Lean Six Sigma, but also towards a somewhat more general area - Sustainability. After that, in the next time period, 2021 until now, Lean Six Sigma remains an equally popular topic, and the focus of lean research in the pharmaceutical industry on Supply Chains declines, while the focus of research returns to Lean Manufacturing, which again becomes the most popular.

This implies that there was no focus on a specific tool, method or concept of Lean looking from a higher level (Figure 8). However, Figure 9 shows that the topics in the literature are somewhat broader than those shown in Figure 8. Figure 9 presents a Sankey diagram that connects the most important authors in the sample of papers

(left), topics in their research (middle), and journals that served as sources for the authors (right).

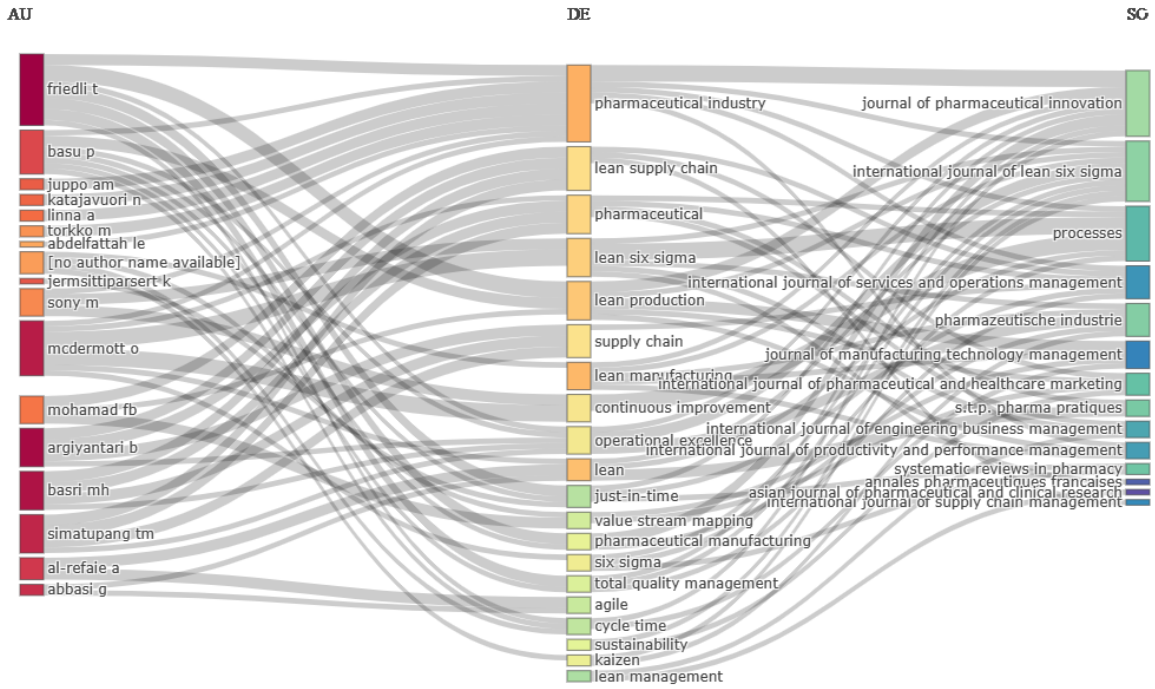

Figure 9: Authors, Themes and Sources

The most important authors and journals related to the implementation of lean in pharma had been determined through the bibliometric analysis already (Figure 5 and Figure 6). Additionally, Figure 9 shows that concrete solutions and applications of lean tools can be found in the literature, but each tool and/or technique is present in only one or two papers. Emerging tools, techniques and concepts are: JIT, Value Stream Mapping, Kaizen, TQM.

The diagram shown in Figure 10 more closely explains the change in focus of research. The x-axis shows the years of appearance of certain keywords, and the y-axis shows the keywords themselves. The diagram also provides information about the frequency of use of a particular keyword.

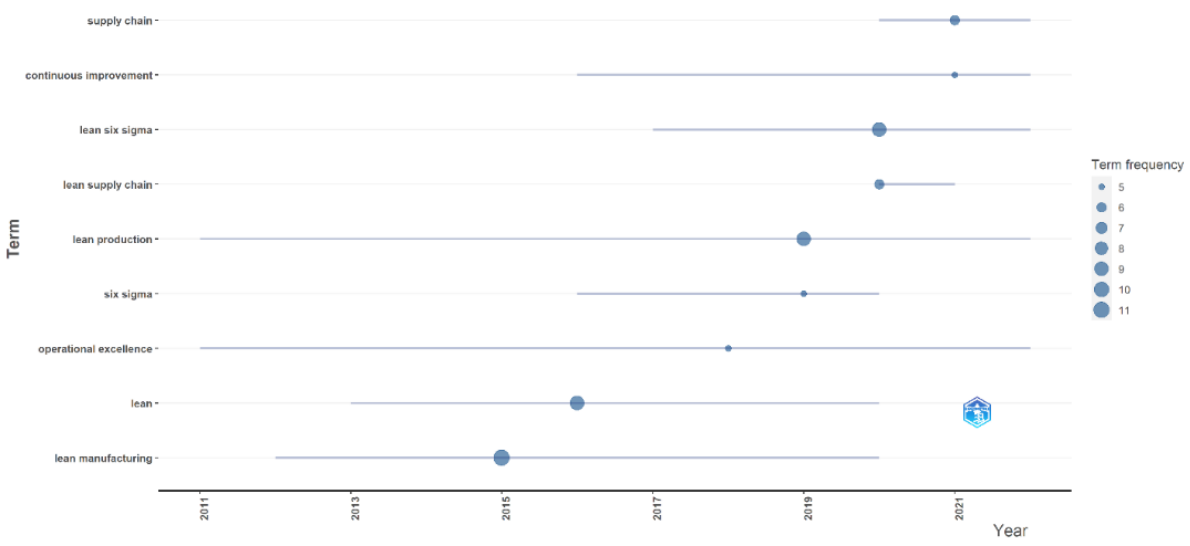

Figure 10: Key terms and their importance

Although Figure 9 shows a vast number of different research topics, Figure 10 confirms that they are not widespread and frequent. Looking at Figure 10, the most repeated topics in research are Lean and Lean Production (in two iterations – as Manufacturing and Production), with 10 and 11 repetitions. All other keywords appear much less. Lean Supply Chains are present since 2019 and appear 7 times, which can be linked to the COVID-19 crisis. The lowest number of repetitions is present in Operational Excellence and Six Sigma methodology, with five each.

4 Conclusion

The bibliometric analysis conducted in this paper has provided valuable insights into the landscape of scholarly research within the Lean in pharma domain. Through the systematic collection, organization, and analysis of bibliographic data, an understanding of the research trends, influential authors, seminal publications, and the overall structure of the scholarly communication network within this field was explored.

The research confirms that the literature is still underdeveloped, leaving a lot of room for future studies in the domain. This analysis revealed several key findings: The existence of two separate bodies of literature; Prominent research clusters around

Ohno and Womack, but the lack of lean-in-pharma-related clusters; Well-developed research networks, but small author footprint. The first published paper in this domain was published in 2004, more than a decade since lean was popularized.

This paper presented trends and patterns in the literature regarding the use of Lean in the pharmaceutical industry. These findings contribute to the understanding of the intellectual structure of the field and can also offer valuable guidance to researchers. It is important to acknowledge the limitations of this study as well. Firstly, the sample size is relatively small for bibliometric analysis. Although this could not be fully anticipated due to the relatively small number of publications, future research should consider including additional databases beyond Scopus. Secondly, this study provides only a high-level, bird's-eye view of the literature. This limitation stems from the nature of the bibliometric analysis, which puts emphasis on citation counts, co-authorship, and keyword frequency does not account for the quality or depth of content.

Limitations naturally guide towards future research. Future research should conduct a deeper qualitative exploration of the literature in order to capture conceptual depth and better understand the contextual nuances.

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