Assessment of the flexibility of implementing lean tools

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Abstract: Lean production has already proved to constitute an effective management philosophy when eliminating time loss in production processes. However, achieving economic results is currently insufficient. In the context of this study, research was conducted on the Web of Science platform in order to identify which lean tools are of most widespread use in the process industry, as well as their associated benefits. The publications obtained from this research were subjected to a quantitative analysis, which revealed that 80% of the documents comprise articles from journals, while only 20% appeared in conference proceedings. Of these publications and articles, 44% were cases studies, 35% consisted of research and 21% corresponds to questionnaires. With regard to distribution by country, it was found that approximately 50% of the documents published were limited to only three countries– India, Malaysia and the United States of America. Regarding the sector of activity, this distribution allowed to observe that the metalworking sector is the most targeted, followed by the textile and automotive areas, with a total of 24, 10 and 10 publications, respectively. This analysis allowed one to establish that the most frequently implemented tool mentioned in the articles is VSM (Value Stream Mapping), with a percentage of 65%. This is followed by 5S, which is also of widespread use, representing 48%, when compared to the total number of publications collected in the Web of Science.

Keywords: Lean Tools, Lean Production, Lean Implementation, VSM, 5S.

1. Introduction

Lean Production aims to reduce costs and eliminate activities that do not add value. Lean production targets eight different types of waste, seven of which are related to the production process: overproduction, waiting, transportation, defects, inadequate processing, as well as unnecessary stock and handling. The eighth waste is associated to the squandering of skills pertaining to the team itself. In this sense, the use of lean tools generates benefits for companies [1]. It should point out that every company’s main objective resides in the rapid delivery of products, at the lowest cost, without compromising quality [2-5]. This goal can be achieved through the adoption of various tools and techniques such as just-in-time (JIT), Kanban, TPM, cellular production and 5S, which aim to reduce cycle time and remove any type of waste in the production process [6-10]. This paper seeks to identify the lean tools which are most commonly used in the process industry, as well as their associated benefits. At the end of this study, one expects to: identify which lean tools make the most significant contribution and produce the greatest impact in the improvement of processes in organizations; determine which lean
tools are most commonly used in different countries and activity sectors; ascertain which scientific journals or international conferences present the largest quantity of studies carried out in the field of continuous improvement by implementing Lean methodology and its tools. This article is divided into four separate parts: section 1 consists of the introduction; section 2 describes the methodology used to carry out this analysis; section 3 deals entirely with the results and discussions; and section 4 presents the conclusions of the study.

2. Methodology
The collection of publications from the Web of Science platform began with the sequence of two keywords, which were inserted in the analysis: "lean tools", which produced a sample of 349 publications (see table 1). This set of articles was then subjected to a second phase of manual research; on this occasion, the analysis was carried out by using the set of words: "lean manufacturing". In this screening activity, the articles that did not contain this combination of words were excluded. After a second screening, the sample was reduced to a total of 121 articles.

| Step | Description |
|------|-------------|
| 1    | Definition of theme |
| 2    | Selection of the type of documents which were possible and eligible for research |
| 3    | Selection of the best platform, and its time period |
| 4    | Selection of terms to research |
| 5    | Collection of articles from the platform Web of Science based on the first research action ("lean tools") – N=349 |
| 6    | Implementation of the manual filter “lean manufacturing” – N=123 |
| 7    | Qualitative and quantitative analysis of the publications collected – N=121 |
| 8    | Synthesis of the conclusions drawn |

3. Results and Discussion
All of the 121 publications were compiled on a table in MS Excel® and were subsequently analyzed.

3.1. Distribution according to the year of publication
Following the categorization of the articles, it was possible to verify that there has been a steady increase in publications from the year 2015 onwards, with the exception of 2019, when a slight drop occurred, as shown in figure 1. It should be pointed out that the first publications registered on the platform only appeared in 2006. One can also observe that the material published between 2016 and 2020 represents more than half of the publications for the period covered, totaling 67%. This corresponds to 81 of the 121 publications, indicating that these are themes which will, in all likelihood, tend to increase over the years.

![Figure 1. Publications by year.](chart-url)
3.2. Distribution according to places of publication

The journal which have published the highest number of articles was “Production Planning & Control: The Management of Operations”, with seven publications. Figure 2 presents the distribution of articles according to their place of publication (journals, magazines, conference proceedings). However, and in order to simplify the graphic display, one restricted journals to those which had issued more than one publication. Accordingly, a total of 71 journals were excluded from the graph. This great diversity of publications indicates that the topic addressed covers an extremely wide spectrum.

![Figure 2. Journal of publication.](image)

3.3. Distribution according to type of publication

With regard to the type of publication, most of the documents, namely 80% (97 out of 121 publications), consisted of articles from journals, while only 20% appeared in conference proceedings (24 out of 121 publications), as is shown in figure 3.

![Figure 3. Type of publication.](image)

The publications were also divided into the following types of research:

- **Case study** – Where the current state of a given company is analyzed, followed by a proposal of the lean tools which are most suitable for the processes involved, with presentation of the results of this implementation;
• Questionnaire – A questionnaire is conducted at several companies, generally in the same sector of activity, so as to ascertain which are the most commonly implemented lean tools, and their respective benefits;
• Research study – This is of a more empirical approach, and is usually supported by a review of literature.

It should be pointed out that there are some cases of questionnaires which were conducted at companies with the purpose of evaluating their current state. However, these types of publications are considered to be case studies, since they constitute the base for subsequent analysis. This distribution is presented in figure 4. Accordingly, 44% are case studies (53 of the 121 publications), 35% are research studies (42 of the 121 publications), and 21% correspond to questionnaires (26 of the 121 publications).

![Figure 4. Type of research.](image)

3.4. Distribution according to country and sector of activity

On analyzing the distribution of publications by countries, as shown in figure 5, it can be observed that approximately 50% of the documents (59 out of 121 publications) are restricted to three countries – India, Malaysia and the United States America. The main reasons behind the top 3 is constituted of these countries is because they are some of the most industrialized countries, and because in this countries there are a strong linkage between the Academy and the Industry, allowing the researchers to perform implementations and analyze the corresponding results, being also possible and interesting to publish these results, disseminating the findings achieved. The tradition of publishing, the need for publishing of the researchers and the type of industry sectors covered by these countries are certainly other factors that empowered the results obtained.

![Figure 5. Distribution of publications by country.](image)
With regard to the sector of activity and excluding those considered "Non applicable" and "Other", the distribution allowed one to observe that the area of highest reference was metalworking, followed by the textile and automotive sectors, with a total of 24, 10 and 10 publications, respectively, as presented in figure 6. Indeed, based on this data, it can be inferred that the subject "Lean Tools" has been addressed in a wide range of industrial areas. “Non Applicable” correspond to works where it is not possible to identify the industry field, and “Other” correspond to sectors not classified in the remaining items described in the graph and, because the number of works published in each field is too small, they were not highlighted in the graph, being put together under the name of “Other”.

**Figure 6.** Distribution of publications by activity sector.

**Figure 7.** Distribution of publications by Lean tools and methodologies.

### 3.5. Distribution according to Lean tools and methodologies

The main objective of this study was to identify which lean tools and methodologies were mentioned most often in the published articles and were consequently implemented in the most varied sectors of activity. Accordingly, and as shown in figure 7, the articles were grouped according to different tools and methodologies. Thus, from the 121 publications, we have analyzed just 95, because the content of the others did not mention the lean tools and methodologies used. Through this analysis, it was possible to conclude that the most frequently mentioned tool in the articles is VSM, with a percentage of 65% of
the total number of publications collected in the Web of Science, which corresponds to 62 in 95 publications. This indicates that the authors attribute great importance to the analysis or mapping of the value stream of industries. Furthermore, this tool is always the first step taken when identifying problems along the production line, as well as when analyzing the current state of product value. Also used frequently, and in second place, is 5S methodology, which is represented in 48% of the publications, corresponding to 46 in 95 publications. This is the tool which is used most frequently by the authors in the context of workplaces (gemba). This shows that, if production is to be efficient, the workstations must be organized in such a way to reduce all types of waste as far as possible.

Table 2 presents some conclusions drawn from a few case studies which discuss the tool referred to most frequently in the publications analyzed: the VSM. It was found to be the most commonly used tool, since it serves as the basis for most case studies, providing information as to the current state of the company.

| Author/Year | Analysis |
|-------------|----------|
| (Choudhary et al., 2019) [11] | A new tool called Green Integrated Value Stream Mapping was implemented (GIVSM), which allowed for gains in results such as: an improvement in environmental performance, with a reduction of 77% in the carbon footprint, as well as enhanced operational efficiency, which led to a 63% reduction in delivery deadlines. |
| (Parab and Shirodkar, 2019) [12] | The implementation of VSM in this case study revealed that waiting time and overproduction constituted the largest sources of waste in manufacture process flow. Due to this study, there was a decrease in production lead time and WIP stock, which amounted to 62.74% and 66.09%, respectively. Additionally, the total distance covered by the component was reduced from 290 to 73 meters. |
| (Deokar et al., 2019) [13] | After the implementation of VSM, the results pointed to a 15% reduction in the time cycle required for the drilling operation, as well as a decrease of 57.46% in induction hardening, and a reduction of 26.4% in the grinding process. |
| (Dadashnejad and Valmohammadi, 2018) [14] | The study results indicated that there was a significant relation between VSM and operational losses in the production processes. The test results demonstrated that, when lean approaches are used - including lean tools and special value stream methods - these will lead to a reduction in operational losses. |
| (Saravanan et al., 2018) [15] | From the results observed, productivity increased from 7 to 10 parts when VSM was implemented, and that total processing time was reduced by approximately 24%. |
| (Andreadis et al., 2017) [16] | The results of this study suggest that benefits such as reduction in lead time, improved productivity, lower cycle times and less stock can only be achieved through the implementation of VSM. |
| (Rahani and Al-Ashraf, 2012) [17] | The case study used VSM as a visual tool to aid in the detection of hidden waste and its sources. |
| (Singh et al., 2006) [18] | The results of this study showed that the total reduction of working time was 16.9%, while machine time was reduced by 14.17%, when compared to the original processing method. An important contribution of this article is that it provides a logical and rational methodology for the selection of VSM tools, which led to the identification of waste in an organization. |

4. Conclusions and future studies

This article summarizes the relationship between the concepts of “lean tools” and “lean manufacturing”. In order to obtain a database to support a study of the concepts, extensive research of scientific publications was carried out on the Web of Science platform. This covered a total sum of 123 publications, which thus provided an impartial view of these concepts. Accordingly, the main objective of this study was to investigate the current state of industrial organizations worldwide, while focusing on lean practices and implementations in their production. A first quantitative analysis was undertaken of the publications obtained. This allowed for a classification of the articles into three main categories, namely: case studies, research or questionnaires. It was also possible to organize the publications into categories, according to their respective sectors of activity, countries, and places of publication. Once this stage was completed, it was then possible to draw conclusions, and identify which lean tools and
methodologies were most prominent, and which were implemented most frequently. It was also possible to determine which sector had been addressed most frequently. As for the main conclusions derived from the analysis, it is possible to mention the following:

- The industrial area with the greatest focus on lean tools is that of metalworking, which is followed by the textile and automotive sectors;
- The most frequently used tool in publications was VSM, with a percentage of 65% (corresponding to 92 out of the 95 publications), followed by 5S methodology, with 48% (corresponding to 46 out of the 95 publications) in relation to the total number of publications collected on the Web of Science;
- VSM always constitutes a first step in the process of identifying problems along the production line, as well as when analyzing the current state of product value.

These data indicate that the authors attribute great importance to the analysis using value stream mapping in organizations, and that this is almost always the first stage in the identification of problems along the production line. Besides this, other aspects of production seem to be equally significant, namely those of storage and the cleaning of workstations, which ultimately lead to a reduction in waste and more productive operations. A proposal for future studies would be to analyze both the level of development, as well as the benefits, inherent to the implementation of lean methodology in the services sector. Due to the fact that this area of activity has been evolving constantly, it would be of great interest to gain an understanding of how processes can be improved, and whether lean thinking would be a good contribution to their optimization.

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