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Lean production and Industry 4.0: Strategy/management or technique/implementation? A systematic literature review

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Abstract

Lean production and Industry 4.0 are two concepts that have been studied in recent years, focusing mainly on the relationship that exist between them. Several authors state that lean manufacturing cannot be efficient without the implementation of Industry 4.0 technologies. For this reason, the aim of this paper is to understand how these concepts can be implemented in a company. Results show that the academic research is divided between two different clusters: (1) strategic/managerial and (2) techniques/implementation.

Keywords: Lean Porduction, Industry 4.0, Clusters, Sistematic Literature Review

1. Introduction

During the last years, there was a growing interest for Industry 4.0 (I4.0) and Lean Production (LP) concepts.

I4.0 is a concept developed in 2011 at the Hannover fair in Germany. The concept is able to offer to the company faster and more flexible processes through the use of ICT technologies [1]. I4.0 predicts a cooperation between private sectors, university and government and it is based on "Networks of manufacturing resources (manufacturing machinery, robots, conveyor and warehousing systems and production facilities) that are autonomous, capable of controlling themselves in response to different situations, self-configuring, knowledge-based, sensor-equipped and spatially dispersed and that also incorporate the relevant planning and management systems" [6]. I4.0 involves the whole production system, from production to service post-sell [22].

Chiarini et al. [8] identify specific strategies for I4.0 which are grouped into four differentiated clusters:

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- ICT and digitalization, which involve all production and logistic;
- Cyber-physic systems, sensors, robot, 3D printing etc.;
- Network communication and integration with Internet of Things (IoT);
- Simulation, Big data and Cloud Computing.

With the implementation of artificial intelligence, the production became dynamic and independent, delivery time reduced, the quality of products improved and it is possible to produce customized and better-quality goods [3, 10, 15, 17].

According to Buer et al. [6], the main objectives of I4.0 are:

- Workplace improvement;
- Reduced delivery time;
- Best quality of products;
- Sustainability.

Although the concept of I4.0 has acquired notoriety for some time, now some companies fail in its implementation. LP is the management technique that has spread, since 1990, in creating efficient processes [20].

It is common among various sectors and it has the aim to eliminate waste from the production process and then to improve and increase the activity flow, increasing the value and quality of the product perceived by customers [38].

Kamble et al. [17] identify the advantages of LP:

- To improve the production;
- To reduce production costs;
- To reduce environmental impact
- To add greater social sustainability.

This technique is simple and efficient and, above all, it is in line with the shared vision of the company [30-33, 35]. Indeed, all employees have to be involved in the production process for becoming able to identify problems and anomalies and find a solution for the problem [30-33, 35-36].

Nowadays, it is still difficult to implement LP within companies because many of them try to use these techniques when it is not easy to use them. Trying to solve this problem, it is necessary to use ICT technologies [6]. This is the reason that led the authors to perform this study, in order to identify the relationship between the I4.0 and LP. These two concepts are able to reinforce each other, in order to develop business opportunities in a more efficient way [10-11, 13-14].

2. The relationship between LP and I4.0

LP and I4.0 are two concepts that are obtaining more and more importance and connection. Many literature studies have been investigating the connection between these two concepts for lots of years.

Tortorella and Fettermann [35] conducted a survey of 110 Brazilian manufacturing companies where they tried to analyze the implementation of I4.0 and LP.

The results of this study were: (1) Companies with extensive implementation of I4.0 technologies also have the predisposition to adopt LP in case of success; (2) The company that decides to adopt LP technique is very likely to apply I4.0 technologies.

I4.0 and LP must be combined because they can add value to customers [5].

I4.0 will affect LP because limits can be exceeded, and new challenges implement. The speed of information sharing allows the company to differentiate itself and have greater competitiveness on the market [35].

I4.0 and LP use standardized control and are capable of increase productivity and flexibility [34].

LP and I4.0 must be studied to verify their effective implementation in the company.

The main goal is to identify two study clusters. The first is called "Strategy/Management" and studies all the papers in which LP and I4.0 are looked at as the strategies to be applied in the company.

The second cluster is called "Technical/Implementation" and analyzes all papers implementing LP and I4.0.

3. Methodology

The paper proposes a systematic literature review (SLR) to analyze the relationship between LP and I4.0. The SLR is based on identification, assessment of particular research issues or study events. SLR is based on the identification, evaluation of particular research themes or study events.

From literature, the SLR process is based on the following steps [23]:

1. Formulation of research question (Section 2);
2. Collecting of materials: identification of materials and units of analysis (Section 4).
3. Descriptive analysis: evaluation of collected materials (Section 5).
4. Selecting of categories: identify the categories and size of the study (Section 6).
5. Material evaluation: evaluation of defined categories and dimensions and obtaining research results (Section 7).

The SLR process is shown in the following Figure 1:

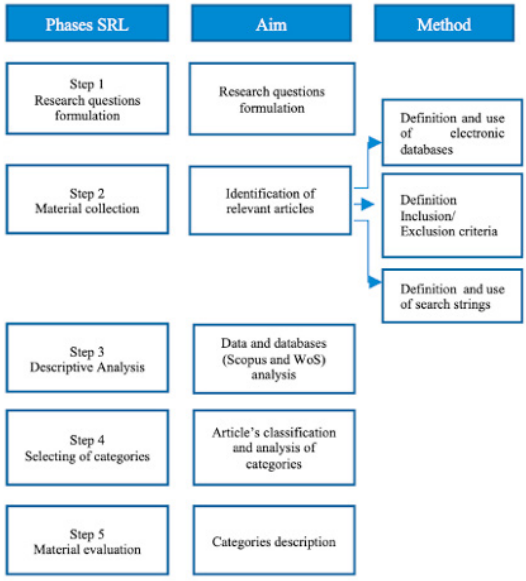

Fig. 1 Revision process. Authors' elaboration

4. Collecting of materials

The collection of materials was carried out through two databases: Web of Science (WoS) and Scopus. On WoS the search was made according to the topic instead on Scopus the research was conducted for "*Title, keywords and abstract*".

The search was performed on March 27, 2020. The considered keywords are I4.0 and LP and the selected documents types were articles.

In Scopus, 52 articles have been identified, selecting "Engineering", “Business, Management and Accounting”, “Computer Science”, “Decision Sciences” e “Economics, Econometrics and Finance”. In WoS, the following keywords I4.0 and LP have been used, and 47 articles have been identified.

Subsequently, more in-depth research was conducted and only 15 articles of the previous 47 have been selected.

The articles identified by two datasets have been compared for the elimination of duplicates which were 6 in all. On the study database, where 25 articles have been collected by Scopus and WoS have been reported.

The following figure (Figure 2) shows the identification of relevant articles process.

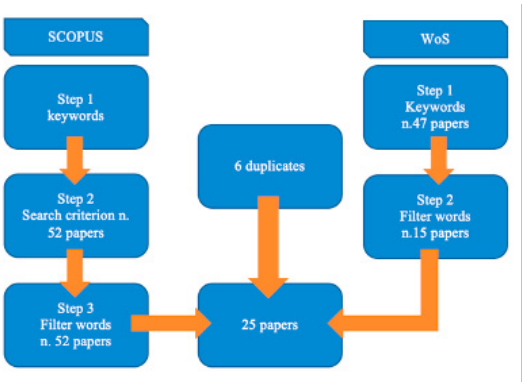

Fig. 2 Identification of relevant articles process. Authors elaboration. Authors' elaboration

5. Descriptive analysis

Through the descriptive analysis, it was possible to carry out a descriptive-quantitative analysis on the completeness of the available data. 25 articles collected by Scopus and WoS were reported on the study database. Analyzing the dataset, it is possible to note that the study about I4.0 and LP is growing, indeed in 2019 the largest number of publications is related to these topics (Figure 2).

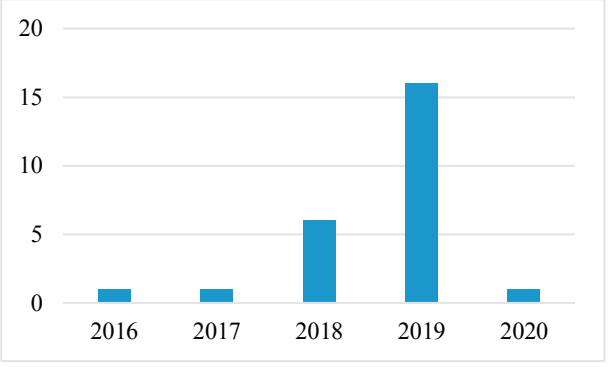

Fig. 3 Number of publications for years. Authors' elaboration

"International Journal of Production Research" is the journal with the major number of publications of these topics (7), followed by ”Journal of Manufacturing technology management” (2) and IFAC-Papers online (2). Figure 3 shows the number of publications for years.

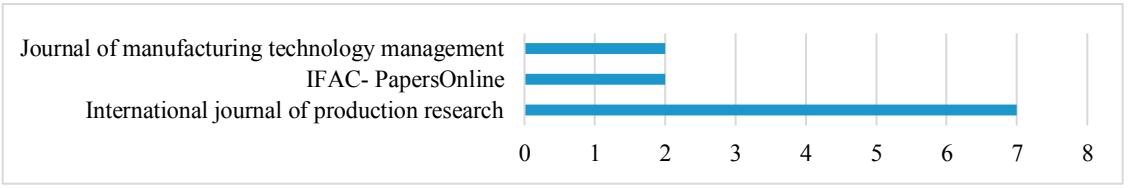

Fig. 4 Publications for Journal. Authors' elaboration

6. Selecting categories

In this section, literature is analyzed in detail. Table 1 shows the categories identified for this search.

Some categories were defined through a partial analysis of documents, while others were identified after a further detailed analysis. In particular, Table 1 shows, for each category and structural dimension, the considered approach, which can be inductive or deductive.

Table 1 Structural dimension and analytical categories. Authors' elaboration

Structural Dimension	Analytical Categories
Methodological Research	Review Survey Case Study Focus Group
Cluster of research	Strategy Technical
Sector of industry	Manufacture Multiple Bike industry
Country of first Author	Brazil China Croatia France Germany India Italy Japan Namibia Norway Portugal Sweden Taiwan Turkey

7. Material evaluation

7.1. Methodology research

Methodological Research is the first dimension analyzed. Figure 4 shows the classification of the articles according to identified categories.

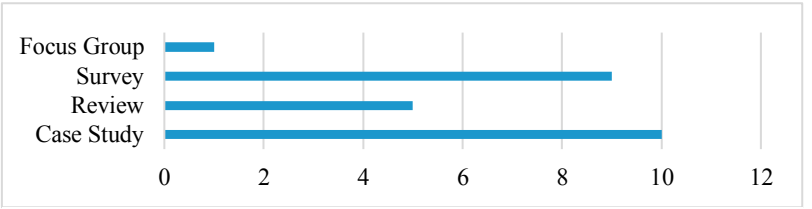

Fig. 5 Research methodologies employed. Authors' elaboration

The articles analyzed were “Case Study” (10), follow “Survey” (9), “Review” (5) and “Focus Group” (1).

7.2. Geographical focus

The geographical origin of articles was obtained considering the country of the first author (Figure 5).

The analysis shows that Brazil is the country with the highest number of papers (6 papers, which correspond to 24% of the total), followed by Italy (6 papers), Germany and Norway (2 paper for country).

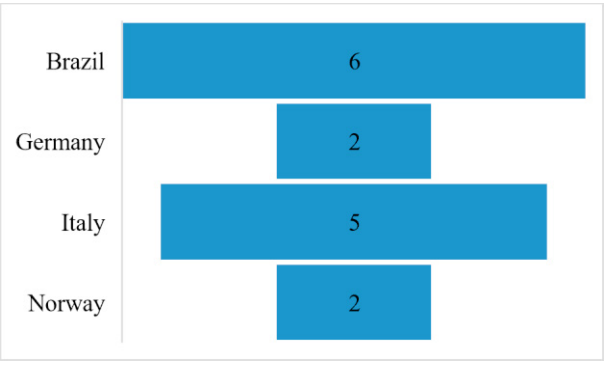

Fig. 6 Country of origin first Author. Authors' elaboration

A more detailed analysis for the origin of articles shows that the 52% of articles have European origin; 24% of the literature originates in America, 20% originates in Asia and finally, the remaining 4% of literature has African origin (Figure 6).

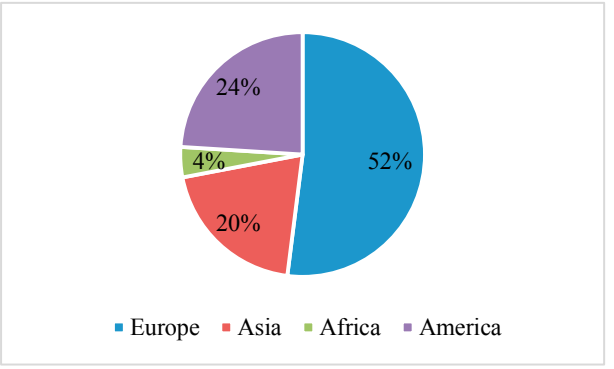

Fig. 7 Continent of origin first Author. Authors' elaboration

7.3. Cluster

By analyzing the available papers, it's possible to identify two different study clusters.

The first cluster considers all cases in which LP and I4.0 are applied as the management strategy that is adopted in the companies and the cluster is called "Strategy/Management".

The second cluster includes all cases where LP and I4.0 are implemented in the companies and its name is "Technical/Implementation".

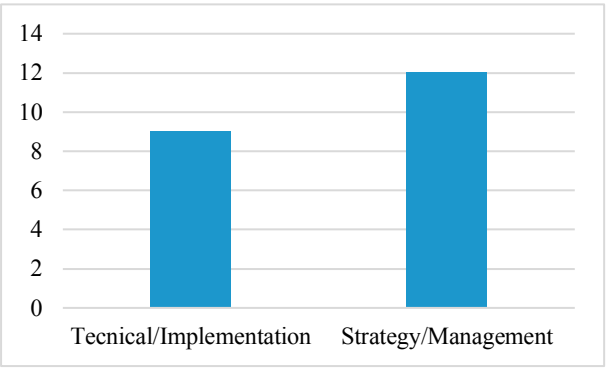

Fig. 8 Clusters. Authors' elaboration

In the last image, the largest number of articles is identified in the "Strategy/Management" cluster (Figure 7).

Most of papers analyze the relationship between LP and I4.0 and their application in the companies' results. In some cases, to understand the relationship between two concepts, a survey was conducted to understand how LP and I4.0 influenced the companies.

In other cases, systematic analysis was conducted to verify the implementation of these concepts. Other studies conducted, demonstrate the importance of LP and I4.0 applications by identifying new application models such as "Lean Automation", "Lean Management" and "Lean Smart Manufacturing".

I4.0 and LP were also studied individually in all their aspect to identify improvements.

8. Discussion

In this section, results obtained from the conducted study are discussed. The analysis of the paper (limited to the analysis of the sample) shows a greater involvement over time between the concepts of I4.0 and LP.

Nowadays, the literature available among the concepts is not sufficient and the fields of application of these tools are not always available. However, we can identify the advantage of applying these concepts.

As we know, LP has some limitations, such as the volatility of demand and the poor customization of the product. Through the application of I4.0 technologies to the production process, it will be possible to make the lean production an effective system, as well as remove its limitations and make the technique more effective. The combination of techniques allows companies to be successful because technology and man will work together.

The analysis shows that the literature relating the I4.0 and LP is increased over the years, indeed in 2019 there is the highest number of publications. Articles took place in various journals, including the "International journal of product research". From the analysis of papers, structural dimensions and related analytical categories were identified. Structural dimensions identified are: 1) methodological research, 2) research cluster, 3) industrial sector and 4) country of the first authors. The considered articles are mainly case studies and surveys. As already announced, the articles I4.0 and LP are integrated into the company as a managerial strategy. The sectors analyzed in the articles are manufacture, multiple and bike industry. The country of origin rank of the first author sees Brazil, followed by Italy, Germany and Norway.

Further studies on these issues are needed for allowing an efficient implementation and to better understand their current popularity as managerial strategy.

9. Conclusion

The aim of our research was to analyze the concepts of I4.0 and LP. After the study, two different study clusters have been identified and analyzed: “Strategic/Management” and “Technical/Implementation”. The analysis carried out shows that the cluster with the greatest number of documents is "Strategic / Management". Companies have applied the concepts of i4.0 and LP as managerial strategies.

Research has some limitations. First of all, few keywords are used to conduct the research, which has led to a narrow analysis on the topics. Second, there were few papers available, so the search process produced few results.

For future research, it is necessary to broaden the present research with a greater number of keywords, linked however to the concepts of LP and I4.0.

It will be necessary to repeat a new search, increasing all the new articles that were published after March 27, 2020.

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