Lean Green Tendency: A Systematic Literature Review

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Abstract. Lean philosophy and Green practices have been identified as management approaches that allow organizations to reach better economic and environmental results. Nevertheless, some authors argue that these results can be enhanced with the Lean and Green practices integration. This synchronous effort has led to developing a new Lean philosophy branch, the Lean Green. Through a systematic literature review, this work aims to deepen the Lean Green state of the art, as well as to understand how companies have adopted this approach. The results showed that Lean Green is still an emerging theme in scientific research, with an increasing trend of publications in the last six years in worldwide, adopting distinctive research strategies. Companies' main motivations and barriers to adopting Lean Green were also identified. Finally, as practical implications, were identified a set of key factors that could help organizations to adopt Lean Green, namely critical implementation factors, facilitator models and tools, as well as the main results and advantages obtained.

Keywords: Lean, Lean Green, Systematic Literature Review

1 Introduction

Nowadays, environmental concerns and the importance of sustainability are becoming increasingly relevant and the target of the whole society's attention. Since then, it has established itself as a key societal issue, deserving much attention from academics, government entities, and organizations (Ershadi, M., Qhanadi, O. & Hadji, M., 2021). Furthermore, as a response to climate change, and the challenges inherent to it, companies are committed to finding solutions to combat these environmental concerns through business management, interactions with stakeholders, thus enhancing the development of green practices and their social responsibility (Candrianto, C., Aimon, H. &, Sentosa, S., 2023).

The Lean Philosophy arises from the need for change and the desire to improve the entire process of an organization, based on the “Toyota Production System” which aimed to provide better product quality to the customer, at the lowest cost and in the shortest time delivery, by reducing waste, developed by Taiichi Ohno (Ohno, T., 1988). Subsequently, and with the publication of the revolutionary book “The Machine That Changed the World”, the term Lean Methodology spread as a form of management, and

a way to achieve continuous improvement and optimization of production processes. (Womack, J., Jones, D. & Roos, D., 1990).

Thus, Green and sustainable goals are increasingly part of the work agendas of manufacturing companies, having developed different types of efforts (Garza-Reyes, A., Yu, M. & Kumar, V., 2018). Therefore, adopting Lean and Green practices could boost sustainable organizational performance (Kovilage, 2021). However, several authors argue that implementing Lean and Green methodologies should follow an integrated and synchronous methodology. In this way, organizations can achieve a greater competitive advantage than when Lean and Green are implemented separately (Mittal, V., Sindhwani, R. & Kalsariya, V., 2017). As a result of this integration, an emerging branch of Lean philosophy appears called Lean Green (LG). This integration has as its main objective to improve processes at the operational level, reducing costs not only by reducing and limiting non-value-added activities but also physical waste derived from the system, which consequently ends up reducing the organization's ecological footprint (Garza-Reyes et al, 2018; Kovilage, 2021).

Still, implementing these integrated strategies takes work, and some barriers must be overcome for these practices to be successfully implemented (Singh, R., Gohil, A. & Shah, D., 2016). Thus, the main work´s aim is to contribute to deepen the LG knowledge at two distinct levels:

- Aim 1 - academic research: to characterize the state of the art of LG in scientific research field, namely, to identify trends, types of publications, and the most prevalent research methodologies and strategies;
- Aim 2 - practical perspective: To deepen the knowledge about LG in companies' implementation perspective, such as understanding the motivations for its adoption, identifying the tools adopted, critical success factors, barriers to its implementation, results, and advantages achieved.

To this end, a mixed research methodology was followed, with quantitative and qualitative data analysis supported by the development of a systematic literature review.

This paper is organized into five sections. The first section is the introduction, followed by presenting the systematic literature review methodology performed. In the third section, we find the literature review, analyzing the themes of Lean, and LG as well as how they are associated. Finally, section four presents the result analysis and discussion, then the conclusion with the research's limitations as well as proposals for future work.

2 Methodology

A concrete methodology is essential for research success, allowing for achieving the proposed objectives more effectively. Initially, we proceeded with a narrative literature review to support the conceptual foundation for understanding and framing the topic: LG.

Then, a systematic literature review was developed based on the guidelines of Denyer and Tranfield (2009) which define three main stages:

Stage 1- Planning the review, allowing a discussion of the objectives and the main research questions as shown:

- How has LG been studied in the scientific research field? (Aim 1: state of the art of LG)
- How have organizations adopted LG? (Aim 2: companies' implementation perspective)

Stage 2 – Data gathering: identifying, selecting, and synthesizing data from the relevant literature using an explicit and replicable criterion for inclusion and exclusion of documents. This step was performed at two levels, a broader one to answer the first research question. The documents were collected in the Scopus database since this database is globally recognized for covering multidisciplinary fields. It should be noted that this database is made up of a large number of different publications, such as articles, reviews, book chapters, etc. Therefore, Scopus is a database with a selective approach to indexing documents (documents from a pre-selected list of publications). This database also stands out for offering advanced search and filtering features, which allow the development of more complete systematic reviews of the literature. (Martín-Martín, A., Thelwall, M. & Orduna-Malea, E., 2021). The table below describes all the steps for the first document gathering database.

Table 1. Steps for first level of data colleting

Steps	Total of Documents	Excluded	Selection criteria
1st – location on Scopus database	212	--	Title, Abstract and Keywords: "Lean Green"
2nd – Period	210	2	By 2022, as it is the intention to analyse complete years for a comparative analysis
3rd – Scientific areas	178	32	We selected the three most representative areas and the areas most related to the conference theme: Engineering; Business, Management and Accounting; Environmental Science
Document Type	155	23	Considering the first research question, the documents were limited to articles, conferences and review
Specific keywords	113	42	Limited to the following specific keywords; "Sustainable Development"; "Lean"; "Sustainability"; "Green"; "Green Manufacturing"; "Lean Production"; "Lean Manufacturing"; "Lean Green"; "Lean and Green"; "Lean Management"; "Lean-Green"; "Lean-Green"
Source	103	10	we considered only documents from Journal and Conference proceeding
Idiom	103	0	All in English
Publication Stage	102	1	one "article in press" was excluded

Subsequently, a more refined selection was made, adopting additional selection criteria to answer the second research question since its focus is at a microanalysis context directly linked to companies. At this level, we considered only the period previously demarcated as growth trend, i.e., from 2016 to 2022, gathering 95 documents as the second research question focuses on the business context, the following subject areas were excluded: Decision Sciences Computer Science Mathematics Economics, Econometrics and Finance Earth and Planetary Sciences Agricultural and Biological Sciences, Materials Science Medicine, building a database with 25 final documents.

Stage 3 – Data analysis: the LG state-of-the-art was supported in the bibliometric Scopus results. Then, a content analysis of the document's abstracts was also performed to understand the research methodologies applied in the LG area. Finally, concerning how companies have adopted and implemented LG, each author conducted a content analysis according to the following categories: Motivations; Models and tools; Barriers, Critical factors, results, and advantages. Once the 25 articles were read and analyzed in detail, some led to the "snowball" effect selecting other publications that have contributed significatively to the second research question of this work.
The data analysis and discussion are described in section 4.

3 Theoretical Foundations

3.1 Lean Philosophy

After the end of the second world war, due to the scarcity of resources such as workforce and materials, Toyoda, the president of the automobile company Toyota, together with Taiicho Ohno, developed a system named "Toyota Production System" (TPS). This system was able to address the difficulties of that time successfully. Over the last few decades, the Lean concept has been extended to other production companies as well as the service industry. Its main objective is to eliminate wastes detected across the production process. By waste, it means all activities that do not add value to the final product (Kovilage, 2021; Taj & Berro, 2006; Womack, et al, 1990; Zenchanka & Malchenka, 2018). The following types of waste are, therefore, identified: defects, waiting timing, excessive movements, excessive production, inventory, excessive processing, and transportation (Kovilage, 2021; Singh et al., 2016).

As a management tool, the Lean philosophy supports several types of industries, through the maximum reduction of waste, intending to increase product value via optimization of the production processes (Danese, P., Manfè, V., & Romano, P., 2018). The objective is to reduce waste while attending to the client's request with minimal costs and time (Bhamu & Singh, 2014).

Lean, as a management philosophy, is based on the following five principles (Womack, J. & Jones, D., 2003): 1-Value creation: product/service value is defined by the client; 2 - Value flow: identification of all actions, requirements, or necessities that the product requires to reach the client; 3- Optimization of value flow: bring fluidity to all steps of the company's production flow; 4- Pull system: the order to start the production is only given with the quantities that the final client wants; 5- Search for perfection: always do more and better. Afterward, with the changes in organizations'

necessities, two more principles were identified: 6- Stakeholders identification; 7- Continuously innovate (Pinto, 2014).

The Lean philosophy also considers a set of tools and techniques that look for waste elimination, contributing to the organization's continuous improvement (Ahmad, S., Abdullah, A., & Talib, F., 2021; Kovilage, 2021; Singh et al., 2016; Womack, J. & Jones, D., 2003). Adopting Lean practices allows the reduction of human effort, stock quantity, and product development time, also allowing the increase of energy efficiency. One can mention the positive results of implementing the Lean philosophy: the consumption of fewer resources, the implementation of quality improvement programs, and the reduction of reworks (Ershadi et al, 2021; Zhu, Q., Johnson, S., & Sarkis, J., 2018).

3.2 Lean Green

The Lean and Green practices contribute to managers reaching better economic, social, and environmental performance for the organizations. Green practices include the integration of ecological thinking in supply chain management, including product design, the search and selection of materials, production processes, the final delivery of the product to the consumer, and the product's end-of-life, considering all product life cycle (Singh et al., 2016).

The concept of LG was created to answer the problem of integrating Lean and green. The benefits of this integration are better environmental quality, lead-time reduction, production cost reduction, and improved relationships between customers and suppliers. LG works as a tool to reach the maximum exponent of sustainability once it allows the interaction between all sustainability components, bringing several organization benefits. As a result of integrating Lean and Green systems, a strategy emerged, that may help companies reach better economic and environmental performance. Recent studies have advocated that this integration benefits companies implementing Green and Lean practices (Singh et al., 2016). Green production can be characterized as reducing waste and increasing the efficiency of production processes. Therefore, this consists of a shared objective between the economic side, where Lean focuses on production, and the ecological side, where we can find the sustainability approaches (Dieste, M., Panizzolo, R., & Garza-Reyes, J., 2020). To summarize, the main objective of LG is to improve operational activities while simultaneously improving environmental efficiency (Kuppusamy, B., Bangaru, M., Santhanam, S., 2017).

4 Results analysis and Discussion

Concerning the main goals set, in the first place we present the results of the Leen Green state of the art, trying to identify trends, types of publications, and the most prevalent research methodologies used to investigate this emergent concept. Then, in point 4.2 we discuss the second goal regarding practical perspective, namely identifying the main tools adopted, critical success factors, barriers, and advantages achieved by LG implementation.

4.1 How has LG been studied in scientific research?

Based on the criteria for gathering documents in Scopus, a list of 102 articles was compiled, with publishing evolution throughout time as shown in the figure below.

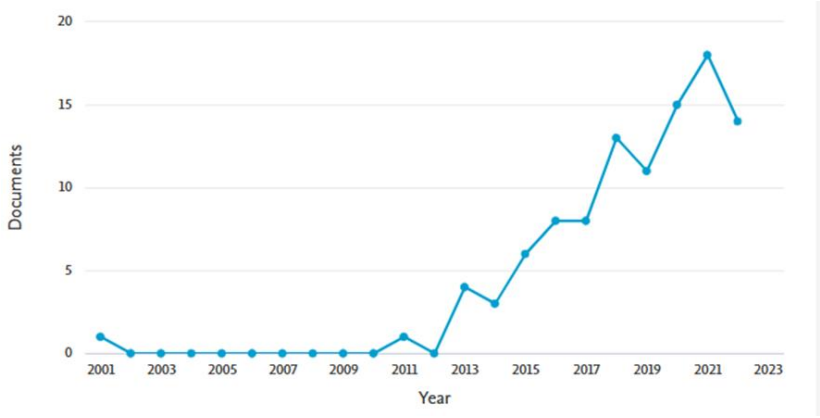

Fig. 1. Nº of publications per year in the Scopus

The first publication was in 2001 to investigate the relationship between Lean Manufacturing (LM) practices and environmental performance in the automobile assembly industry (Rothenberg, S., Pil, F. & Maxwell, J., 2001). In the subsequent decade, there were no publications on the LG subject, with a slight increase in interest by the end of the first decade of 2000. However, the exponential growth in LG publications emerged from 2016 onwards.

Considering the areas classified in Scopus, it was found that "engineering" leads the list with 26.3% of total selected publications, after Business, Management and Accounting, and Environmental Science.

The subject has also aroused interest worldwide, with publications in Asia, Europe, and America. However, with a more significant number of works developed in India. It is also interesting to highlight Portugal's 3rd position, which is relevant to the current economic development context.

The research methodologies around the subject LG has been developed through different strategies, namely literature review, case study, focus group, and surveys. Various authors (Marques, P., Carvalho, A., & Santos, J., 2021; Teixeira, P., Sá, J., & Silva, F., 2021; El, A., Arif, J. & Azari, M., 2022; Queiroz, Junior & Melo, 2022; Zekhnini, K., Cherrafi, A. & Bouhaddou, I., 2022) have developed theoretical foundations through literature reviews with different objectives and strategies. For example, Queiroz et al (2022) extracted document through latent Dirichlet allocation (LDA), and the main results revealed that digitization is a facilitator for Lean and Lean-Green. Other authors seek to identify the contributions of Internet of Things (IoT) to sustainable supply chain management (SSC) through a systematic review of existing literature. El et al, 2022; Zekhnini *et al.*, (2022) reviews the relationship between digital technologies, Lean, Green, Sustainability, and supply chain performance. Teixeira *et*

al., (2021) performed a structured bibliometric literature review focused on the link between Lean, Green and Sustainability concepts. Malesios, C., De, D. & Moursellas, A., (2021) conducted a systematic literature review of 58 articles published between 2005 and 2018 in leading journals.

The development of case studies has proven to be a strategy adopted by several authors. Martinho, R., Lopes, J. & Jorge, D., (2022) developed a case study contributing to a gap in integrating the Internet of Things in Continuous Improvement processes, especially to facilitate diagnosis and problem-solving activities concerning manufacturing workstations. (Thekkoote, 2022) conducted a case study in a multinational retail company, aiming to improve both operational and sustainability performance. Marques, et al (2021) developed a pioneering case study, one of the first publications concerning the application of Lean management in the food retail sector to improve both operational and sustainability performance. Schmitt, T., Wolf, C. & Lennerfors, T., (2021) aimed to understand the complementarities and conflicts between Lean and circularity throughout a case study.

In the empirical research supported by surveys, the authors Waqas, M., Honggang, X. & Ahmad, N., (no date) measured green total factor productivity (GTFP) based on panel data for 68 provincial-level cities in China from 2006 to 2019. In addition, Fatima E., Rachid & Guio, R., (2022) collected data from 210 manufacturing organizations and relied on the structural equation modeling technique to examine the direct effect of Lean practices on sustainability with green production as a mediating variable.
Kovilage, (2021) through a focus group of 15 experts used the interpretive structural modeling (ISM) technique to explore the interactions between Lean practices, green practices, and sustainable organizational performance measures.

4.2 How have organizations adopted LG?

In this section we are looking for a more comprehensive understanding of the practical application of Leen Green, trying to highlight motivations, tools, critical success, barriers, and advantages for organizations.

Motivations for LG implementation

Companies right now are increasingly aware and fulfilling ecological measures, some imposed by legislation, others of voluntary decisions that come from their social responsibility, client, and market pressures. As a result, companies are looking more and more to implement “greener” management strategies, reducing waste, and opting for more ecologically efficient processes (Al-Swidi, A., Al-Hakimi, M. & Gelaidan, H., 2022). Organizations that implemented Lean and Green practices achieved better results than if they focused on just one initiative. This is because the integration of Lean and Green practices has a greater impact on organizational performance when implemented together. (Cherrafi, A., Garza-Reyes, J. & Kumar, V., 2018).

It is also evident that companies have been opting to be pro-environmental since this option presents several advantages to the organization, such as: increased productivity, costs minimization, environmental protection, consolidation of a good

public image and improvement of the long-term financial performance (Al-Hakimi, M., Al-Swidi, A. & Gelaidan, H., 2022).

The awareness raising on sustainability management (its benefits and consequences) is a fundamental factor since management commitment is the central pillar for any management practice's implementation and success (Candrianto et al., 2023). The necessity to improve environmental performance due to the rising energy costs, pollution, and global warming, has been present in companies' agendas (Thekkoote, 2022). Moreover, in this era of fast technologic improvements, growing environmental awareness and depletion of resources, there is an urgent necessity to improve the use of raw materials and available services, so that the main objectives, such as the cost-benefit ration and quality improvement, may be accomplished (Ahmad et al., 2021). The integration of Lean and Green suggests a new approach to economic and environmental issues. In this way, an innovation process is required to maximize the impact of the effects of this LG synergy and allow companies to be more competitive and economically sustainable (Cherrafi et al., 2018).

LG Manufacturing is a philosophy to be followed by small industries to define a strategy focused on sustainable development since the Green aspect allows the organization to fit into fields more directed towards the sustainable aspect such as legislation, certificates, conscious use of raw materials. In turn, Lean stands out in the operational aspect, and process optimization since they provide the reduction of waste, which also falls under the Green aspect. Thus Lean and Green, when implemented together, potentialize positive organizational productivity impacts (Innovation, 2018).

Different studies show that the integration of Lean and Green practices implies benefits in terms of profits, quality, while at the same time reducing the environmental impact (Schmitt et al., 2021). Lean and Green, when integrated, increases revenue and improves company image by combining Lean production with a "green" manufacturing strategy. Companies can thus decrease costs and risks, increase revenue and enhance brand image (Pérez, P., Pérez, R. and Paz, M., 2022).

Models/Tools/practices adopted for LG implementation

LG practices become essential for organizations looking for competitiveness and environmental sustainability (Zhu & Zhang, 2020).

From the analysis of the selected documents, we identified several recommendations and contributions at different levels so that organizations may understand how to adopt LG, from more holistic and integrated models focused on Lean principles and sustainability issues.

The authors Kuppusamy et al., (2017) developed the Lean-Green Resourced Person (LGRP) model, which focused on integrating Lean and Green practices to help organizations study and implement Lean-Green strategies in their operations. This model will lead the organization to adopt Lean-Green practices, reducing consumption time. In addition, the integration and implementation of the Lean-Green techniques have a unique and original approach, since they defend that Lean-Green practices begin with identifying employees and their intervention and influence area (Kuppusamy et al., 2017).

A hybrid implementation model for LG with LM, denominated Lean–Green Manufacturing System (LGMS) was proposed by the authors Mittal et al., (2017). This system will lead to holistic improvements in the existing productive efficiency models, since it will be possible to reduce more waste compared to a single methodology.

The implementation of practices that relate LG with the supply chain allows the organization to achieve better economic, social and environmental performance. It is important to emphasize that the benefits of implementing these practices in the supply chain include cost and lead time reduction, better relationship with stakeholders, which also leads to improved environmental quality (Cherrafi et al., 2018).

Another tool was Green Lean Six Sigma (GLS), referenced as a comprehensive method that aims to reduce waste and process variation, decreasing the negative environmental impact during the life cycle product (Thekkoote, 2022). In LG, the employees use fewer natural resources and follow the 3R principle (reduce, reuse, recycle), leading to moderate waste emissions (Ahmad et al., 2021).

It is also important to mention that the Lean approach is explained through the standard ISO 14001: Environmental Management System (EMS) in the vast universe of ISO standards. This standard consists of an environmental normalization that assists in more efficient business management while keeping the commitment to protect the environment. Therefore, it makes sure that a company utilizes its resources and energy sustainably, allowing it to reduce costs through Green practices (Ahmad et al., 2021; Kovilage, 2021).

Several studies have shown evidence that the quality management systems' practices (QMS) are facilitators of the environmental management systems to obtain greater returns from these practices. The synergies between quality and environmental objectives have contributed to evolutions in both these fields (Garza-Reyes et al., 2018).

Barriers to LG implementation

Although both philosophies, Lean and Green, provide a competitive advantage to organizations, companies with little experience in management tools present resistance to implementing these practices. In this case, the role of top management is crucial to the success of its implementation. Coordination problems between the organization's various departments and poor communication present significant barriers when implementing the practices mentioned above (Singh et al., 2016).

However, in many companies, efforts are made isolated, justified by the need for more communication in their various departments, which implies a considerable overlap of efforts and expenses. Therefore, it is possible to overcome this obstacle by cross-synchronously implementing measures and practices (Kovilage, 2021). Poor employee training and their low ability to learn new techniques and work methods are also barriers. Therefore, the organization's Human Resources (HR) involvement is crucial to implementing Lean and Green practices (Singh et al., 2016). It can also be presented as a limitation, the result of Lean and Green approaches being time-consuming. Sometimes, it may take years before significant results can be found.

The LG Management system analysis detected barriers that prevented it from being fully implemented. Some examples include reluctance to interrupt production, low consumer consistency, limited resources available for production, inadequate

regulatory framework, resistance to change, and inadequate employee involvement and organizational structure that is not prepared for change (Kumar, V., Rahul, M., & Kapur, S., 2016).

The mentality of the organizations presents itself as a challenge in implementing Lean and Green practices since, in some instances, there needs to be a better understanding of the concepts by the organization elements (Innovation, 2018).

Critical success factors for LG implementation

The authors Ahmad et al. (2021) attempted to identify the drivers of green innovation implementation by studying the relationship between organizational performance and company competitive advantage, considering the impact of management commitment and Human Resource (HR) practices. They also found that the interest and purpose of implementing the Integrated LG System increased surprisingly with employee involvement, as both approaches lead to reduced waste and product cost, while continuously improving the quality of products and processes (Ahmad et al., 2021).

HR are a key resource for achieving sustainable development of companies. The employee's management efficiency and validity is an index for measuring sustainability (Zhu & Zhang, 2020).

Resource constraints, such as energy or water in small and medium-sized businesses, have proven to be a critical factor in developing Lean and Green practices more systematically and continuously (Innovation, 2018)

LG results and benefits

Green production is characterized as a method that minimizes both waste and pollution. It aims to modify conventional production practices to make them greener and more energy efficient. Several studies show that the integration of Lean and Green practices in production implies that companies obtain benefits in terms of profits and quality while minimizing environmental impact (Innovation, 2018).

Green production is an integrated method that targets all waste streams related to the design, manufacturing, use, and disposal of products and materials. Additionally, LG practices are considered a comprehensive method to simultaneously reduce the negative environmental impact and produce standardized products. A well-designed system can reduce operating costs and increase product value by using raw materials, energy, and labor more rationally (Thekkoote, 2022).

As a result, when applied together, Lean and Green techniques can provide companies with better results than would be possible if they were being applied individually.

The coordination of LM and Green practices can bring benefits to organizations, such as reduced costs, reduced lead time, improved process and environmental quality, and increased employee commitment. Thus, LM practices could positively impact sustainable performance (Thekkoote, 2022).

Lean and Green, when integrated, increases revenue and improve the company's image by combining Lean production with a "green" manufacturing strategy.

Implementing Lean and Green thinking practices in the supply chain is also noted as an advantage. As a result, comes to the Product- Services - System (PSS) is developed to drive both business excellence and environmental sustainability.

5 Conclusion

Companies should be responsible and aware of their environmental implications and, in parallel, enhance their competitiveness. In this respect, LG management can be a valuable tool for achieving environmental objectives by mitigating the environmental impacts of industrial activities (Dieste et al., 2020).

The results from the systematic literature review revealed that the integration of Lean and green is an emerging topic, with significant growth in the last six years, from a worldwide perspective. It was further verified that the research has been carried out mainly in Engineering, Business, Management and Accounting, and Environmental Science. This research area has been developed through different strategies (literature review, case studies, surveys), each of them providing different contributions. The literature review emphasizes the importance of the digital era, attempting to understand the role of Information Technology (IT) in the consolidation of the LG approach. Case studies were developed to demonstrate the relationship between Lean management and sustainability performance, in several sectors. In turn, research surveys have contributed to the definition of indicators that allow evaluation of the impact of green practice on productivity, as well as the role and impact of LG on organizational sustainability performance.

From the practical lens, the results showed that not only legal requirements and market pressures are motivating organizations to implement LG. Additionally, but there is also a pro-environmental attitude that fosters the awareness that LG, when implemented simultaneously, leads to better organizational performance. To consolidate this integration, several holistic and hybrid models were identified, namely: LGRP (Kuppusamy et al., 2017); LGMS (Mittal et al., 2017); GLS (Thekkoote, 2022). Notably, there are studies that point to EMS and QMS as facilitators of Leen-green integration.

However, in this LG journey, organizations are faced with obstacles due to a lack of experience, lack of coordination, and communication between departments. Thus, it is important to develop strong top management support, cross-synchronous implementation measures, as well as LG management training.

The main limitation of this paper is the fact that it was considered only the Scopus database. Thus, we intend to deepen this research, expanding the scope to other databases. It is also intended to further develop the LG state-of-the-art, using content analysis and bibliometric analysis software to enrich the results, increasing the knowledge of LG.

As a future research path, it would be interesting to deep LG in Industry 4.0, to better understand the role of IT in this paradigm.

In summary, lean manufacturing practices and green practices improve the company's performance with the environment, so Lean and green production together increase the organization's efficiency and competitiveness (Ahmad et al., 2021).

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