# Relationships Between Lean and Sustainability Manufacturing : A Literature Review

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## Abstract

The Manufacturing Industry is not only required to continue to increase productivity but must fulfill products that are environmentally friendly both in terms of raw materials, processes and finished products must produce impacts that do not damage the environment. The purpose of this paper is to explore and present the relationship between lean manufacturing and sustainability manufacturing. Specifically focusing on identifying and analyzing existing literature to see gaps and see future research opportunities. This paper also looks at lean manufacturing from a TBL (Triple Bottom Line) perspective, namely an economic, social and environmental perspective.

## Keywords

Literature Review, Sustainability Manufacturing, Lean Manufacturing

## 1. Introduction

Over the past few years, there has been increasing pressure on organizations to manage production processes responsibly to improve their environmental and social performance (Siegel et al. 2019). In the manufacturing industry, almost all manufacturing industry players are now taking steps to commit to sustainability, especially in operations and following their own methodologies to achieve their respective company's sustainability goals (Gupta et al. 2018). To eliminate waste, streamline processes, and increase added value, it is important for contemporary manufacturing organizations to implement lean manufacturing and of course this concept is beneficial for achieving sustainable benefits (Ben Ruben et al. 2019). Company leaders are also not only required to increase financial strength and social benefits but there is an urgent need to reduce the negative environmental impact of manufacturing industrial activities, one of the systems for implementing quality improvement, namely lean manufacturing (Yadav et al. 2020). Lean manufacturing has proven its positive effect on operational and economic performance in many cases and there is awareness about sustainability with the Triple Bottom Line approach, namely economic growth, environmental preservation, and social responsibility (Henao et al. 2019). In the context of lean manufacturing and sustainable manufacturing as the chosen topics, it is necessary to conduct a literature review to see the linkages and help guide future research. The concept of lean manufacturing has been carried out from various previous studies to analyze issues related to sustainable manufacturing, for this reason this paper aims to see and describe opportunities for future research.

## 2. Methods

The aim of this article is to get an overview of the interrelationships between lean manufacturing and sustainable manufacturing in the future. Specifically focusing on identifying and analyzing existing literature to see gaps and see future research opportunities This literature review consists of various

published database sources through Elsevier, Taylor and Francis, Emerald Insight, Springer, Wiley and IEEE. Journals that contribute to issues related to lean manufacturing are Journal Production Planning and Control, Journal of Science and Technology Policy Management, Journal of Cleaner Production, International Journal of Sustainable Engineering, International Journal of Lean Six Sigma, Sustainable Production and Consumption, International Journal of Production Research, Journal of Manufacturing Technology Management, International Journal of Quality and Reliability Management, Business Strategy and the Environment.

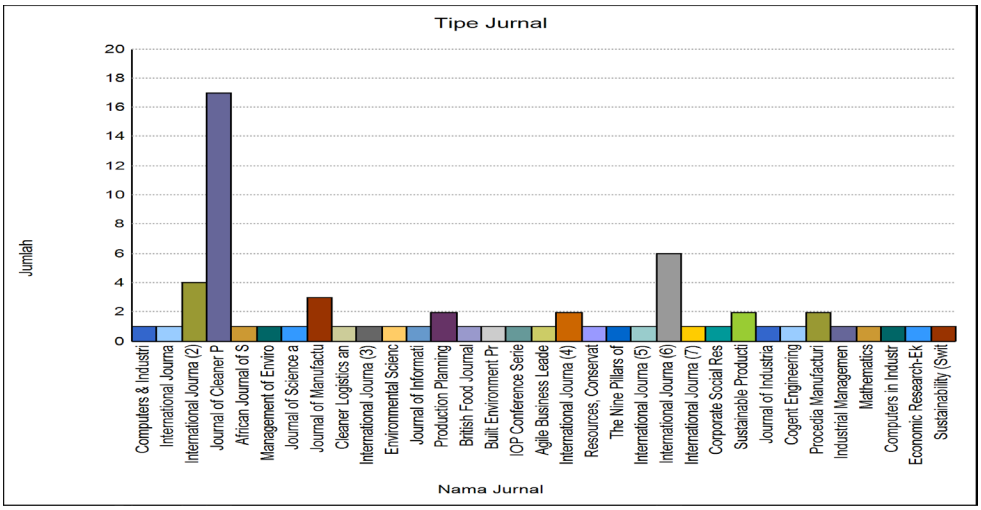


Figure 1. Klasifikasi Jurnal lean dan green

In analyzing articles about lean manufacturing, many have discussed lean manufacturing from the 1990s until now, in 2022. This article is limited to reviewing from 2013 to 2022.

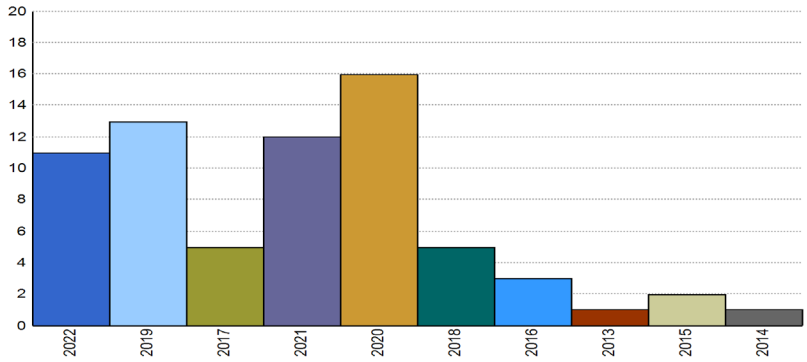


Figure 2. Journal distribution each year

Based on Figure 2. Journal publications start from 2013 to 2022, where the highest number starts in 2020, 2019,202, 2022, and the lowest is in 2013 and 2014. This shows that lean, green and sustainability continues to grow with a large number of publications each year.

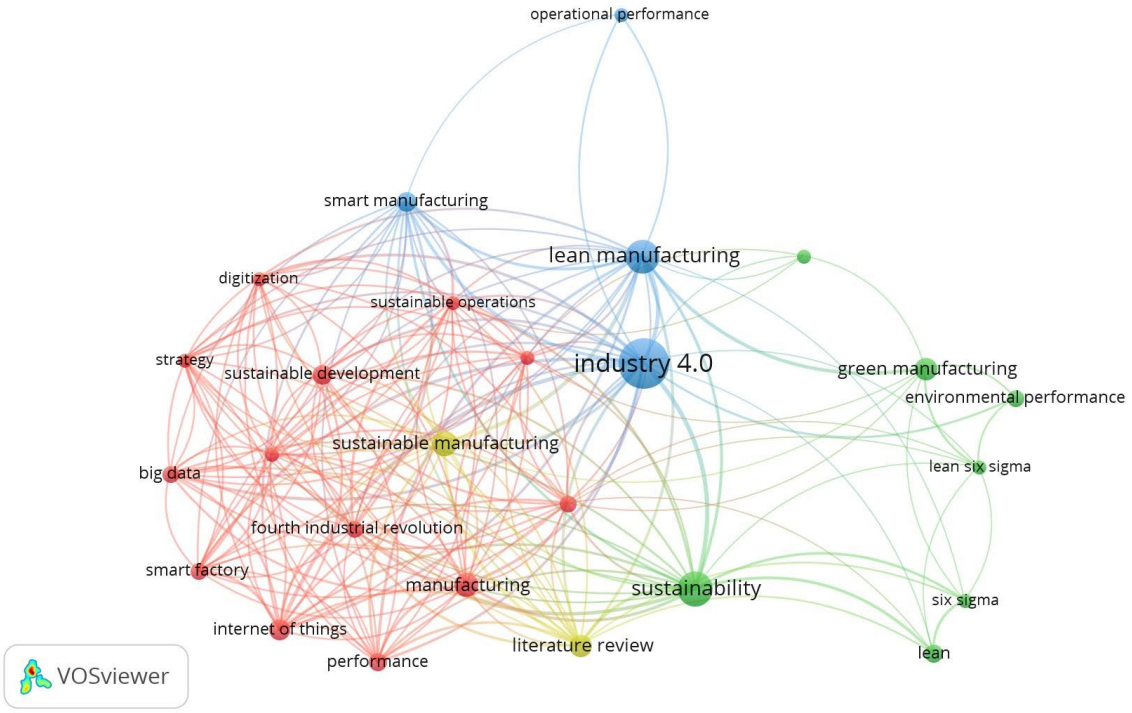


Figure 3. Topic areas on lean, green and sustainability

The software used for bibliometric analysis is VOS-viewer version 1.6.18 (Teixeira et al. 2021). Where it can be described there are 4 clusters, namely the first cluster 49 link strength (red color), the second cluster 80 link strength (green color), the third cluster 100 link strength (blue color), the fourth cluster 55 link strength (yellow color). The most discussed topics are industry 4.0, sustainability, sustainable manufacturing, lean manufacturing, smart manufacturing, environmental sustainability, sustainability development. While the topics that are still little discussed are operational performance, critical success factors, environmental performance, lean six sigma, lean and green manufacturing.

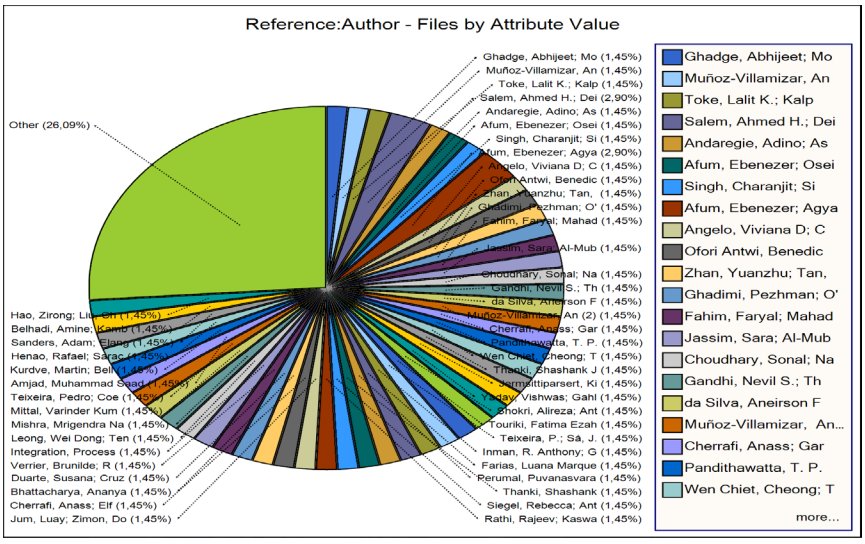


Figure 4. Author of lean and green integration

Gamabr 5. menunjukkan tahapan dalam menjaring literatur , it is first done by searching for articles using boolean logic for keywords namely "lean AND green", lean AND Sustainability Manufacturing", lean AND green manufacturing", "lean OR Sustainable Manufacturing", "lean OR green". Kemudian dilakukan seleksi artikel dengan jumlah sekitar 100 artikel, selanjutnya terpilih 65 artikel yang berhubungan dengan sustainable manufacturing.

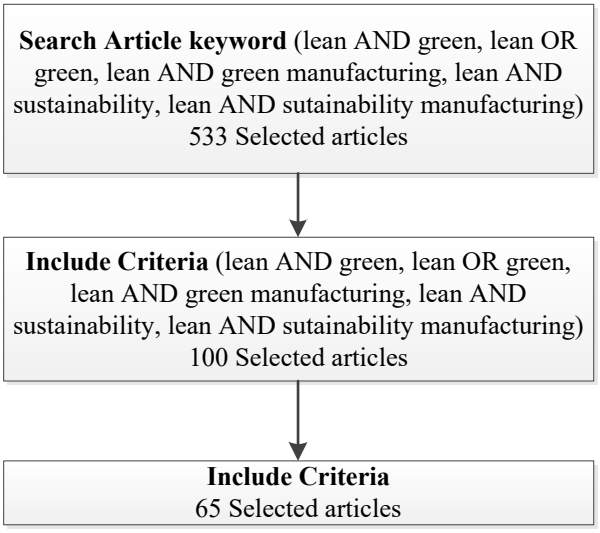


Figure 5. Flowchart of gathering data of publications

## 4. Results and Discussion

In research on lean manufacturing and sustainability manufacturing, there are several classifications, namely the relationship between lean and Industry 4.0, integration of lean and green which of course is associated with measurement of sustainability performance as seen from social, environmental, operational or economic relations with 18%, for environmental relations and operational or economic by 29%, for environmental relations by 23%, for operations by 29% can be seen in Table 1. Meanwhile, a country that discusses a lot about lean manufacturing is India.

Table 1. Relationship between Lean Manufacturing and Sustainability

| Author | Main Contribution | Performance Effect | | |
|---|---|---|---|---|
| | | SP | EP | OP |
| (Hartini et al. 2020) | to develop a manufacturing sustainability index (MSI) based on lean and sustainability concepts using sustainable value flow mapping. | √ | √ | √ |
| (Zhan et al. 2016) | To examine the relationship between lean and green integration on environmental performance and business performance in Chinese manufacturers | | √ | |
| (Inman & Green 2018) | provides an empirical integrated operating model of lean and green-related companies. | | √ | √ |
| (Ciliberto et al. 2021) | to examine the relationship between sustainable production, lean production and Industry 4.0 to prove the need to adopt lean methodology and Industry 4.0 technology in a sustainable development perspective for enterprises. | | √ | |

| | | | | |
|---|---|---|---|---|
| (Kamble et al. 2020) | developed and validated a research model investigating the relationship between I4T, LMP, and SOP | √ | √ | √ |
| (Gaikwad & Sunnapwar 2021) | explores the synergies between Lean, Green and Six Sigma practices to propose an integrated LGSS framework for continuous and incremental improvement in the Indian manufacturing industry. | √ | √ | √ |
| (Belhadi et al. 2020) | in this study takes an integrated view of BDA (Big Data Analytic), LSS (Lean Six Sigma), GM (Green Manufacturing), and EP (Environtment Performance) by investigating the direct and indirect effects of BDA capabilities on EP in the presence of an LSS approach and GM as a mediating variable. | | √ | |
| (Jermsittiparsert et al. 2020) | to determine the mediating role of lean manufacturing between industrial technology 4.0 and the environmental performance of the Thai garment industry; | | √ | |
| (Buer et al. 2021) | to investigate and clarify how lean manufacturing and factory digitization interact, and the impact these two domains have on operational performance | | | √ |
| (Hao et al. 2021) | The motivation of this research is to reveal how lean production and serviceability impact on sustainable performance. | | √ | √ |
| (Kumar et al. 2020) | To identify Critical Success Factors (CSF) for implementing Sustainable Lean Manufacturing from the existing literature and assess the impact of CSF on the economy, society and environment based on industry experts. | | √ | √ |
| (Sanders et al. 2016) | explores the relationship between lean manufacturing practices (total quality management, on-time production, on-time purchasing, total productive/preventive maintenance), agile manufacturing, and operational and financial performance. | | | √ |
| (Buer et al. 2018) | explores this new area and presents the current state of research on the relationship between Industry 4.0 and lean manufacturing. | | | √ |
| (Chiarini & Kumar 2020) | This research investigates and demonstrates how Industry 4.0 technologies and Lean Six Sigma tools and techniques can be integrated to give organizations a competitive advantage. | | | √ |
| (Ghobakhloo & Fathi 2020) | shows how small manufacturing companies can leverage their Information Technology (IT) resources to develop digital-lean manufacturing systems that offer sustainable competitiveness in the Industry 4.0 era. | | | √ |
| (Choudhary et al.2019) | This research aims to develop a simple tool to measure and improve operational performance and is environmentally friendly without large capital costs or strong technical knowledge. | | √ | √ |
| (Singh et al. 2020) | to identify critical success factors (CSF) for implementing green lean practices (GLP) in the manufacturing industry through a literature review and to develop a conceptual model | | √ | √ |

To see the research that has been done on lean, green and sustainability topics. Dimana consists of references, contributions and results in the research can be seen in Table 2.

Table 2. Research on lean, green and sustainability topics.

| No | Referensi | Kontribusi | Hasil |
|---|---|---|---|
| 1 | (Hartini et al., 2020) | to develop a manufacturing sustainability index (MSI) based on lean and sustainability concepts using sustainable value stream mapping. | framework for evaluating and assessing the sustainability performance of manufacturing processes. |
| 2 | (Singh et al., 2020) | to identify critical success factors (CSF) for implementing green lean practices (GLP) in the manufacturing industry | This paper analyzes the dependency forces and driving forces of CSFs identified with the help of MICMAC analysis. “Top management commitment” and “Government support” are the most significant CSFs to successfully implement GLP. |
| 3 | (Gandhi et al., 2018) | this research attempts to fill this gap by identifying and prioritizing integrated LM and GM drivers for Indian manufacturing SMEs. | The results reveal that top management commitment, technology upgrade, current legislation, green brand image and future legislation are the five most important drivers for integrated lean and green manufacturing adoption in Indian manufacturing SMEs. |
| 4 | (Zhan et al., 2018)) | To examine the relationship between lean and green integration on environmental performance and business performance in Chinese manufacturing | In particular, the findings of this study indicate that the most significant items in green and lean mindsets and attitudes are 'company culture and results' (with a mean score of 3.94) and openness to learn (with an average score of 3.84). ). |
| 5 | (Inman & Green, 2018) | provides an empirical integrated operating model of the enterprise in relation to lean and green. | While lean practices can result in some improvements in environmental performance when implemented separately, combining lean practices with green practices provides significant improvements in environmental performance |
| 6 | (da Silva et al., 2021) | to introduce innovative procedures to increase the efficiency of manufacturing processes | The results show that the new MCDEA model is the model that presents the best discrimination of Decision Making Units (DMU) with respect to their efficiency. It also gives a statistically similar weight dispersion to that produced by the other MCDEA models tested for almost all the variables investigated. |
| 7 | (Choudhary et al., 2019) | develop simple tools to measure and improve operational performance and be environmentally friendly without large capital costs or strong technical know-how. | GIVSM helps improve operational efficiency by reducing waiting times by 63% (Figure 5), and at the same time improving environmental performance by reducing the carbon footprint associated with green waste by 49% (Appendix 2) and the overall carbon footprint by 77% |

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|---|---|---|---|
| 8 | (Ciliberto et al., 2021) | to examine the relationship between sustainable production, lean production, and Industry 4.0 to prove the need to adopt lean methodologies and Industry 4.0 technologies in a sustainable development perspective for companies. | This productive environment finds application in I.4.0 and digital environments, where supply chains can become flexible, intelligent, integrative and responsive thanks to technology. Consequently, despite the difficulty in collecting data, a quantitative analysis of the beneficial effects in terms of both environmental and social benefits from the integration of the three main pillars, I.4.0, LP, and CE, would be desirable.. |
| 9 | (Buer et al., 2018) | explores this new area and presents the current status of research on the relationship between Industry 4.0 and lean manufacturing. | The literature findings are classified into four research streams: (1) Industry 4.0 supports lean manufacturing, (2) lean manufacturing supports Industry 4.0, (3) the performance implications of Industry 4.0 and integration of lean manufacturing, and (4) the influence of environmental factors on Industry 4.0 and lean manufacturing integration |
| 10 | (Buer et al., 2021) | to investigate and clarify how lean manufacturing and factory digitization interact, and the impact these two domains have on operational performance | identified a strong correlation between digital technology users and lean manufacturing practices, indicating compatibility between the two domains. Both factory digitization and lean manufacturing practices are significant positive predictors of operational performance levels. Moreover, it is shown that their concurrent use results in greater performance benefits, suggesting a synergistic relationship between the two domains regarding their impact on operational performance. |
| 11 | (de la Vega et al., 2020) | to design and validate a data collection instrument (survey) that will evaluate the influence of CSF on the implementation of LM improvement projects in the transportation equipment manufacturing sector in Mexico | each yielded statistically satisfactory results. |
| 12 | (Kumar et al., 2020) | To identify CSFs for implementing SLM from the existing literature. | Top management is identified as an influential CSF, which assists in the implementation of Sustainable Lean Manufacturing (SLM) and leads other CSFs.<br>It has been analyzed before that sustainable manufacturing (lean and green practices) gives superior results |

| | | | |
|---|---|---|---|
| 13 | (Umar et al., 2021) | to examine the impact of Industry 4.0 on economic and environmental performance through the mediation of green supply chain management (GSCM) practices in the context of an emerging economy, such as Pakistan. | The results show that GSCM practices mediate the influence of Industry 4.0 on economic and environmental performance. Also, the results show that GSCM practices are positively influenced by Industry 4.0 and environmental performance is positively related to GSCM practices and financial performance is positively related to GSCM practices. |
| 14 | (Afum, Agyabeng-Mensah, et al., 2020) | explores the relationship between green manufacturing practices, operational competitiveness, corporate reputation and sustainable performance dimensions and advances mediation approaches. | The results show that green manufacturing has a significant positive impact on social, economic and environmental performance. However, corporate reputation and operational competitiveness were found not to significantly affect economic performance. The mediation analysis also shows that operational competitiveness, corporate reputation and environmental performance do not play a mediating role between green manufacturing and economic performance. Furthermore, social performance was found to mediate the relationship between green manufacturing and economic performance. |
| 15 | (Afum, Osei-Ahenkan, et al., 2020) | examine the explanatory links of green supply chain integration (GSCI) between green manufacturing practices (GMP) and sustainable performance (economic performance [EP], environmental [EnP] and social [SP]) | The results show that GMP has a significant positive effect on sustainable performance (EP, EnP and SP). Again, GMP has a significant positive effect on GSCI. In addition, the GSCI plays a mediating role between green manufacturing practices and sustainable performance |
| 16 | (Toke & Kalpande, 2019) | to identify and analyze the critical success factors (CSF) of green manufacturing (GM) behind the successful achievement of environmental sustainability in the Indian manufacturing industry. | From this study, it was found that the top management-commitment (TMC) attribute received the highest weight (0.201) and was ranked first. Public concern for the protection of the natural environment gets the second highest weight (0.182). Competitiveness (0.015), product eco-labelling (0.016) and reverse logistics practices (0.016) received the lowest weight |

## 5. Conclusion

To achieve competitiveness and create opportunities in highly competitive markets, lean manufacturing is needed to make it happen in both the manufacturing and service industries. Sustainable manufacturing systems aim to meet the needs of the present without compromising the ability of future generations to meet their own needs (Ben Ruben et al. 2019). Based on the explanation above, this article has reviewed several articles on lean manufacturing and sustainability manufacturing in order to provide an overview, views and opportunities for further research. However, it can be concluded that firstly, survey research on the relationship between lean and sustainability is still limited. Second, the dimensions of social performance are still lacking in discussion. Third, there is still little connection between the three dimensions of sustainability, namely social, economic and environmental simultaneously. In addition, there are also opportunities for future research to use more than one method to further enrich research results. Then the method used uses AHP, ISM-MICMAC, Fuzzy followed by SEM.

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