CARMA 2024

6th Int. Conf. on Advanced Research Methods and Analytics
Universitat Politècnica de València, València, 2024
DOI: https://doi.org/10.4995/CARMA2024.2024.17833

A scientometric review on green manufacturing systems for small and medium sized enterprises (SMEs)

Jorge Naranjo Perez[1], Lihong Zhang[2], Xirong Li[3]

[1]Department of Mechanical, Aerospace and Civil Engineering, University of Manchester, United Kingdom, [2]Department of Project Management, University of Manchester, United Kingdom, [3]Department of Mechanical, Aerospace and Civil Engineering, University of Manchester, United Kingdom.

How to cite: Naranjo Perez, J.; Zhang, L.; Li, X. 2024. Paper A scientometric review on green manufacturing systems for small and medium sized enterprises (SMEs). In: 6th International Conference on Advanced Research Methods and Analytics (CARMA 2024). Valencia, 26-28 June 2024. https://doi.org/10.4995/CARMA2024.2024.17833

Abstract

This paper will discuss the current state, barriers, and potential opportunities that small and medium-sized enterprises face in an ever-changing need for sustainable innovation in manufacturing industrial processes. A scientometric literature review has been conducted to provide a solid understanding of green manufacturing systems, specifically on developing manufacturing businesses which may lack intellectual capital, resources and technology as opposed to multinational settled corporations. This literature review also examines potential advantages, drawbacks, and solutions for those SMEs who adopt these sustainable and green manufacturing practices. The employment of the software CiteSpace has aided to deliver this methodology and demonstrate a bigger picture of the prevailing scientific literature that is currently available. The key findings reveal a range of challenges faced by SMEs depending on their geographical positioning. A step-by-step approach beginning with the implementation of cost-efficient management techniques and advancing towards investments in green technologies can facilitate this transition.

Keywords: *Scientometrics; Green manufacturing; Small and medium sized enterprises (SMEs).*

1. Introduction

The importance of manufacturing systems is to produce goods with a given input. This input includes raw materials, machinery, and workforce. They all work together to produce finished goods which can satisfy customer demand (Nassimbeni, 2003). The manufacturing industry has a very strong correlation with the economic growth of a country, and it is the driver of productivity development, according to Speering (2018). The need for sustainability implementation in manufacturing systems has been essential due to multiple factors such as its implications on the environment; tougher government regulations; soaring energy prices and minimization of waste to reduce overhead costs (Giret et al., 2015).

The current research gap to be revised is that SMEs together account for almost 70% of the global pollution (Gurria, 2018), hence thorough scrutiny must be taken into this topic to contribute towards a more environmentally friendly planet. The reason SMEs have such a strong impact on this given data is that they account for 90% of businesses worldwide; influence a quarter of the world's population and supply larger companies with the relevant resources (Shrimali, 2022).

Due to the ever-increasing customer demand towards eco-friendly manufacturing business strategies, it is essential for SMEs to tackle these by exploring ways of waste minimization, reducing energy consumption, and adopting circular economy principles. These include cost-effectively adopting renewable energy sources, recycling, and reusing materials by implementing environmentally safe production processes to reduce energy consumption and toxic waste footprints. The following graphs show a clear illustration of the density number of micro, small and medium sized enterprises (MSMEs) in the world, split into different colour codes (see Figure 1).

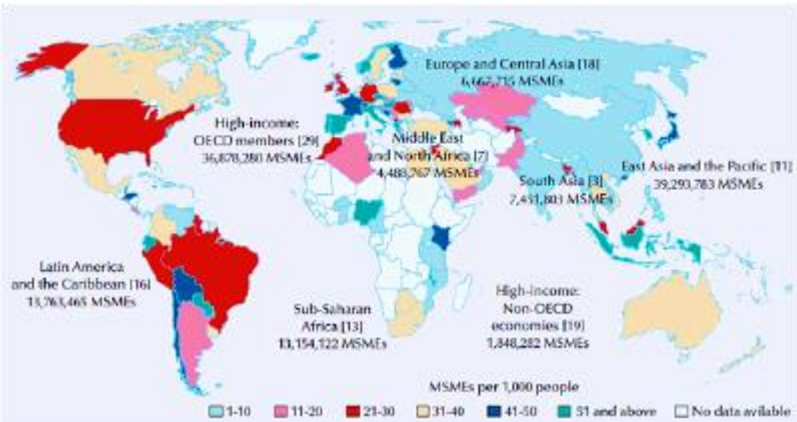

Figure 1. MSMEs density around the world, (Robu, 2013).

Countries with a green colour code, have the greatest number of MSMEs per 1,000 habitants. Based on Giret et al. (2015) previous statement, we can deduce that countries such as Spain or Indonesia, have highly dependent economies on MSMEs. In terms of actual numbers of MSMEs, East Asia and the Pacific have the highest number of MSMEs, with 39,293,783 of them. This serves as a demonstration of the imperative need to meticulously address the environmental footprint of SMEs, given their significant influence on a worldwide scale.

Additionally, these emission practices are categorized in the Scope 3 emissions (Shrimali, 2022). Scope 3 emissions refer to pollutants that occur as a result of a company's activities but are not directly owned by the company. This includes emissions from sources such as waste disposal of purchased goods and services from suppliers or employee commuting via public transportation (Li et al., 2019). This particular type is 11.4 times greater than normal emissions and is frequently the most difficult to eliminate in comparison with scopes 1 and 2 (Shrimali, 2022).

Study shows that the main challenges faced by SMEs in the adoption of sustainable practices are access to funds, advanced technological assistance, and a motivated workforce. It is clear to say that SMEs in economically strong countries have greater ease in the application of these compared to LEDCs such as India, Thailand, Indonesia, etc (Abdullah et al., 2023). This statement can be strongly supported by the fact that developed countries have a carbon dioxide footprint four times above, compared to developing nations and threefold energy intensity (World Bank, 2013), which means that there is a clear discrepancy depending on how well economically developed the specific country is, where the SME is settled.

The aim of this paper is to make a thorough examination of the existing literature concerning green manufacturing systems for SMEs, while also explore potential research topics for future investigation which will guide practical research efforts and minimize the environmental footprint caused by manufacturing systems.

The primary objective is to examine a range of strategies, technology implementations, and practices that enable SMEs to reduce their environmental impact, and simultaneously, enhance their operational efficiency. Nevertheless, a robust awareness has to be made exposing the various barriers and opportunities SMEs face in adopting these methods to influence policy makers and encourage these implementations through appropriate recommendations. Despite these challenges, green manufacturing offers countless benefits which contribute towards the common goal of promoting a greener and more sustainable future. A scientometric approach on the current literature depth in this field will be exposed with the use of the software CiteSpace. This will help visualize trends and citation impacts between numerous scientific publications.

2. Methodology

Scientometrics is the mensurable study of scientific research. It involves the evaluation of scientific publications, citations, collaborations, and impact factors to provide an understanding into trends of scientific research on a particular field (Masic, 2022). The software program that will be used is CiteSpace due to its advanced features, that allow a high volume of data processing, tutorial systems, and user forums to provide necessary help, as well as a range of interactive tools including size and colour combinations (Chen, 2006). A software comparison to obtain the most optimal platform was done against VOSviewer, however, this software lacks advanced features for new research fields, has limited functionality with respect to CiteSpace, and is slower in processing large datasets (Ding & Yang, 2020). In the following, a 4-step process will be presented that will show how the input data will be collected, introduced in the program, and analysed.

2.1. Data collection

A dataset of articles was obtained from the Web of Science by selecting the following search strings: [‘green manufacturing systems’ or ‘sustainable manufacturing systems’ and ‘SME’ or ‘small enterprises’]. The searches were limited to topic category only. This means that articles were only selected if the given strings were located either in the title, abstract or author keywords. This created a more accurate approximation for the extraction of admissible papers. After obtaining the dataset, a screening approach was implemented to enhance the refinement of papers for the literature review. The subsequent systematic process of selection and screening is depicted in Figure 2.

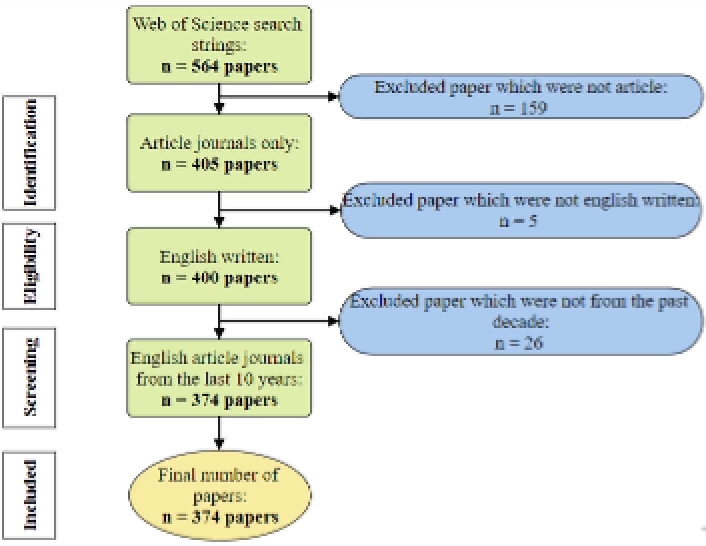

Figure 2. Self-adapted systematic review flow chart (Nandi and Nedumaran, 2021)

The search engine identified a total of 564 papers containing the relevant key terms shown in Figure 3. However, to narrow down the search, the selection was refined to include only article types and those that were English written. This led to a significant downsize of 416 papers. The number of papers published per year using this refinement is shown in the following bar chart and adapted from the Web of Science results (*see Figure 3*).

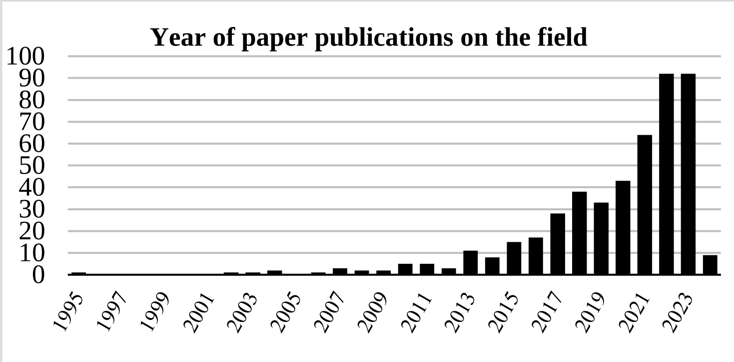

Figure 3. Bar chart showing number of publications from 1995 to 2024.

An exponential growth of article papers relating green manufacturing systems for SMEs can be seen in the past decade. A consideration of data spanning in the past decade was selected, as it comprised a 92.38% of all results, thereby enabling an accurate sample of papers to be reviewed. This resulted in 374 article papers that will be utilized for the science mappings.

3. Results and Findings

3.1 Networks

A mesh-like structure was generated giving valuable information about co-citation data, citation bursts and result visualizations. This specific type of network has been separated into clusters, shown in Figure 4.

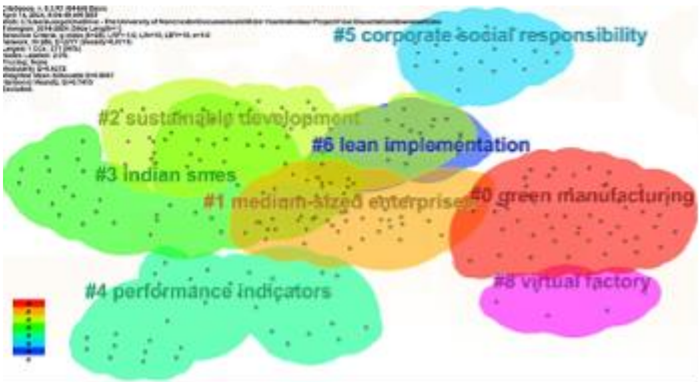

Figure 4. Cluster Network generated by CiteSpace.

A cluster refers to a group of related scientific publications that are closely linked based on citation patterns. These cluster visually represents the relationship between different papers (Chen, 2006). The tiny circle connections are nodes, which represent individual articles. Node spacing is influenced by factors number of citations and overall network density (Liu et al., 2022). The next meshwork generated shows a co-citation mapping, showing highly cited papers.

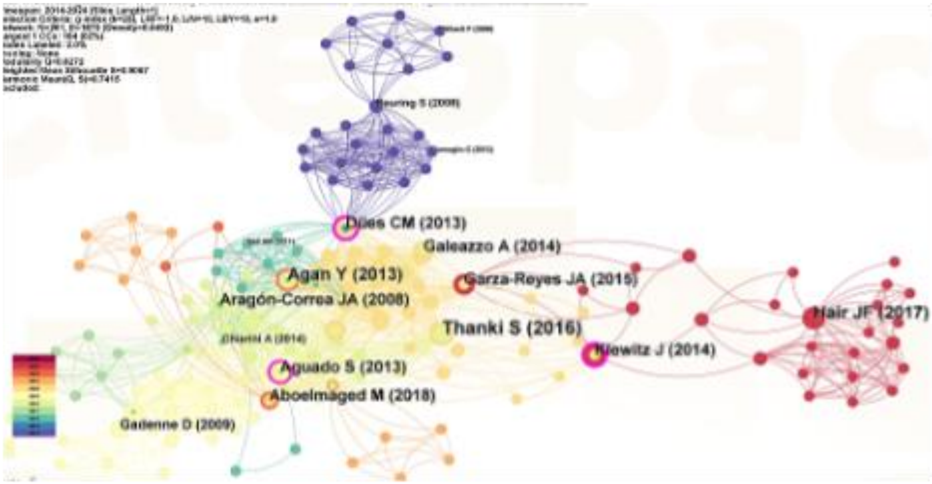

Figure 5. Co-citation network generated by CiteSpace.

Additionally, the institution and country network map highlight the global distribution collaboration based on co-authorship association. It helps identify connections between different organizations and regions and classify potential research patterns, emerging collaborative opportunities, or world scientific sequences (Zheng and Wang, 2019).

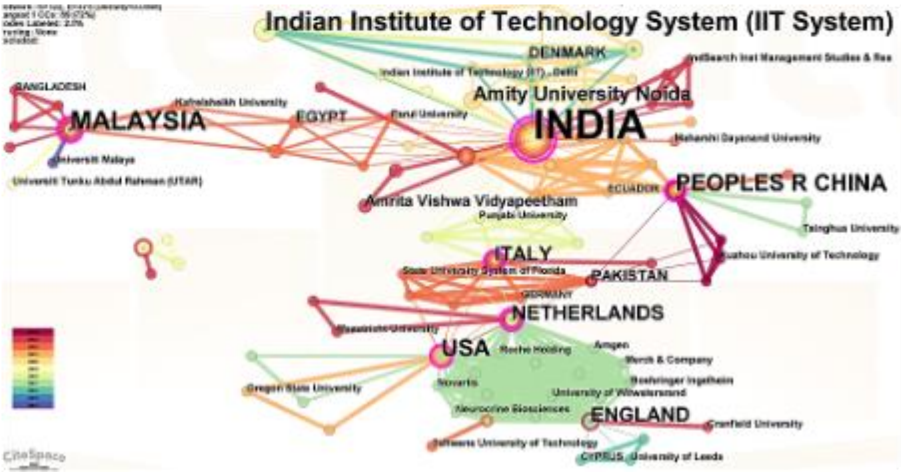

Figure 6. Institution and country network.

3.2. Analysis of the output network

In the cluster network diagram, 8 observable clusters can be identified. There are 4 clusters which are highly concentrated in the middle of the diagram '*sustainable development*', '*medium sized enterprises*', '*lean implementation*', and '*Indian SMEs*'. This tells that a great effort and scientific research has been done in those fields.

Through the co-citation network from Figure 5, it can be seen that Hair F. has been emerging actively during recent years; however it has been highly diverged from the middle of the map, which may suggest that low collaboration has been done with previous work from other authors. This can be interpreted as a beneficial development, as he is departing from the established scientific research and venturing into unexplored realms of study.

Those countries that have made a significant advancement in this field are India, followed by Malaysia, USA, and China respectively. This is supported by their node size and high centrality degree based on their ring size. A higher degree of centrality is observable in developing countries as opposed to economically developed countries which may signify a greater need of scientific research in those areas. The Indian Institute of Technology System (IIT System) has been the biggest research institution on this matter and substantial collaborative work can be seen based on their high linkage degree. Nodes extending from China by the Xuzhou University of Technology is indicative of their active publication of papers and ongoing advancements in research. This is further supported by their delineation and colour coding on the map, pointing towards developments made in the year 2024.

4. Conclusion

Green is an integral component of the foundational principles of sustainability, in conjunction with the economic and social pillars. To ensure a sustainable machining process, green manufacturing systems must be fulfilled by effectively reducing waste and energy consumption through a combination of management and technological strategies. SMEs with limited resources can begin implementing cost-effective management approaches by leveraging circular economy strategies. Once these approaches have been successfully integrated, SMEs may consider investing in technological solutions including efficient production machinery, renewable energy utilization, and environmental management systems. A notable focus of research centrality has been discovered in India, which highlights the necessity to increase scientific endeavours to offer valuable insights and methodologies for SMEs to effectively transition towards sustainable green manufacturing practices.

In conclusion, it is hoped that this study has provided valuable information for authors seeking to embark into this topic and understand the direction and process involved. The integration of green manufacturing systems in SMEs is imperative due to their worldwide influence in providing a prosperous future for not only the economy but preserving the existing natural ecosystems for future generations.

References

Abdullah, A., Saraswat, S., & Talib, F. (2023). Barriers and strategies for sustainable manufacturing implementation in SMEs: A hybrid fuzzy AHP-TOPSIS framework. *Sustainable Manufacturing and Service Economics, 2,* 100012. https://doi.org/10.1016/j.smse.2023.100012

Chen, C. (2006). CiteSpace II: Detecting and visualizing emerging trends and transient patterns in scientific literature. *Journal of the American Society for Information Science and Technology*, *57*(3), 359–377. https://doi.org/10.1002/asi.20317

Ding, X., & Yang, Z. (2020). Knowledge mapping of platform research: a visual analysis using VOSviewer and CiteSpace. *Electronic Commerce Research*, *22*. https://doi.org/10.1007/s10660-020-09410-7

Giret, A., Trentesaux, D., & Prabhu, V. (2015). Sustainability in Manufacturing Operations scheduling: a State of the Art Review. *Journal of Manufacturing Systems, 37,* 126 140. https://doi.org/10.1016/j.jmsy.2015.08.002

Gurría, A. (2018). SMEs are key for more inclusive growth. *OECD Observer*. https://doi.org/10.1787/25aa3d56-en

Li, M., Wiedmann, T., & Hadjikakou, M. (2019). Enabling Full Supply Chain Corporate Responsibility: Scope 3 Emissions Targets for Ambitious Climate Change Mitigation. *Environmental Science & Technology*. https://doi.org/10.1021/acs.est.9b05245

Liu, D., Che, S., & Zhu, W. (2022). Visualizing the Knowledge Domain of Academic Mobility Research from 2010 to 2020: A Bibliometric Analysis Using CiteSpace. *SAGE Open*, *12*(1), 215824402110685. https://doi.org/10.1177/21582440211068510

Masic, I. (2022). Scientometrics: The imperative for scientific validity of the scientific publications content. *Science, Art and Religion*, *1*(1), 56–80. https://doi.org/10.5005/jp-journals-11005-0017

Nandi, R., & Nedumaran, S. (2021). Understanding the Aspirations of Farming Communities in Developing Countries: a Systematic Review of the Literature. *The European Journal of Development Research*. https://doi.org/10.1057/s41287-021-00413-0

Nassimbeni, G. (2003). Local manufacturing systems and global economy: Are they compatible?: The case of the italian eyewear district. *Journal of Operations Management, 21*(2), 151–171. https://doi.org/10.1016/S0272-6963(02)00090-6

Robu, M. (2013). The dynamic and importance of smes in economy. *The USV Annals of Economics and Public Administration*, *13*, 84–89. https://ideas.repec.org/a/scm/usvaep/v13y2013i1(17)p84-89.html

Shrimali, G. (2022). Scope 3 emissions: Measurement and management. *The Journal of Impact and ESG Investing*. https://doi.org/10.3905/jesg.2022.1.051

Speering, J. (2018, July 29). *Why manufacturing is essential for economic growth?* Aspioneer. https://aspioneer.com/why-manufacturing-is-essential-for-economic-growth/

World Bank. (2013). *World Development Indicators 2013*. World Bank.

Zheng, K., & Wang, X. (2019). Publications on the Association between Cognitive Function and Pain from 2000 to 2018: a Bibliometric Analysis Using CiteSpace. *Medical Science Monitor, 25*, 8940–8951. https://doi.org/10.12659/msm.917742