Sustainability and Risk in Manufacturing: A Bibliometric Analysis and Future Research Direction Using R

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Abstract. The manufacturing industry in Indonesia experienced investment growth of 38% in the first semester of 2022 compared to the first semester of 2021. This achievement is accompanied by a target to make Indonesia an environmentally friendly industry. However, various global problems, such as the COVID-19 pandemic and the Ukraine and Russia Wars, have become threats to the sustainability of the manufacturing industry in the world, including Indonesia. One of the problems that arise is disruption of supply, manufacturing activities, and other risks that can hamper the sustainability of the manufacturing industry.

1 Introduction

The manufacturing industry in Indonesia experienced investment growth of 38% in the first semester of 2022 compared to the first semester of 2021. This achievement is accompanied by a target to make Indonesia an environmentally friendly industry [1]. As of September 2022, data from the Ministry of Investment or the Investment Coordinating Board (BPKM) shows that the manufacturing sector contributes 40.9% to total incoming investment [2]. However, manufacturing growth is accompanied by several global problems, including the COVID-19 pandemic and the Ukraine and Russia Wars.

COVID-19 impacts the global value chain, disrupting supply as manufacturing companies' primary input for production activities [3]. This condition is exacerbated by the war between Ukraine and Russia, which has caused the supply of raw materials for manufacturing to experience supply disruptions. Although Russia and Ukraine account for only about 4% of the global GDP in 2021, the interconnectedness of global supply chains has caused this conflict to impact industrial supply chains [4]. There needs to be an effort from the manufacturing industry to overcome the problem of raw material supply to achieve a sustainable manufacturing industry.

In addition, the world is also faced with challenges in achieving sustainable development goals (SDGs). Based on the assessment and ranking of sustainable development goals (SDG) in 2022, Indonesia scored 69.2. It is ranked 82 out of 163 countries and is below other ASEAN countries, such as Thailand (44), Vietnam (55), Singapore (60), and Malaysia (72) [5]. One of the targets to be achieved is a sustainable industry with assessment indicators, namely emissions and waste produced by the industry.

The sustainable manufacturing level is divided into three classes: system, product, and process. Sustainable manufacturing at the process level has several objectives, including reducing energy consumption, reducing waste, increasing product durability, reducing health hazards and dispersion of toxins, improving manufacturing quality, increasing product recovery, and developing renewable energy [6]. Energy consumption in the product life cycle, the manufacturing industry has a tremendous environmental impact due to high energy consumption, waste generated, and greenhouse gas emissions [7]. So, the target requires the industry to implement a sustainable sector. However, to achieve sustainable manufacturing targets, optimal risk management is necessary.

Climate change poses a risk to the manufacturing industry and the financial system, where this risk involves policies, technology, and markets that lead to a low-carbon economy [8]. So, if a manufacturing company does not consider these risks, the company's reputation can result in losing customers. The Industrial
Revolution spurred rapid industrial growth, which led to the greenhouse effect, which increased environmental, social, and economic risks [8]. The industry must face risks related to sustainability aspects. Still, few studies have examined sustainable risk assessment or sustainability risk [9], so the study of sustainability and risk can make an essential contribution to business sustainability in various fields. Managing business opportunities and risks in organizations can affect the achievement of reputation, welfare, growth, stakeholder engagement, value, long-term sustainability, and business contributions that realize sustainable development [10].

Measuring sustainability performance in estimating risk uncertainty can help and facilitate decision-making to choose the best strategy [11]. With limited resources of raw materials, energy, and demands of interested parties, manufacturing companies need to pay attention to sustainability aspects to achieve sustainable long-term performance. Ongoing risk potentially threatens the organization, impacting a system's sustainability [12]. Sustainability and risk is a potential organizational threat impacting a system's sustainability [13]. Research to identify sustainability risk has been conducted by several previous researchers [9], [13]-[17].

The increasing use of technological devices poses the potential for increased environmental impacts and challenges for product designers, manufacturers, risk analysts, and environmentalists in designing and developing various systems [14]. Sustainability risk research on recycling and remediation activities has been carried out in previous research, including integrating sustainability risk management in determining remediation locations [18] and designing sustainable risk management models for the recycling industry [19]. These studies show that sustainability and risk studies in several areas or fields, such as supply chains, circular economy, and others, still have the potential to be developed. Thus, this research was conducted to explore future research opportunities related to sustainability and risk in manufacturing.

2 Objectives

This study was conducted to investigate the development of research in recent years related to sustainability and risk in manufacturing. This research is expected to map or group research topics often carried out by researchers related to the subjects studied. The results of this study are expected to provide recommendations for researchers who will research these topics related to fields of study in sustainability and risk in manufacturing.

3 Research in sustainability and risks

The increasing use of technological devices globally, which raises the potential for increased environmental impact, poses more significant challenges for product designers, manufacturers, risk analysts, and environmentalists in designing and developing various systems [14]. Measuring sustainability performance in estimating risk uncertainty can help and facilitate decision-making to choose the best strategy [15]. With limited resources of raw materials, energy, and demands of interested parties, manufacturing companies need to pay attention to sustainability aspects to achieve sustainable long-term performance. Therefore, this literature review was conducted to review research on the application of sustainability and risk.

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<th>Research Study Areas</th>
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<td>Circular Economy</td>
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<td>Computer Science, Engineering, Business</td>
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<td>Materials Science, Materials</td>
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<td>Engineering, Business Science, Decision Sciences</td>
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Assessment of sustainable risks has been carried out in several areas shown in Table 1. So, evaluating sustainability and risk can contribute to business sustainability in various fields. Based on the literature review in Table 1, most of the research objectives on sustainability and risk are carried out in the supply chain area. Meanwhile, several previous studies focused more on product development in the manufacturing area. Therefore, research on sustainability and risk still has the potential to be developed, especially in the manufacturing industry.

4 Methodology

This research determined the main keywords in the Scopus database: sustainability, risk, and manufacture. Furthermore, search limits are selected at each stage, as shown in Table 2.

Table 1. The area of sustainability and risk

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Table 2. Identify the title of the research article on Scopus data.
Furthermore, the database search results will be analyzed using R 4.2.2 software with the biblioshiny analysis category.

**5 Result and discussion**

Article documents were then sorted for the years 2013 to 2022 so that they became 664 articles. In the last ten years, the average annual increase in research has been 24.66% (Figure 1). These results suggest that researchers' interest in this topic is growing. This is in line with the demands of stakeholders for creating a sustainable industry. The number of studies on the subject of sustainability and risk began to experience a rapid increase in 2016 and beyond.

*Fig. 1. Annual scientific production*

The published articles are primarily from sustainability journals and journals of cleaner production, as shown in Figure 2.

*Fig. 2. Most relevant article sources*

The publisher of this Journal has a field of publication related to environmentally friendly and sustainable production and consumption. Sustainability is an international journal in the cross-disciplinary area of environmental, cultural, economic, and human social sustainability with open access and is published online by MDPI. Meanwhile, based on the number of citations (shown in Figure 3), the Journal of Cleaner Production is the publisher with the most cited articles. So, articles in the publisher journal of cleaner production are the most reputable and trusted by researchers in making the results of these publications as a reference for research conducted by the authors.

*Fig. 3. Most cited article sources*

Based on the author's country of origin shown in Figure 4, China has the highest author and number of documents for single corresponding and multiple corresponding categories. The United States, India, Italy, and the United Kingdom followed it. In comparison, Indonesia is ranked 19th out of 20 countries. So, research related to sustainability and risk in manufacturing in Indonesia is still rare and has the potential to be developed considering the growth of the manufacturing industry in Indonesia. Status as a producer and market spread across sectors, one of which is automotive, is the basis for the high research interest of researchers in the field of sustainability in China [32].

*Fig. 4. Corresponding Author's Country*
In addition, as the world’s largest developing country, China must be able to practice efficient consumption and not pollute the environment [33].

The analysis results of trending topics using biblioshiny (Figure 7) show that research with the keywords industry 4.0, covid-19, resilience, circular economy, sustainable supply chain, and renewable energy is a research topic that became a trend in 2019 and above. These topics also continue to be a trend today. Research related to these topics can still follow current research needs. Meanwhile, other topics that were trending and rarely discussed after 2020 in research articles are optimization, safety, life cycle assessment, risk management, and supply chain management. However, even though it has started to be rarely discussed, these topics can still collaborate with other trending and current topics.
Research collaboration related to Industry 4.0, circular economy, and recycling topics with risk management and risk assessment is a potential topic to be developed because it is based on analysis Thematic; this collaboration is rarely done. The results of the thematic study shown in Figure 8 show that the circular economy is in the same cluster as industry 4.0, and recycling is in the quadrant of basic themes; the position of this study explains that this research topic is still little developed, but has a high level of relevance or need. In other clusters in the same quadrant, the issues of risk management, sustainable manufacturing, and several other topics also have the same research potential. The results of the analysis in Figure 9 related to the evolution or development of research topics are grouped into three periods, namely: period 1 (2013 - 2016), period 2 (2017 - 2019), and period 3 (2020 - 2022) show evolution research as shown in the figure.

6 Conclusion

Research on sustainability and risk in manufacturing has increased significantly in the last ten years, with an average increase of 24.66% based on bibliometric analysis using RGui 4.2.2. software, the topics of discussion that most often appear outside search keywords are industry 4.0, circular economy, and chain management supply. Many researchers relate the field of sustainability and risk studies to these topics. In comparison, the current developing topics, in addition to the two issues discussed earlier, COVID-19, resilience, and renewable energy, began to develop in 2019. At the same time, the results of thematic studies explain that there are three groups of topics that still need to be extended again, namely group 1 (circular economy, recycling, and industry 4.0), group 2 (sustainable manufacturing, risk assessment, life cycle assessment), and group 3 (sustainability, risk management, and supply chain). Collaborative topics between groups, such as circular economy with risk management and risk assessment or Industry 4.0 with risk management and life cycle assessment, are potentially done in the future because they are rarely done.

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References


