ISSN 2683-345X
journal homepage: http://ijiemjournal.uns.ac.rs/

International Journal of Industrial Engineering and Management

Volume 14 / No 4 / December 2023 / 311 - 325

Review article

Using Index Function and Artificial Intelligence to assess Sustainability: A Bibliometric analysis

M.G. Cardoso[a,b,c,*], E. Ares[b], L.P. Ferreira[a,c], G. Pelaez[b]

[a] ISEP, Polytechnic of Porto, R. Dr. António Bernardino de Almeida, 4249-015 Porto, Portugal;
[b] Uvigo– Department of Engineering Design, School of Industrial Engineering, University of Vigo, Vigo,36310, Pontevedra, Spain;
[c] INEGI - Associate Laboratory for Energy, Transports and Aerospace, R. Dr. Roberto Frias 400, 4200-465 Porto, Portugal

ABSTRACT

Industrial sustainability has increased, focusing on social, economic, and environmental. The aim of this study is to carry out a systematic bibliometric analysis of the existing literature on sustainability indices and artificial intelligence-based tools for measuring and assessing the sustainability of production systems. For this statistical analysis, three scientific databases - Web of Science, Elsevier's Scopus and Dimensions - were used to identify relevant research articles and explore their temporal and geographical distribution. This data sheds light on the development of sustainable manufacturing and encourages future research in this area. This research aims to increase knowledge about sustainable development.

ARTICLE INFO

Article history:

Received May 4, 2023
Revised September 14, 2023
Accepted October 16, 2023
Published online October 23, 2023

Keywords:
Sustainability Index Function;
Sustainability Manufacturing;
Triple Bottom Line;
AI Sustainable Manufacturing

*Corresponding author:
M.G. Cardoso
mon@isep.ipp.pt

1. Introduction

In the last few decades there has been a growing interest among researchers in the field of sustainability. This has resulted in new approaches to various aspects of sustainability, such as productivity assessment techniques, implementation, and strategic planning in related fields [1]. The concept of sustainability and its implementation has received considerable attention from owners, managers, researchers, organisations, and manufacturing companies for several reasons. These include reducing non-renewable resources, adopting more stringent environmental protection standards, increasing demands for health, safety and social justice in the workplace, and customers' growing preference for environmentally friendly products [2]. It has therefore become increasingly clear that sustainability criteria need to be integrated into all decision-making processes in all sectors of our society [3].

Over time, the importance of Artificial Intelli-

Published by the University of Novi Sad, Faculty of Technical Sciences, Novi Sad, Serbia.

http://doi.org/10.24867/IJIEM-2023-4-341

gence (AI) technologies in increasing the capabilities of the manufacturing industry has become progressively apparent [4]. These technologies can improve various facets of the manufacturing process, including performance, product quality and employee well-being [5], [6]. For example, AI-powered robots are capable of performing complex tasks and making recommendations to managers based on real-time data. Machine learning algorithms can help manage tasks and evaluate projects, allowing manufacturers to identify areas for potential improvement [7], [8]. In addition, many managers are currently using AI to anticipate equipment failures and facilitate timely repairs, avoiding costly unplanned downtime. This enables manufacturers to maintain seamless operations and increase overall productivity [8], [9]. To contribute to a more sustainable production system, the implementation of AI technologies in manufacturing enables companies to operate more efficiently, improve product quality, and ensure employee well-being, while reducing downtime and costs [10].

The study aims to analyse the literature on sustainability indices and AI-based tools for assessing the sustainability of production systems, and to identify notable papers and authors. It also aims to perform a statistical analysis of sustainable manufacturing, analyse the temporal and geographical distribution of papers, contribute to knowledge on sustainable development, and promote practical solutions to improve sustainability in production systems. Overall, the study aims to provide a better understanding of sustainable manufacturing and to promote future research in this area.

In addition, this research analyses the Sustainable Index Function SIF developed by Naderi et al. [11], to gain insight into its strengths and limitations. The main contribution of this study is to synthesise the main findings on this topic into a conceptual model consisting of sustainability support tools that can help managers improve the sustainability of their production systems, taking into account the Triple Bottom Line (TBL).

This paper is organised in the following sections. Section 2 presents a review of the literature that describes some of the main sustainability approaches and the SIF developed by Naderi et al. [11]. Section 3 outlines the research methodology and the criteria for collecting and analysing all relevant information. Section 4 presents the results of the bibliometric research. Section 5 discusses the research opportunities and limitations identified in this work, while Section 6 presents the conclusions of the bibliometric analysis and outlines future research directions.

2. Literature Review

2.1 Sustainability approaches

In their research, some authors have chosen an approach focused on optimised management to improve sustainability within the value chain [12], [13]. Currently, several studies show the importance of integrating environmental concerns with lean manufacturing practices, which leads to the acquisition of new skills that quality managers must possess in the era of Industry 4.0, which shows how important it is to make systems production more sustainable [14]-[16].

The production process is constantly evolving, which is a major challenge for manufacturers [17]. It is essential for manufacturers to meet the demands of their customers by providing quality products at an affordable price, while at the same time ensuring the sustainability of their production processes and product life cycle [17]. In addition, with the increasing focus on reducing the global environmental impact, companies need to minimise energy consumption, especially from non-renewable sources, greenhouse gas emissions and the use of scarce natural resources [18]. The concept of sustainability was first introduced by the World Commission on Environment and Development of the UN General Assembly in 1987 and has since been widely recognised [19], [20].

Sustainability in manufacturing involves producing products with minimal environmental impact, using natural resources responsibly and prioritising the safety of employees and communities, as stated by Huang et al. [21]. The goal of sustainability is to balance the material needs of the population with their health [22]. In the product life cycle [23], sustainability plays a critical role and manufacturing companies should implement sustainable policies in their production systems [24]. To achieve sustainability goals [25], companies need to adopt an approach that integrates the three fundamental principles of sustainability, namely economic, environmental and social considerations [26].

In the manufacturing industry [27], ecological sustainability has emerged as a primary concern to address the environmental impacts of industrial activity [28]. The adoption and integration of sustainable production methods in industrial companies is imperative, not only for the preservation of the environment [29], but also for the establishment of lasting prosperity and resilience during a global landscape that is becoming increasingly environmentally attuned [30]. To facilitate the wise use of resources, it is imperative that companies use renewable energy sources, reduce waste, and make a firm commitment to reducing environmental impact at every stage of the production process [27], [31].

In recent years, researchers have focused their efforts on the main pillars of sustainability, commonly known as the TBL [19]. In summary, it is essential for manufacturing companies to keep up with the evolving production process and achieve sustainability goals by implementing policies that consider economic, environmental, and social factors, ultimately leading to sustainable manufacturing practices.

2.2 Sustainability Index Function

One purpose of the SIF is to provide a comprehensive assessment of the sustainability performance of a production system, enabling the best decisions to be made on the three aspects of the TBL: environmental, social, and economic impacts. Through the use of SIF, it is possible to identify areas for improvement, set sustainability targets, and track the progress of all processes over time towards achieving the preestablished targets.

A sustainability index is a composite score that provides an overall picture of sustainability performance. This is usually based on a set of sustainability indicators, which in turn are based on specific sustainability metrics [32]. The index was developed with the purpose of assessing and determining the sustainability performance of manufacturing companies. It has been designed to identify areas for improvement [33].

Veleva et al. [34], introduced the approach of core indicators and supplementary indicators, where the core indicators are applicable to any industry, while the supplementary indicators are applicable to a specific context. On the other hand, a modular approach with generic industry and context-specific indicators was developed by Azapagic et al. [35].

Over the last decades, the Vigo Manufacturing Engineering Group has studied the Sustainability Assessment Methodology (SAM), which has undergone several transformations and developments involving different researchers. This study originates from the doctoral thesis of [36], who developed an objective function (Equation 1) called the Economic Index Function (EIF) using data from a hierarchical model of manufacturing systems.

$$EIF = production\ EIF + environmental\ EIF + social\ EIF \tag{1}$$

Peláez [37] improved the EIF by comparing results from computer simulation models of complex manufacturing systems. Ferreira et al. [38] continued Peláez [37] work by applying other simulation systems. In a subsequent study Naderi et al. [11], identified effective indicators and their components were identified. This research is in line with the SDGs, which encourage the development of frameworks that promote the circular economy and more sustainable modes of production and consumption. Naderi et al. [24] proposed a SAM, based on the identified indicators, to strengthen decision-making in companies. The methodology aims to provide a comprehensive assessment of sustainability factors, taking into account stakeholder perspectives. The Sustainable Economic Index Function (SEIF) associated with the production criteria was defined by Naderi et al. [11] as Equation 2.

$$\begin{aligned} SEIF = {} & productionFixed\ costs + \\ & Costs\ associated\ with\ non-use\ of\ machinery + \\ & Costs\ associated\ withdelays\ in\ delivery\ time\ and \\ & elimination\ of\ defects + \\ & Costs\ associated\ with\ pallets + \\ & Costs\ associated\ with\ energy\ \ consumption + \\ & Costs\ associated\ with\ size\ and\ transportation \end{aligned} \tag{2}$$

Based on the selected production, environmental, and social indicators, a Generalised Economic Index for Sustainability function has been developed for practical application, in consultation with the company manager. When using this formula, the accuracy of the data input and the specific characteristics of the organisation should be taken into account. Consequently, the set of coefficients (α, β, γ) can be defined for each aspect, resulting in the Economic Index for Sustainability function being expressed by Equation 3, where *EIFS* represents Economic Index function of sustainability, *EIFP* represents Economic Index function of Production, *EIFE* represents Economic Index function of Economical and *EIFS* represents Economic Index function of Social [24]:

$$EIFS = \alpha \times EIFP + \beta \times EIFE + \gamma \times EIFS \tag{3}$$

Equation 4 is a general formula for assessing sustainability in manufacturing companies Naderi et al. [24].

$$EIFS = \alpha \times \left[\left(\sum_{j=1}^{n} N_{ij} \times TP_{ij} \times CF_{ij}\right) + \left(\sum_{j=1}^{n} CNU_j \times TI_j\right) + (CPFDD \times TSA) + \left(\sum_{j=1}^{n} B_{ij} \times TM_{ij} \times CM_{ij}\right) + \left(\sum_{j=1}^{n} CNUB_j \times TIB_j\right)\right] + \beta \times \left[\left(\sum_{j=1}^{n} M_{ij} \times CM_{ij}\right) + \left(\sum_{j=1}^{n} NP_{ij} \times TP_{ij} \times CP_{ij}\right) + \left(\sum_{j=1}^{n} P_{ij} \times TP_{ij} \times CPE\right) + \left(\sum_{j=1}^{n} WC_{ij} \times CWC\right) + \left(\sum_{j=1}^{n} W_{ij} \times CW_{ij}\right) + \left(\sum_{j=1}^{n} EA_{ij} \times CEA\right) + \left(\sum_{j=1}^{n} WP_{ij} \times CWP\right)\right] + \gamma \times \left[\left(\sum_{j=1}^{n} NT_j \times HTP \times CHTP\right) + \left(\sum_{j=1}^{n} NT_j \times HFC \times CHFC\right) + \left(\sum_{j=1}^{n} NT_j \times CMPEI\right) + (TIO \times CPS) + \left(\sum_{j=1}^{n} CNM\right) + \left(\sum_{j=1}^{n} CIR\right) + (NQC \times CQC)\right] \quad (4)$$

In short, by utilising this methodology, companies can make informed decisions regarding the adoption of sustainable practices, ultimately leading to more sustainable and responsible manufacturing practices.

3. Methodology and criteria analyses

In a first phase the authors have investigate in the Dimensions database by entering the following keywords: "Manufacturing Sustainability", "Sustainable Index Function", and "Artificial Intelligence". The results indicated that a total of 99,839 works have been published in the last 50 years on the subject matter.

As depicted in Figure 1 (obtained by Dimensions ai), the origin of scientific publications on the topic can be traced back to the 1970s, concurrent with the emergence of the concept of sustainability. A notable increase in publications is observed in 2015, which is in line with the adoption of the SDGs in that year. Another peak is observed in 2020, demonstrating a continued alignment with the goals set to be achieved by 2030.

The authors concluded that there is a lot of published work in the field of manufacturing sustainability. However, even when selecting and analysing studies published in the last five years, it is difficult to identify the most important ones. This makes it almost impossible to obtain satisfactory results.

To perform a more detailed and specific bibliometric analysis, the authors performed a keyword search in journals related to the topic under review (Figure 2).

The keywords considered were "sustainable manufacturing", "sustainable index function", "manufacturing", "triple bottom line", and "AI sustainable manufacturing". The search results initially yielded only five publications, which were considered insufficient for a comprehensive analysis. To overcome this limitation, the authors decided to add a relevant keyword to the search query. The final search query was ("sustainable manufacturing" OR "sustainable index function") AND ("manufacturing" OR "triple bottom line") AND ("AI sustainable manufacturing"). To ensure a thorough review of existing studies, the authors selected three highly regarded scientific databases, namely Clarivate Analytics' Web of Science (WoS), Elsevier's Scopus, and Dimensions.

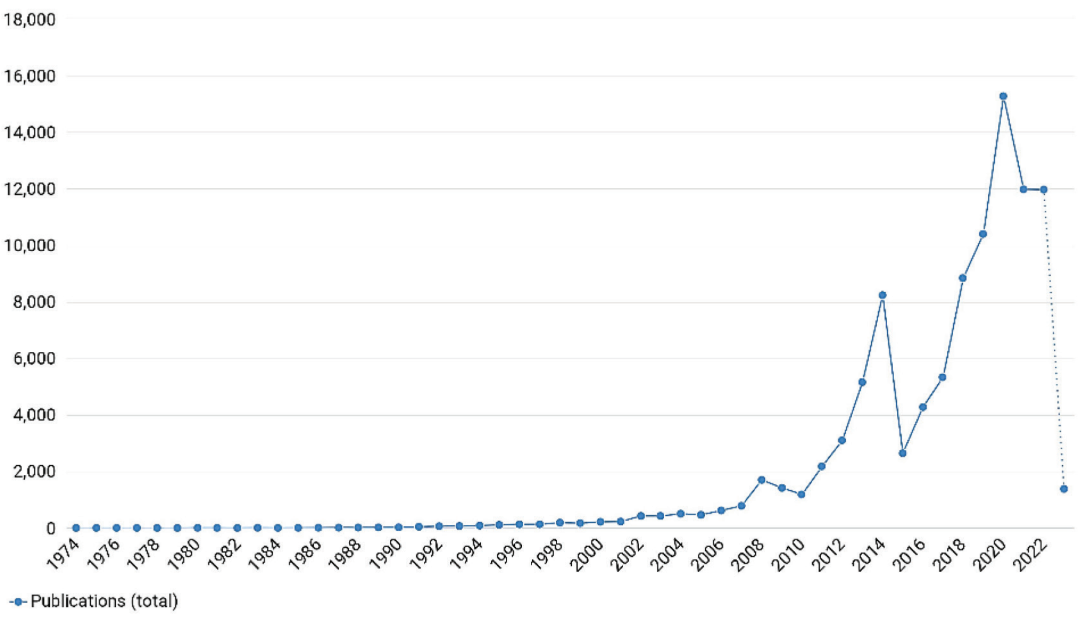

Figure 1. Number of Publications Published in each year

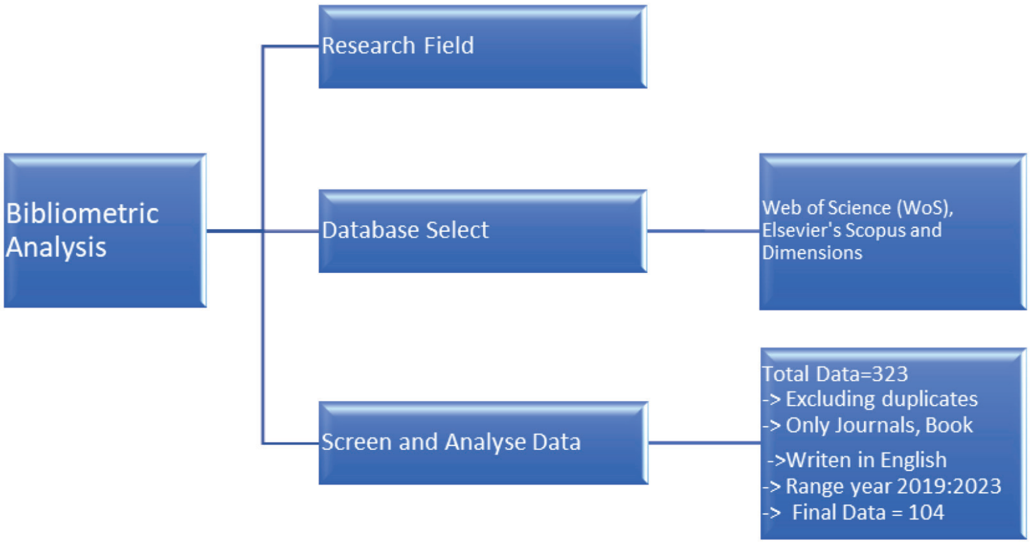

Figure 2. Bibliometric methodology adapted from ([39])

4. Bibliometric Research

4.1 Data collection, processing, and analysis

In order to perform an analysis of the data collected from Web of Science, Elsevier's Scopus, and Dimensions, it was necessary to apply filters to obtain more accurate information. To meet the needs of this research, the first filter applied was limited to papers and reviews written in English only. The range of years was not restricted in order to allow an exploratory analysis of the data and to examine trends from the beginning of the research to the present. The data collected were processed using the Bibliometrix R package from RStudio®, which includes the Biblioshiny tool developed by Aria et al. [40]. This tool contains the main statistical and scientific mapping algorithms required for bibliometric analysis.

The bibliometric analysis followed a series of steps that included the collection of data from three scientific databases, the development of code in RStudio® to merge the three datasets and eliminate duplicates. The next step was to run Biblioshiny, which opened a web page that allowed data to be imported in .xlsx format, and finally to perform a study analysis. Table 1 is a summary of the bibliometric data collection for the period 1998-2023 compared to the last five years.

Table 1. Synthesis of bibliometric data

Main information data	Results	
Timespan	1998:2023	2019:2023
Sources (Journals, Books, etc)	152	104
Documents	300	173
Document Average years from publication	4.06	1.91
Average citations per doc.	12.12	11.49
DOCUMENT CONTENTS		
Keywords Plus (ID)	958	553
Author's Keywords (DE)	392	232
AUTHORS		
Authors	758	490
Authors of single-authored docs	36	18
AUTHORS COLLABORATION		
Single-authored docs.	83	37
Co-authors per doc.	3.04	3.31

4.2 Annual papers Publications and citations

Figure 3 shows the number of papers published per year over the last 24 years, and its analysis shows a slight growth in manufacturing sustainability research in 2013, which has grown exponentially over the last five years.

The study identified 2022 as the year with the highest publication activity, with a total of 74 papers. At the time of the study, 2023 is still in the first quarter and an increase in publications is expected at the end of the year.

Figure 4 illustrates the average number of citations per year, with research published in 2000 having the highest number of citations. However, the number of citations does not remain constant over the years and has increased again after 2018. Figure 5 shows the 15 countries with the highest number of citations. It can be concluded that the United Kingdom, France, and Germany are the most cited countries with 291,162 and 137 citations respectively.

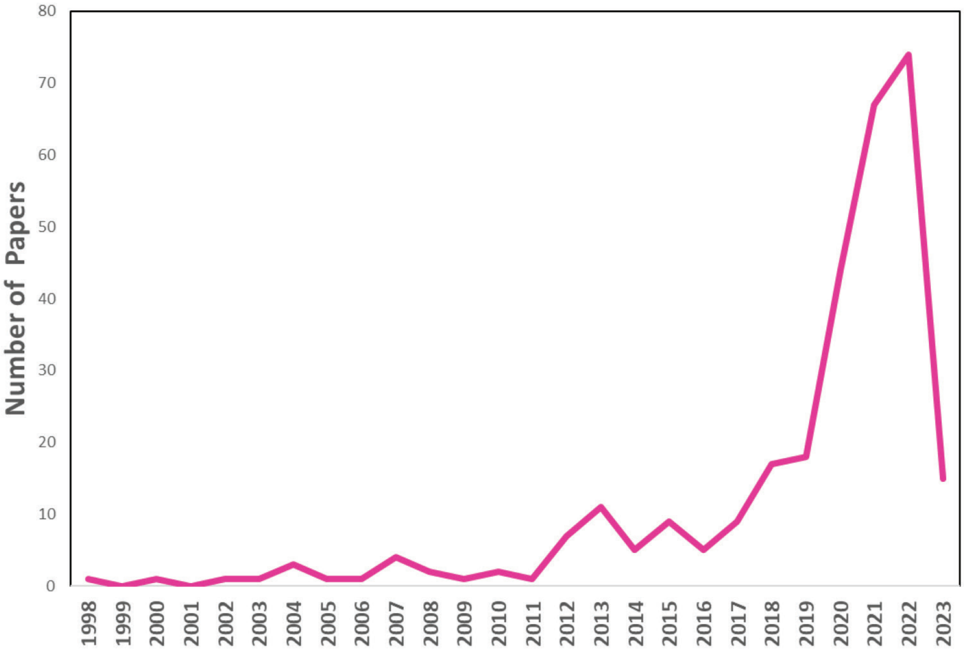

Figure 3. Annual Scientific Production

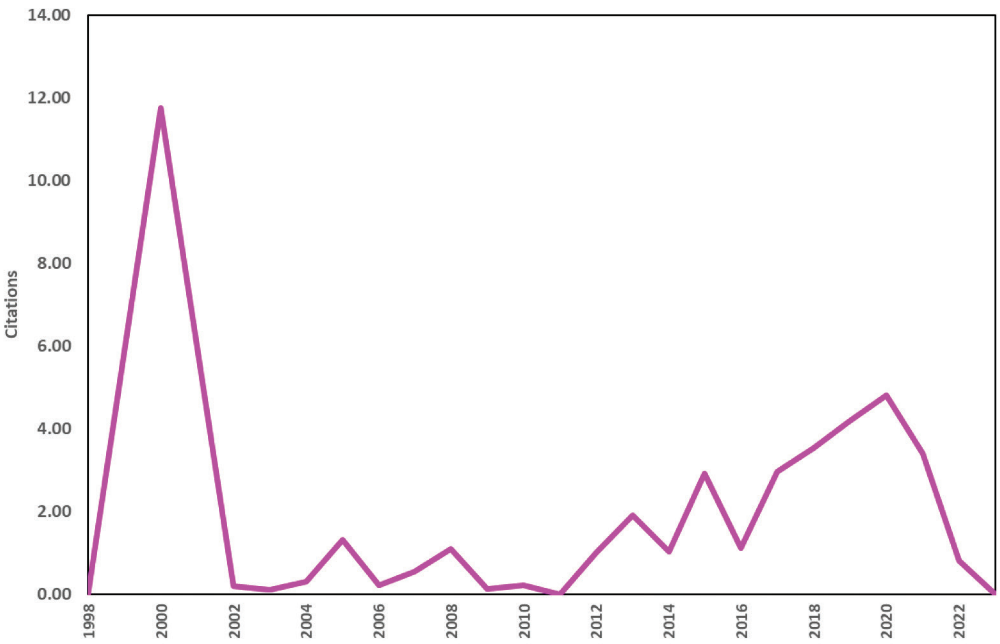

Figure 4. Average Citations per Year

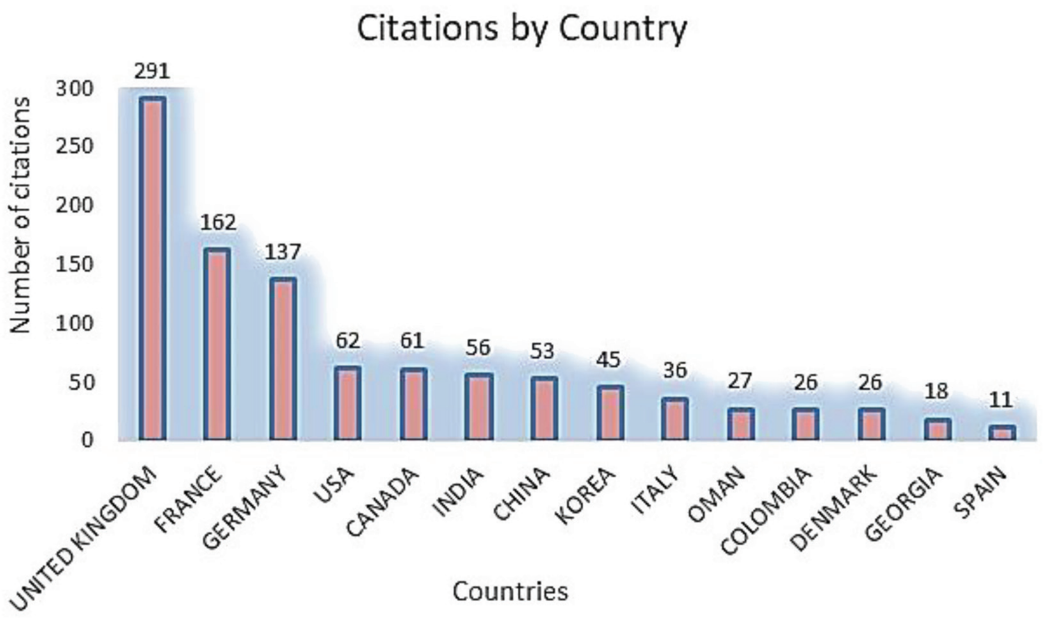

Figure 5. Number of citations by country

4.3 Main Sources and Their Growth

Examination of the growth patterns in the most pertinent sources has revealed the presence of five principal contributors. Sustainability, IFIP, Procedia, IFAC, and the International Journal of Production Research. These sources have played a pivotal role in shaping the discussions within their respective domains. Sustainability stands out as the frontrunner, accounting for 13.91% of total publications since 1998. The following closely are IFIP and Procedia, making contributions of 11.26% and 5.30%, respectively, to the overall body of work during this period, as illustrated in Figure 6.

Figure 7 illustrates the growth trends within these fields, indicating a significant increase in sustainability publications in recent years. This surge underscores the growing significance and relevance of sustainability in contemporary discourse, mirroring global efforts directed toward the achievement of sustainable development goals.

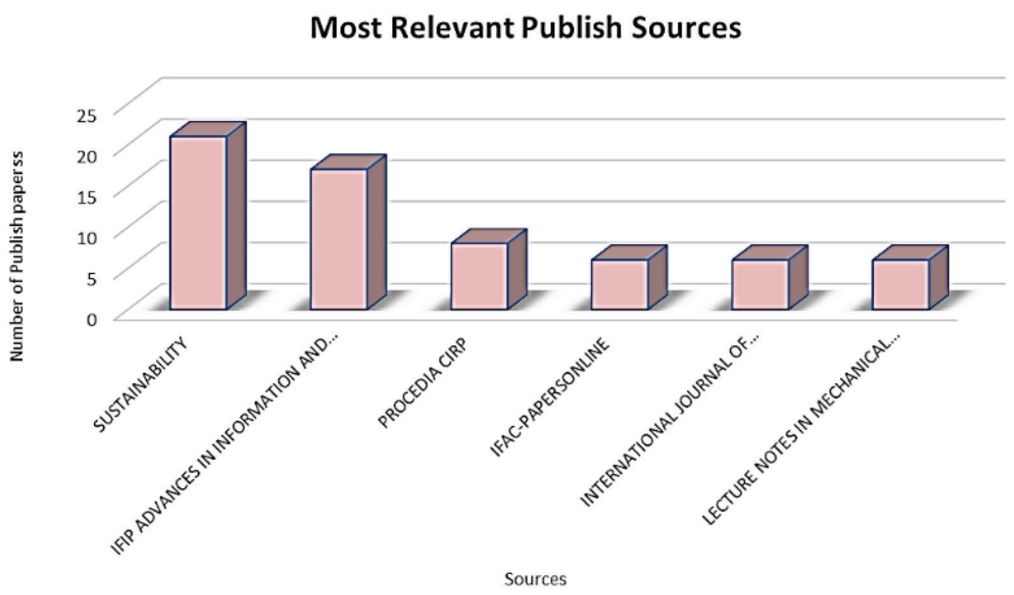

Figure 6. Most Relevant Publish Sources

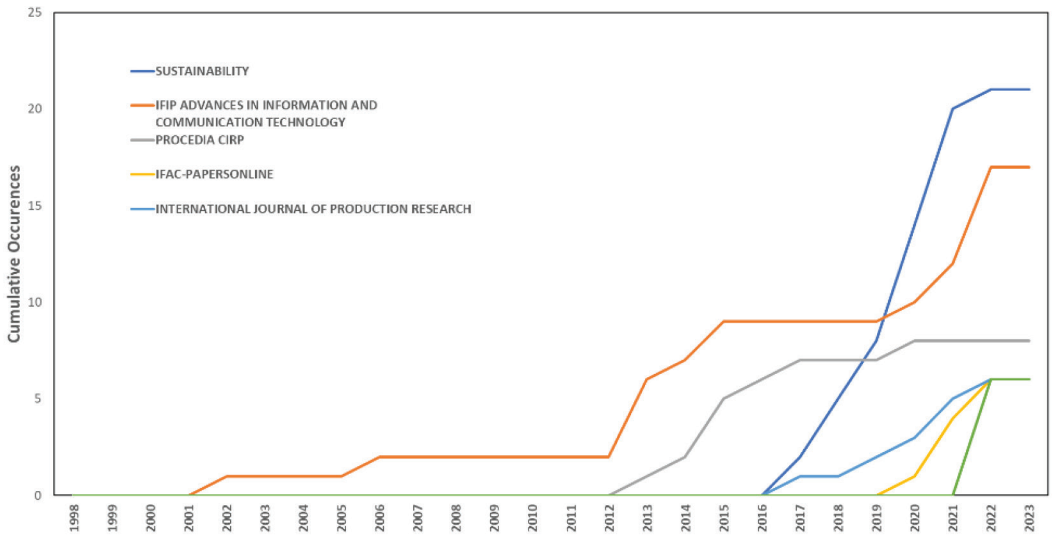

Figure 7. Sources' growth over the time

4.4 Words - Cloud, frequency, and co-wordNet

To carry out this analysis, a word cloud was created based on the most frequently used terms in scientific publications in recent years and that are linked to the keywords used in this research (sustainable manufacturing and artificial intelligence). Figure 8 a) and b) shows the word cloud that representing the most frequently occurring terms in scientific publications. Remarkably, there does not seem to be a significant difference in the frequency distribution of terms between the years 1998 and 2023 compared to the years 2019 and 2023. This is because research and publishing on sustainable manufacturing will only grow exponentially from 2019, as shown in Figure 3. In the last five years, the volume of publications in sustainable manufacturing is approximately 73% of the total research publication.

Figure 9 illustrates the frequency distribution of different keywords over time in this research area. The figure shows that in the initial phase of this research area, the keyword most searched with the highest frequency was "manufacturing", followed by "sustainable" and "artificial intelligence" as the second and third most searched keyword. However, it is worth noting that all the other keywords have become more important in recent years.

Analysing the most popular search terms, two main clusters emerged, one related to "sustainable manufacturing" and the other to "artificial intelligence". Figure 10 shows a strong correlation between all the keywords in these clusters. This suggests that these topics are often discussed together, indicating a growing interest in the intersection of sustainable manufacturing and artificial intelligence. This could be due to the potential of AI to optimise manufacturing processes, reduce waste, improve efficiency, and ultimately contribute to more sustainable practises. It may also reflect a broader societal trend towards the integration of technology and sustainability.

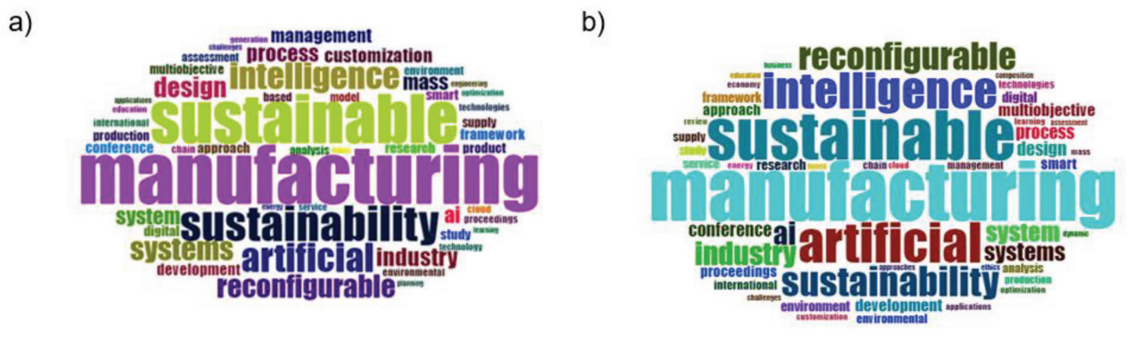

Figure 8. Word Cloud a) 1998-2023; b)2019-2023

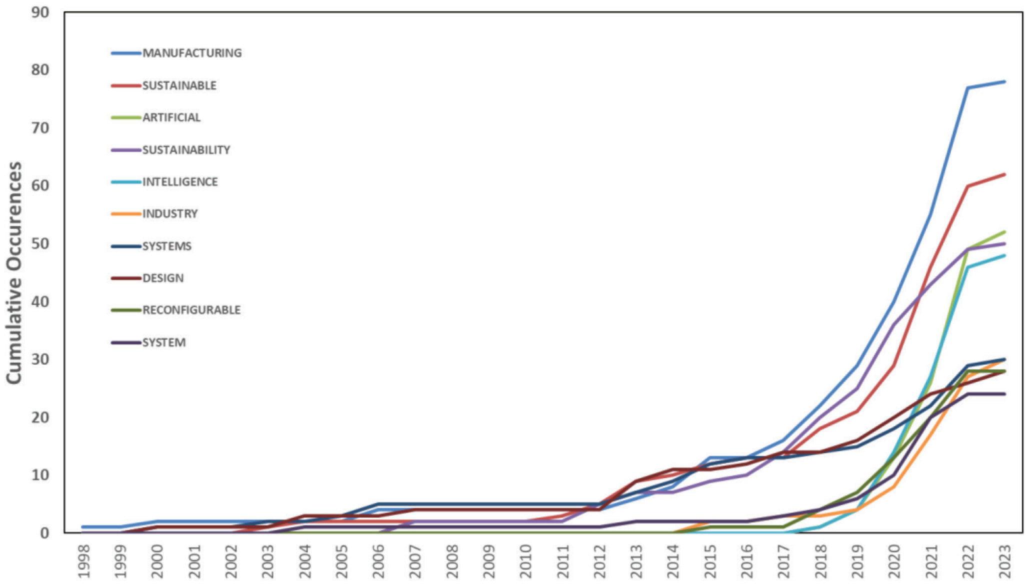

Figure 9. Word frequency over the time

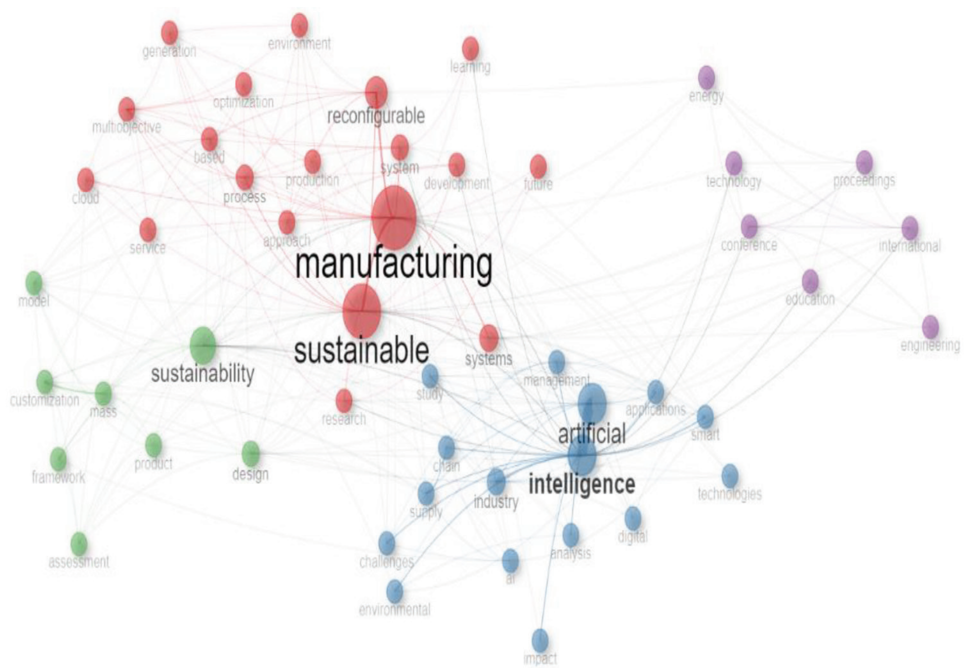

Figure 10. CoWordNet

4.5 Countries production and collaborations

Figure 11 a) shows that the USA, China, Australia, and the UK contribute most to the density of publications in the field of sustainable manufacturing. On the other hand, the African continent has the lowest contribution in this regard.

Figure 11 b) shows the countries with the highest level of collaboration in this research area, with Australia collaborating most with Pakistan, Chile with Colombia, and the USA with China.

4.6 Publication metrics

Table 2 provides a comprehensive framework highlighting the most frequently cited publications from the bibliometric review. The study with the highest number of citations is "Artificial intelligence and business models in the perspective of sustainable development goals: A systematic review of the literature by Di Vaio et al. [41]. This paper investigates the role of AI in shaping sustainable business models, offering a quantitative overview of the academic litera-

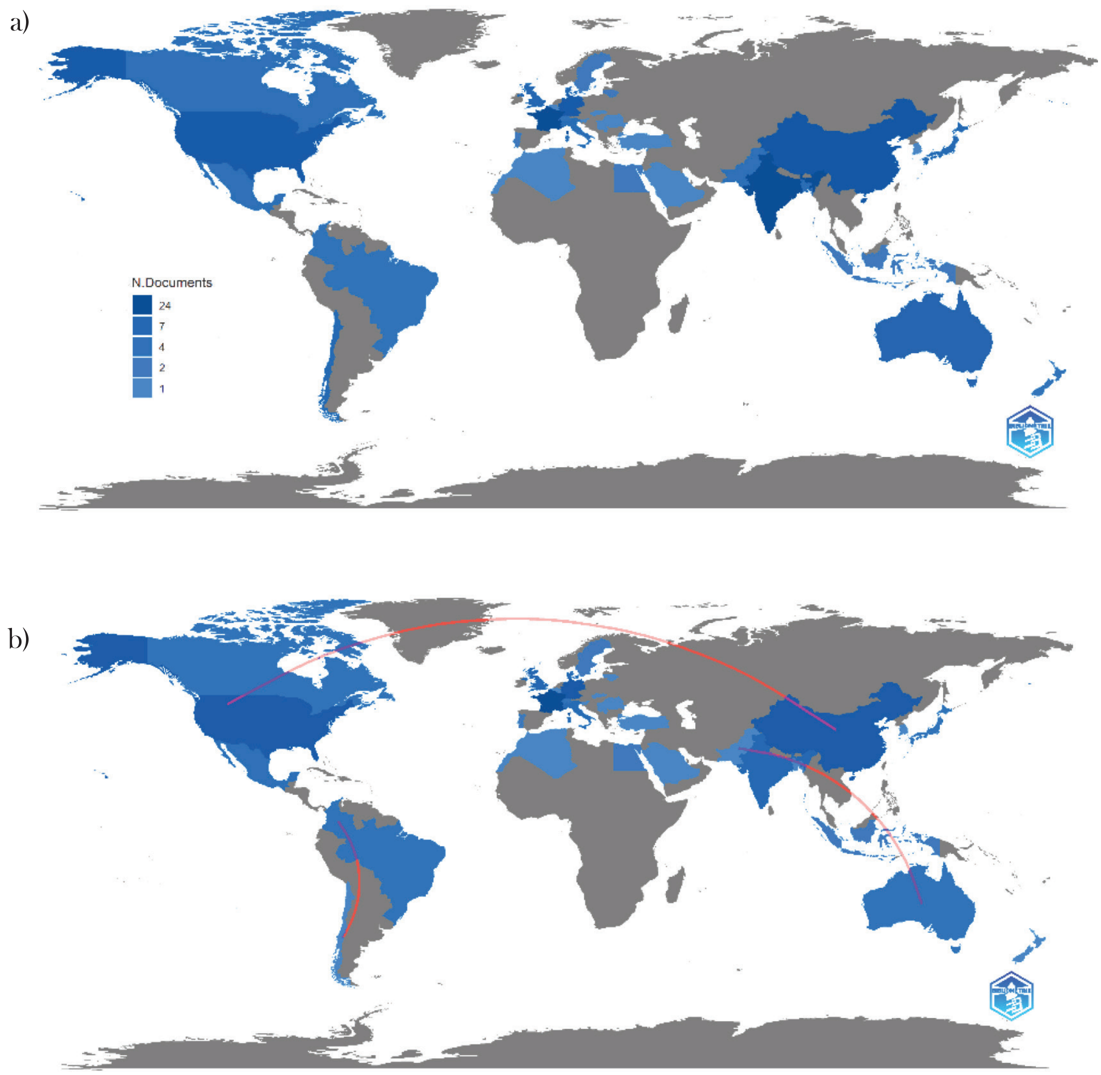

Figure 11. Countries a) Production b) Collaborations

ture in this field. The paper delves into the relationships between AI, rapid advancements in machine learning, and sustainable development. The second most cited paper is "Artificial Intelligence, Transport, and the Smart City: Definitions and Dimensions of a New Mobility Era" by Nikitas et al. [42], which has received 107 citations. This paper explores how AI, equipped with deep learning functions and capabilities, can serve as a tool to address issues that could transform urban environments. The authors conclude that the increased citation count for these studies can be attributed to the expanding research on the application of AI techniques in decision support across various domains, notably in production decision support systems. This trend indicates a growing recognition of AI's potential to contribute to sustainable development and smart city initiatives. The high citation count further underscores the significant impact of these works within their respective fields, influencing subsequent research and contributing to ongoing academic discourse.

In recent years, sustainability has become a prominent concern, drawing significant attention from both individuals and organisations. Recognising the imperative to address the economic, social, and environmental consequences of their actions, these entities have actively contributed to the growing body of research dedicated to understanding sustainable development and formulating strategies to mitigate the adverse effects of economic growth and development on our planet and its inhabitants.

This study embarks on an analysis of research papers published in the last five years with the aim of delving deeper into the current landscape of sustainability research. The papers selected for this study, as detailed in Table 3, comprehensively consider, and apply the three core dimensions of sustainability: economic, social, and environmental aspects. This inclusive approach ensures a well-rounded understanding of sustainability and its multifaceted implications.

Table 2. The Ten Most Cited Publications on the obtained Data

Author	Title	Synthesize Research	Citations
Di Vaio et al. [41]	"Artificial intelligence and business models in the sustainable development goals perspective: A systematic literature review"	Using knowledge management systems (KMS), the authors examine the role of AI in creating sustainable business models (SBMs) in the context of the SDGs. It provides a comprehensive review of the relationship between AI and SBM, identifies research gaps regarding KMS through AI, and discusses the implications of AI in relation to the SDGs.	182
Nikitas et al. [42]	"Artificial Intelligence, Transport and the Smart City: Definitions and Dimensions of a New Mobility Era"	This paper discusses the potential of AI, if used responsibly, to facilitate a sustainable transition. It highlights the importance of building trust and removing risks for the transition to take off, and emphasises that AI-based mobility must be user-centred, understanding and satisfying human users, and society.	107
Kaewunruen et al. [43]	"Digital twin aided sustainability-based lifecycle management for railway turnout systems"	This paper focusses on the development of building information modelling (BIM) for railway turnout systems and life cycle analysis to improve the effectiveness, efficiency and sustainability of design, manufacturing, construction, installation and operation activities throughout the life cycle.	93
Wynsberghe [44]	"Sustainable AI: AI for sustainability and the sustainability of AI"	The authors discuss the sustainability of AI, focussing on sustainable data sources, power supplies, and infrastructure to reduce the carbon footprint of training and/or tuning an algorithm. AI for sustainability refers to the use of AI to address environmental and climate issues and to enhance the accelerating trend towards high performance computing in modelling and simulation.	89
Morgan et al. [45]	"Industry 4.0 smart reconfigurable manufacturing machines"	The authors explore the state of the art in enabling distributed and decentralised machine control and machine intelligence. The paper provides a fundamental research review of reconfigurable manufacturing systems, which have gained global attention for their ability to respond quickly to changing customer requirements, dynamic market conditions and technological advances.	86
Yigitcanlar et al. [46]	"The Sustainability of Artificial Intelligence: An Urbanistic Viewpoint from the Lens of Smart and Sustainable Cities"	In this study, the authors explore and question the sustainability of AI through the lens of smart and sustainable cities and generate insights into emerging urban artificial intelligence. It provides a detailed review of the current state of AI and smart and sustainable cities literature, research, developments, trends, and applications, contributing to existing academic debates in the fields of smart and sustainable cities and AI.	81
Zobel-Roos et al. [47]	"Accelerating Biologics Manufacturing by Modelling or: Is Approval under the QbD and PAT Approaches Demanded by Authorities Acceptable without a Digital-Twin? "	This paper highlights the importance of Quality by Design (QbD) and Process Analytical Technology (PAT) to gain regulatory approval for new biologics manufacturing processes. The research paper highlights the use of advanced technologies such as QbD, PAT, and digital twins to ensure the quality and safety of biologic manufacturing processes and facilitate their approval by regulatory authorities.	62
Hughes et al. [48]	"Perspectives on the future of manufacturing within the Industry 4.0 era"	The main objective of this research work is to analyse the different perspectives on the future of manufacturing in the "Industry 4.0 era" and discusses the challenges and barriers manufacturers are facing in their transition to new technologies. It aims to provide information on Industry 4.0 and proposes a framework for Industry 5.0 in manufacturing.	54
Burström et al. [49]	"AI-enabled business-model innovation and transformation in industrial ecosystems: A framework, model and outline for further research"	In this study, the authors discuss the potential for business growth in manufacturing companies through innovation of AI-enabled business models. The authors conducted interviews with key people to understand how they have adopted AI and transformed their business models. The paper provides a framework for further research on AI-enabled business model innovation in industrial ecosystems.	52

Table 3. Research applying the three sustainability dimensions

Year	Author	Title	Econ.	Social	Environ.
2023	Mantello et al. [50]	"Bosses without a heart: socio-demographic and cross-cultural determinants of attitude toward Emotional AI in the workplace"	X	X	X
2022	Dauvergne [51]	"Is artificial intelligence greening global supply chains? Exposing the political economy of environmental costs"	X	X	X
2022	Andeobu et al. [52]	"Artificial intelligence applications for sustainable solid waste management practices in Australia: A systematic review"	X	X	X
2022	Ernst [53]	"The AI trilemma: Saving the planet without ruining our jobs"	X	X	X
2022	Ronaghi [54]	"The influence of artificial intelligence adoption on circular economy practices in manufacturing industries"	X	X	X
2022	Paraman et al. [55]	"Ethical artificial intelligence framework for a good AI society: principles, opportunities and perils"	X	X	X
2022	Vyhmeister et al. [56]	"Risk as a driver for AI framework development on manufacturing"	X	X	X
2021	Kunkel et al. [57]	"Digitalisation, sustainable industrialisation and digital rebound–Asking the right questions for a strategic research agenda"	X	X	X
2021	Wynsberghe [44]	"Sustainable AI: AI for sustainability and the sustainability of AI"	X	X	X
2021	Gupta et al. [58]	“Assessing whether artificial intelligence is an enabler or an inhibitor of sustainability at indicator level"	X	X	X
2021	Goh et al. [59]	"Regulating artificial-intelligence applications to achieve the sustainable development goals"	X	X	X
2021	Fraga-Lamas et al. [60]	"Green IoT and edge AI as key technological enablers for a sustainable digital transition towards a smart circular economy: An industry 5.0 use case"	X	X	X
2020	Hydén [61]	"AI, norms, big data, and the law"	X	X	X

The authors identified the most relevant publications dealing with the three dimensions of sustainability and the results are summarised in Table 3. The papers are organised according to the main themes, with the most recent publications appearing first, followed by older publications.

The issue of sustainability has gained considerable prominence in recent years as more and more individuals and organisations have recognised the need to address the economic, social, and environmental impacts of their actions. As a result, a growing body of research has emerged that focusses on understanding sustainable development and identifying strategies to mitigate the negative impacts of economic growth and development on the planet and its inhabitants.

Most of the research papers presented in Table 2 indicates that an increasing number of solutions proposed by various researchers involve the development of decision support systems using AI techniques, thereby enabling sustainability to be achieved more effective and efficient manner.

The issue of sustainability has gained considerable prominence in recent years as more and more individuals and organisations have recognised the need to address the economic, social, and environmental impacts of their actions. As a result, a growing body of research has emerged that focusses on understanding sustainable development and identifying strategies to mitigate the negative impacts of economic growth and development on the planet and its inhabitants.

5. Discussion

Although this study effectively met its objectives, several limitations should be noted. Firstly, the Matthew effect, a common problem in bibliometric research, occurs when authors refer to prestigious journals or authors solely because of their reputation, even if the content isn't entirely relevant [62]. Second, the study focused only on peer-reviewed publications, which guarantees quality but omits potentially valuable sources such as dissertations, reports, and theses, potentially affecting the representativeness of the data.

Future research in sustainability assessment offers promising avenues for interdisciplinary collaboration between fields such as computer science, environmental science, and engineering. This collaboration can lead to the development of holistic sustainability assessment models that seamlessly integrate index functions and AI. In addition, there is an opportunity to explore the integration of AI and index functions within the framework of circular economy principles, enabling the assessment of sustainability in resource use, recycling initiatives and waste reduction strategies within a circular economy context. In addition, the application of AI-driven sustainability assessments can be further explored through comprehensive case studies and practical implementations in different industries and sectors. These efforts aim not only to demonstrate the effectiveness of AI-based sustainability assessments, but also to identify best practices and lessons learned for their successful integration into real-world applications.

6. Conclusions and Future Research

This manuscript presents a systematic bibliometric analysis of the Sustainable Manufacturing Index Function together with the AI Manufacturing. The aim of this research is to evaluate the existing literature on the subject through statistical analysis. The study takes into account the years of publication and the average annual citations of the literature.

Through this systematic bibliometric analysis, the methodology used in this study has demonstrated its ability to identify significant prior literature and to identify emerging research trends, as well as research gaps at the intersection of the sustainability index function and IA. This research has made a notable contribution to the field by shedding light on the most and least discussed aspects of the relationship between sustainability and IA, as well as identifying the most relevant research conducted to date, including the respective authors and countries of origin.

Whilst the objectives of this research have been accomplished, it is pertinent to note that limitations exist within the study. Specifically, the research was limited to scholarly publications that have undergone rigorous quality control measures through scientific journal publishing. Nevertheless, this approach resulted in the exclusion of other forms of research such as dissertations, reports, and theses. Additionally, data collection was restricted to the Web of Science, Elsevier's Scopus, and Dimensions platforms, thus possibly excluding certain publications, and potentially affecting the representativeness of the findings presented.

Using artificial intelligence, in future studies will seek to develop a tool capable of evaluating, analysing, and proposing sustainable decisions to optimise production systems.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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