AI COMPONENTS FOR PERFORMANCE MEASUREMENT - A BIBLIOMETRIC APPROACH

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Abstract
This study employs a bibliometric approach to analyze the landscape of artificial intelligence (AI) components used in performance measurement. As organizations increasingly leverage AI for optimizing processes and decision-making, understanding the trends in AI components becomes imperative. The identified AI components are classified based on their roles in enhancing performance measurement, offering insights into the prevalent methodologies and emerging technologies. The bibliometric analysis encompasses a comprehensive review of scholarly articles, conference papers, and patents, systematically exploring the evolving field. In this research, the methodology involves data extraction from reputable academic databases and patent repositories, followed by applying bibliometric techniques to quantify and visualize key aspects. The findings of this study contribute to the existing knowledge by mapping the intellectual structure of AI components for performance measurement.

Keywords: *AI; artificial intelligence; bibliometric; performance; information.*

JEL Classification*: D83, L63, P17.*

1. Introduction

In modern times, Artificial Intelligence (AI) plays a critical role in shaping the technological landscape. It has revolutionized the way we engage with our surroundings, with the core of this transformation being the essential components of AI. These components each play a distinct and crucial role in powering intelligent systems. Measuring the effectiveness of AI systems is a significant challenge, given the broad range of applications and contexts in which they are used.

Our goal with this article is to delve into the realm of AI and its impact on performance measurement. From intricate algorithms and deep learning models to natural language processing systems and user-friendly interfaces, AI components create a multifaceted ecosystem that produces impressive outcomes in fields like facial recognition, voice assistance, and data analysis. Nevertheless, as these components continue to advance, it becomes increasingly crucial to meticulously assess and gauge their performance. In the captivating era of AI evolution, where discoveries and technological progress rapidly succeed one another, bibliometric analysis becomes an essential tool to fully investigate and understand the complex landscape of the field of artificial intelligence, with a focus on performance measurement.

Through bibliometric methods, authors can investigate and quantify scientific production in the field of artificial intelligence, identifying trends, influences, and notable contributions. This approach provides a panoramic view of research networks, connections, and technological evolution, thus facilitating the quantifiable and objective evaluation and classification of performance. By exploring reference works, academic collaborations, and impact within the scientific community, bibliometric analysis allows us to identify not only notable achievements but also gaps or emerging directions in AI research.

In this current era, the scientific community is heavily invested in exploring and developing artificial intelligence. Researchers from various fields, including technical sciences, humanities, and exact sciences, are intrigued by the potential of AI. For some time, scientists have been working to create a self-sufficient system that can think and function on its own, while also working in tandem with human cognition. However, due to the novelty of this field, no comprehensive definition of AI's structure has been established yet. It is believed that AI is "the determining technology of the future", although its history does not exceed a century of existence (Stanila, 2020).

Some researchers believe that AI has its origins in Greek myths, in Aristotle's desire to understand his own thoughts (Kobbacy et al., 2007; Haenlein & Kaplan, 2019). Historically, AI as a scientific endeavor was born in the 1950s, at the confluence of several currents of research, through famous actors and thinkers, such as Claude Shannon (1941), Alan Turing (1950), and Herbert Simon (1979). AI developments have been made possible by the tremendous boom of computing in general and the subsequent digitization of society in particular (Risse, 2019). Also, Walter Pitts and Warren McCullough published the first paper on a mathematical model for creating an artificial neural network in 1943. (McCulloch & Pitts, 1943).

AI was once a mere concept in the realm of science fiction. Nowadays, however, it has become an integral part of our daily routines. While we are still some time away from widespread robot use, AI has already made a significant impact in our lives - albeit in more subtle ways. From weather predictions to email spam filtering, Google search predictions, and Apple's SIRI voice recognition, these technologies are all connected through machine learning algorithms that enable real-time reactions and responses. Although advances in AI technology will also cause difficulties, the benefits AI will bring are superior. (Averkin & Yarushev, 2018)

The paper is organized as follows: Section 2: Literature review for presenting the dimensions that AI affects; Section 3: Research Methodology to describe the methodology and data collection process; Section 4: Results to present results obtained by referring to different criteria based on the investigation methods. After that, in Section 5, we present concluding remarks and summarize the conducted study.

2. Literature review

In the realm of artificial intelligence, scientific articles have shown exponential growth in research and a wide range of applications, with a greater focus on the ethical and social implications of implementing this advanced technology. The field of AI is rapidly evolving, with an abundance of research and development driving innovation and progress. Recent scientific articles have identified key directions and challenges in advancing artificial intelligence, illuminating significant trends and breakthroughs (Bogachov et al., 2020).

Broadly speaking, machine intelligence can be classified into two categories: hard computing and soft computing. Hard computing relies on binary logic, explicit systems, and numerical analysis and necessitates precisely defined analytical models to generate precise outcomes. On the other hand, soft computing can process fuzzy and noisy data and incorporates probabilistic information that enables parallel computing. Utilizing fuzzy logic, neural networks, and probabilistic reasoning, soft computing can create its programs to produce approximate solutions. (Pedrycz, 1990).

Artificial intelligence involves machines that can replicate human-like functions such as reasoning, planning, learning, and creativity. It is widely recognized as a crucial component of society's digital evolution, and the EU has prioritized it. Its practical applications include online shopping, advertising, internet searches, personal digital assistants, machine translation, smart homes and cities, infrastructure, cars, cybersecurity, and even the medical field (Cao et al., 2023).

AI is also defined as “a complex of technological solutions that allow human cognitive function simulation (including self-learning and finding solutions without a predetermined algorithm) and obtaining results that are comparable with specific task performance, with the results of human intellectual activity at least” (Dneprovskaya & Abramitov, 2020; Sukhodolov et al., 2020).

One of the dominant aspects in recent scientific literature is the continued progress in the field of deep learning (Torfi et al., 2020). Deep learning models, such as convolutional neural networks and recurrent neural networks, have had a significant impact in areas such as computer vision, natural language processing, and pattern recognition (Wang et al., 2020).

There is a growing emphasis on the interpretability of AI models and associated ethical considerations. Recent articles explore ways to make AI algorithms more transparent and address ethical concerns, such as algorithmic bias and the social implications of AI implementations (Linardatos et al., 2020; John-Mathews, 2022).

In recent years, scientific literature has focused on the application of artificial intelligence in the healthcare sector, emphasizing disease diagnosis and prognosis. Articles highlight progress in early disease detection, personalized treatments, and efficient medical data analysis (Tran et al., 2019).

Also, artificial intelligence has increased interest in business process automation and using robots in various industries. Scientific literature explores ways to successfully integrate robots and intelligent agents into production and service processes (Aguirre & Rodriguez, 2017).

Research on assistive systems and human-machine interaction constantly expands (Wandke, 2005). Recent articles explore the development of intuitive interfaces, voice assistance, and the relationship between humans and intelligent agents in different contexts (Vaghasiya et al., 2023). Another significant theme addressed in recent literature is artificial intelligence security. Articles analyze possible vulnerabilities of AI algorithms and propose methods to protect against cyberattacks (Villegas-Ch & García-Ortiz, 2023).

The current context of artificial intelligence, as reflected in scientific articles, illustrates exponential growth in research and diversification of applications, as well as increased attention to ethical and social aspects associated with implementing this advanced technology.

Several terms related to artificial intelligence can be found in the literature and need to be identified to further develop the state of the art. But Abioye et al. (2021) graphically captured all these terms in Figure 1.

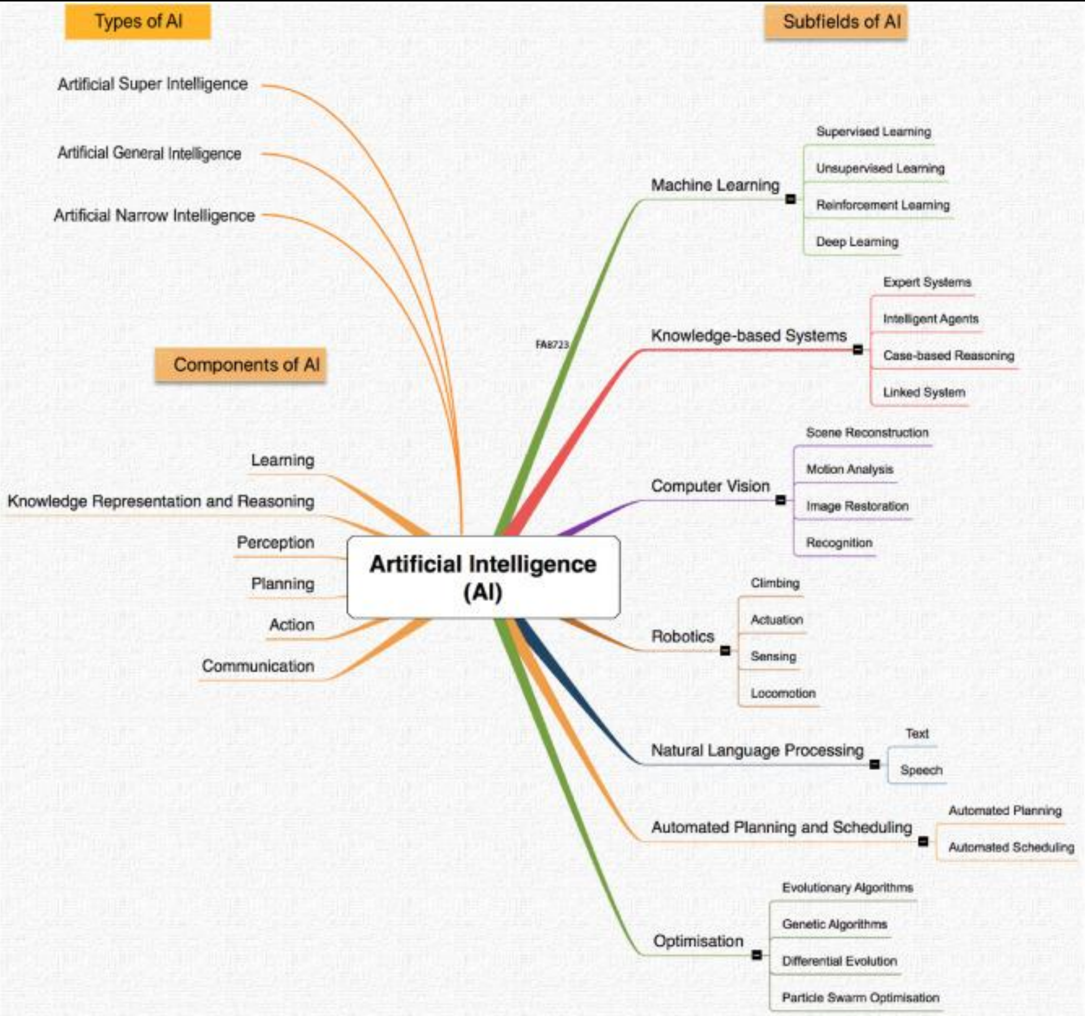

Figure 1. Components, types and subfields of AI

Source: Abioye et al., 2021

The potential for AI to bring about significant economic and social impact across all areas of activity, particularly in the economic and organizational fields, is undeniable. However, the inconsistent history of AI adoption may cause potential adopters within economic entities to approach it cautiously. This raises the question of whether AI truly assists decision-makers in economic entities in making the best decisions and becoming indispensable.

Analyzing how AI can be implemented in decision-making by decision-makers in an entity, we find that it can help in various aspects as follows:

- AI can use machine learning algorithms to find patterns and predictions to help make strategic decisions.
- AI systems can recognize objects and people in images stored by other departments subordinate to management, selecting essential data and converting speech into text so that the manager or decision maker can analyze the relevant data.
- AI used by organizational management can be used to analyze large amounts of data, such as customer behavior or medical data, to find patterns and trends to establish future trends and directions of the entity.

Forward-thinking companies that embrace digital and analytical transformations are gaining a competitive edge, leaving those who lag even further behind. A triumphant implementation of such a program necessitates addressing several crucial factors: identifying the business case, configuring the appropriate data ecosystem, procuring suitable AI tools, and modifying workflow processes, capabilities, and culture (Chui, 2017).

3. Research Methodology

This study aims to explore the Web of Science Database (WOS) and analyze the significant progress achieved in the field of artificial intelligence (AI), in correlation with performance, from its origins until the present day. Using scientific mapping methods and bibliometric indicators, this study examines the leading authors, institutions, countries, and journals involved in AI research and performance correlation.

The research investigation adheres to the PRISMA Statements methodology, which comprises five structured steps as outlined by Moher et al. (2015): (1) developing a data search strategy, (2) collecting relevant data, (3) screening and filtering data, (4) conducting quantitative analysis, and (5) interpreting the findings (see Figure 2). Bibliometric research involves using graphical representations and statistical tables to assess the current state of research and its potential for future development. To collect data, filtering models were employed to identify key works, authors, organizations, countries, and journals in the field. The resulting network of citations and co-appearances was analyzed to identify the main elements of the research landscape.

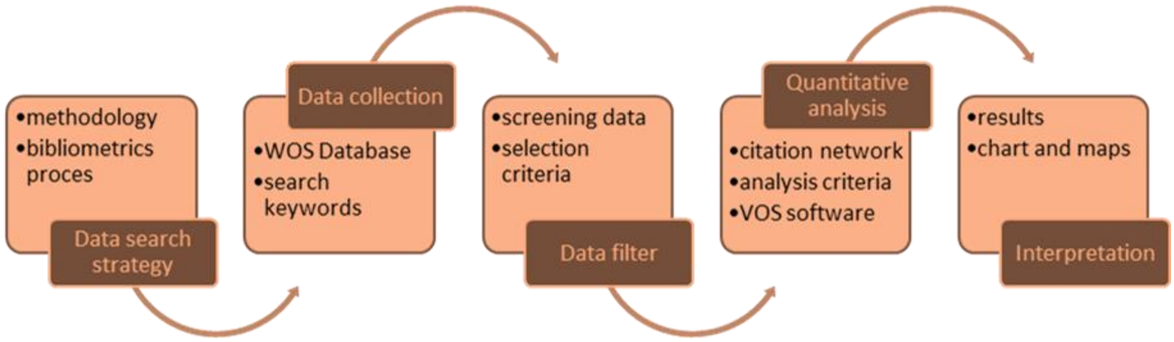

Figure 2. Research phasing in bibliometric research using Prisma

Source: Radu et al., 2021

Our bibliometric analysis utilizes co-citation, co-authorship, and co-occurrence data to identify similarities and group-related items. This data is presented as color-coded results using mapping software. Citations play a crucial role in showcasing the merit of previous research, highlighting the pioneers of the intellectual base in the field, and revealing emerging research trends. Co-citation is a valuable tool for identifying new scientific topics by tracking the frequency with which two papers are cited together in other research. These indicators serve as important metrics for disseminating research and uncovering new scientific topics by examining previously published works. The dimensions of these indicators may include the works' co-citation, authors, or the journals in which the research was published.

Co-authorship serves as an indicator of international recognition and collaborations among authors from various countries. It helps identify relevant nodes that lead to such collaborations. Co-occurrence networks are generated by connecting pairs of articles using a specific set of co-occurrences that define the criteria when using the software (Van Eck & Waltman, 2014). This technique helps identify AI topical in performance dimension and analyze the subject through indicators such as statistical functions. The bibliometric analysis relies on the Web of Science (WOS Core Collection) database as a source of information. This database is chosen for its high level of international recognition in terms of published scientific papers quality and its ability to bring together researchers from a diverse international academic community with a multidisciplinary character.

The search was performed through the WOS advanced search interface, searching for AI and performance terms using Boolean operations (Table 1.). The NEAR / 10 operator searches for registered keywords separated by the other words to form a logical phrase.

Table 1. Data selection in WOS Core Collection

Query **(Terms Searched; Years; Document Types)**	**Results**
TS= AI (All Fields) or artificial intelligence (All Fields) and performance (All Fields) Web of Science Core Collection All Document Types	593,014
TS= AI (All Fields) or artificial intelligence (All Fields) and performance (All Fields) Web of Science Core Collection *Refined by: Article (Document Types) and Science Citation Index Expanded (SCI-EXPANDED) or Social Sciences Citation Index (SSCI) (Web of Science Index) and English (Languages)*	354,488
TS= AI (All Fields) or artificial intelligence (All Fields) and performance (All Fields) Web of Science Core Collection Old Refined by: Article (Document Types) and Science Citation Index Expanded (SCI-EXPANDED) or Social Sciences Citation Index (SSCI) (Web of Science Index) and English (Languages) *Refined by: Economics or Management or Business or Business Finance (Web of Science Categories)*	**3,143**

Source: Data selection with WOS advanced research engine

Our research has yielded a total of 354,488 documents related to AI and performance in the Web of Science Core Collection. To ensure the highest quality results, we narrowed our search to document types (Articles) and Web of Science Index (SCIE and SSCI) in the English language. Further refining our findings using Web of Science Categories, we identified 3,143 relevant documents for our comprehensive study.

4. Results

At the initial level of analysis, we have considered the authors and their contributions. Out of 7,325 authors, we have established a criterion of 5 documents and 5 citations per author, resulting in 132 authors who satisfy this requirement. The number of articles for the top ten authors is then presented in Table 2, sorted by the number of documents, citations, and the degree of connections.

Table 2. Top ten authors with our topic of research

Author	Documents	Citations	Total link strength
Jawadi Fredj	24	338	47
Cheffou, Abdoulkarim Idi	22	309	44
Rozelle, Scott	10	227	36
Yue, Ai	11	204	35
Luo, Renfu	10	228	34
Jawadi, Nabila	15	153	32
Shi, Yaojiang	8	147	30
Zhang, Linxiu	7	145	30
Liu, Chengfang	5	132	23
Louhichi, Wael	9	109	21

In the graphic representation made by the VOSviewer program, two clusters are highlighted according to the number of documents, citations and strength of links (Figure 3).

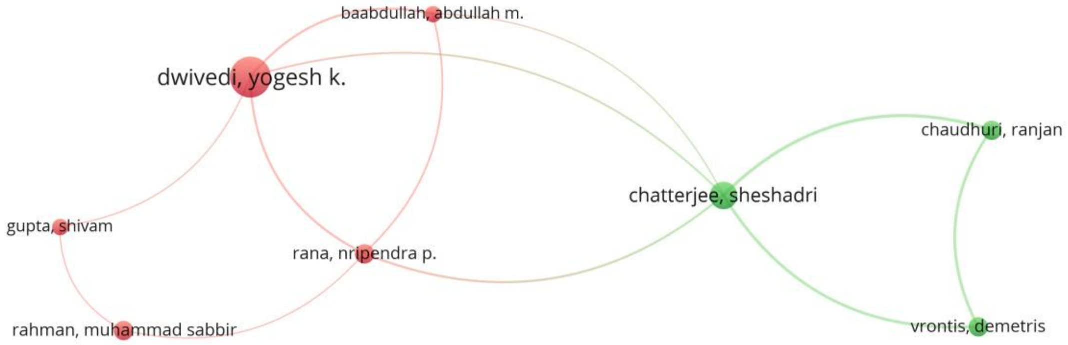

Figure 3. Links between authors of documents, citations and strength
Source: Author's research using VOSViewer Software

The second level of analysis pertains to the organizational affiliation. Our study includes a comprehensive collection of 2825 organizations, where we have set a criterion of 15 documents and 15 citations per organization. This criterion was met by 56 organizations. Table 3 provides an overview of the articles arranged according to the number of documents, citations, and the robustness of the associations.

Table 3. Top of organizational context

Organization	Documents	Citations	Total link strength
Stanford University	33	527	56
National Bureau of Economic Research	22	1021	54
Lebanese American University	18	130	53
Harvard University	31	3637	48
EDC Paris Business School	24	306	44
Asia University Taiwan	14	64	43
King s College London	17	221	43
UPES-University Of Petroleum And Energy Studies	10	37	42
IPAG Business School	18	156	40
MIT Massachusetts Institute of Technology	30	848	40

The graphical representation of affiliation units created using the VOSViewer program is presented in Figure 4, based on the number of documents, citations, and the strength of connections. Additionally, we have set the condition that a cluster must have a minimum of 10 entries.

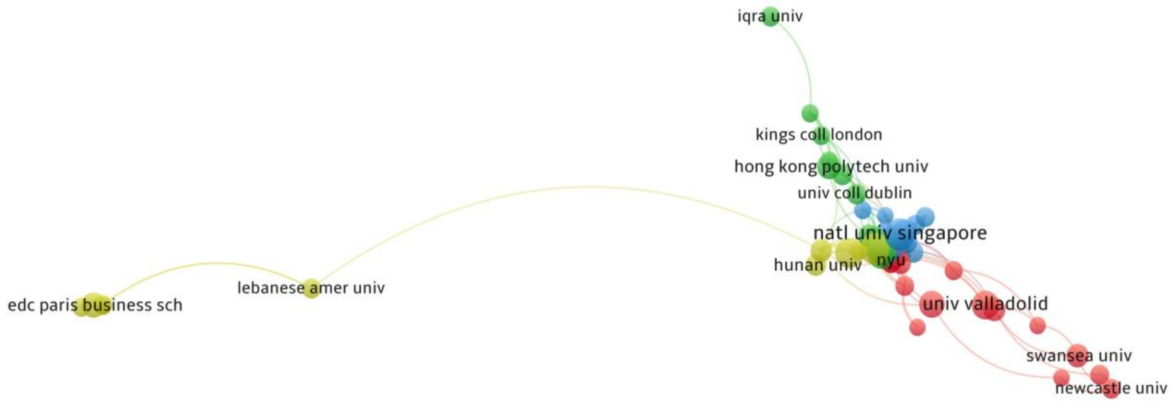

Figure 4. Links between organizations
Source: Author's research using VOSViewer Software

The analysis of the four clusters groups organizations either based on territorial considerations or linguistic considerations. Cluster 1 (Blue) is significantly more condensed, grouping 19 organizations, whereas Cluster 4 (Yellow) comprises 10 organizations and is much more dispersed.

The co-authorship analysis includes a third unit of analysis at the country level of affiliation. Our study includes 102 countries, and we have established that each country must have at least 15 documents and 15 citations to be considered. Based on this criterion, we have identified 41 qualifying countries. Table 4 displays the articles in order of the number of documents, citations, and the strength of connections.

Table 4. Top of the country level of affiliation

Country	Documents	Citations	Total link strength
USA	937	30679	708
England	386	9781	536
China	556	9618	447
Germany	205	5891	289
France	204	3845	284
Australia	172	5141	280
Canada	151	3010	218
India	128	2312	213
Spain	245	5592	166
Italy	124	1923	152

The graphical representation of countries of affiliation, created using the VOSviewer program, is presented in Figure 5, based on the number of documents, citations, and the strength of connections.

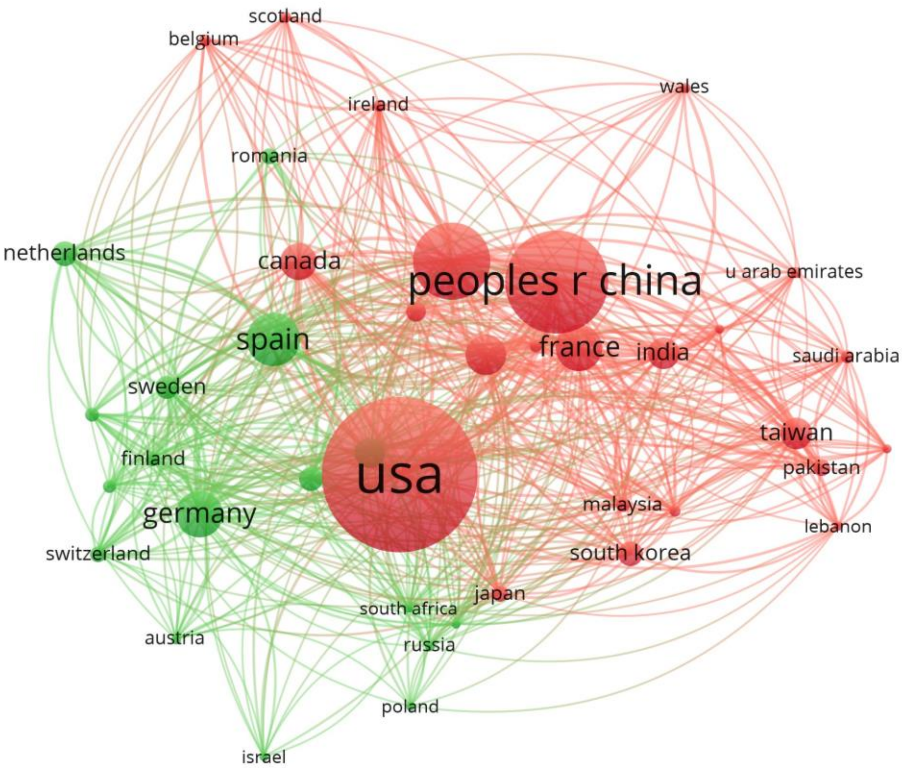

Figure 5. Links between the country level of affiliation
Source: Author's research using VOSViewer Software

Two distinct clusters are discernible, one dominated by the USA and China and many Asian countries strongly polarized. The second cluster is developed at the European level with implications for countries from other continents.

The second analysis direction is developed at the level of co-occurrence using the unit of analysis "All keywords". With 12,219 keywords, we have chosen a minimum occurrence threshold of 25. As a result, 129 keywords meet this condition. Table 5 presents the order of keywords/phrases based on the strength of connections.

Table 5. Top of the country level of affiliation

Keyword	Occurrences	Total link strength
artificial intellingence	677	2621
performance	286	1153
technology	244	1135
impact	293	1076
artificial -inteligence	226	1068
innovation	209	903
management	201	882
model	250	862
AI	183	781
big data	144	713

The graphical representation of keywords/phrases based on the strength of connections created using the VOSviewer program is presented in Figure 6.

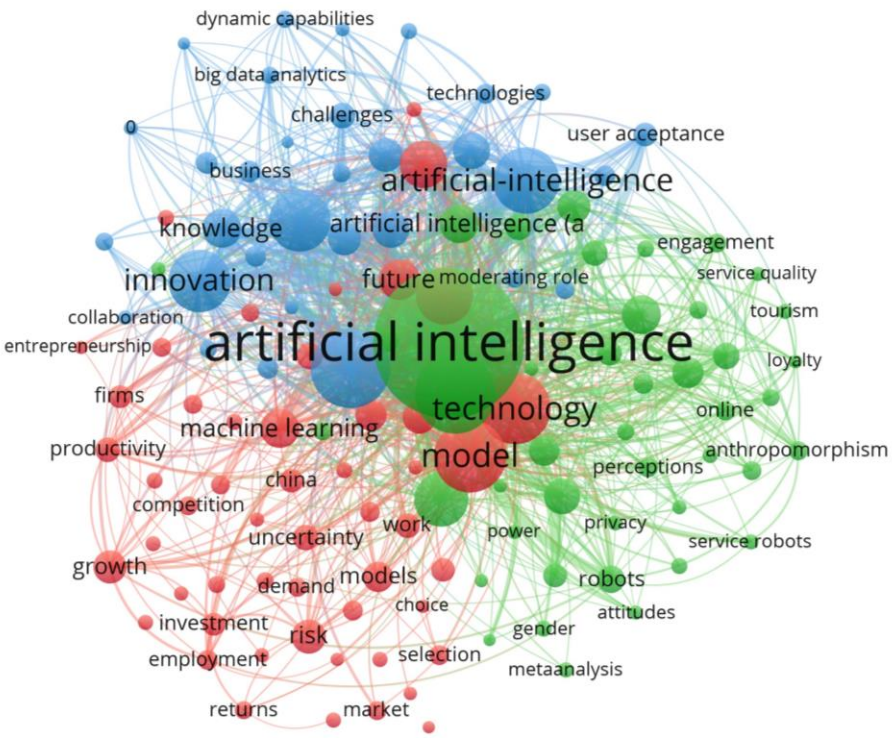

Figure 6. Links between keywords

Source: Author's research using VOSViewer Software

Furthermore, to highlight the strength of connections within the three clusters in which keywords/phrases are grouped, we conducted an analysis on each cluster, emphasizing the word with the highest link strength within the cluster:

- For Cluster 1 – "keyword technology with link strength 1135" (red),
- For Cluster 2 – "keyword artificial intelligence with link strength 2621" (green),
- For Cluster 3 – "keyword performance with link strength 1153" (blue).

The third analysis will be conducted based on the citation level of articles. The first unit of analysis is at the document level. With a total of 3021 documents, we have chosen the number of citations per document to be 60, and 248 meet this condition. The articles are presented in Table 6 based on the number of citations and connections.

Table 6. Top of the citation level of articles

Document	Citations	Links
Artificial Intelligence in Service *Huang (2018)*	846	26
Siri, Siri, in my hand: Who's the fairest in the land? On the interpretations, illustrations, and implications of artificial intelligence - *Kaplan (2019)*	619	23
Artificial Intelligence and Entrepreneurship: Implications for Venture Creation in the Fourth Industrial Revolution - *Chalmers (2021)*	74	17
Brave new world: service robots in the frontline -*Wirtz (2018)*	722	15
Rising with the machines: A sociotechnical framework for bringing artificial intelligence into the organization - *Makarius (2020)*	113	15
How AI capabilities enable business model innovation: Scaling AI through co-evolutionary processes and feedback loops - *Sjodin (2021)*	63	12
The Feeling Economy: Managing in the Next Generation of Artificial Intelligence (AI) Huang (2019)	142	12
How artificial intelligence will change the future of marketing - *Devenport (2020)*	469	12
Service robots, customers and service employees: what can we learn from the academic literature and where are the gaps? - *Vinh Nhat Lu (2020)*	201	10
A strategic framework for artificial intelligence in marketing - *Huang (2021b)*	203	10

The graphical representation created using the VOSviewer program is presented in Figure 7, based on the number of citations and connections.

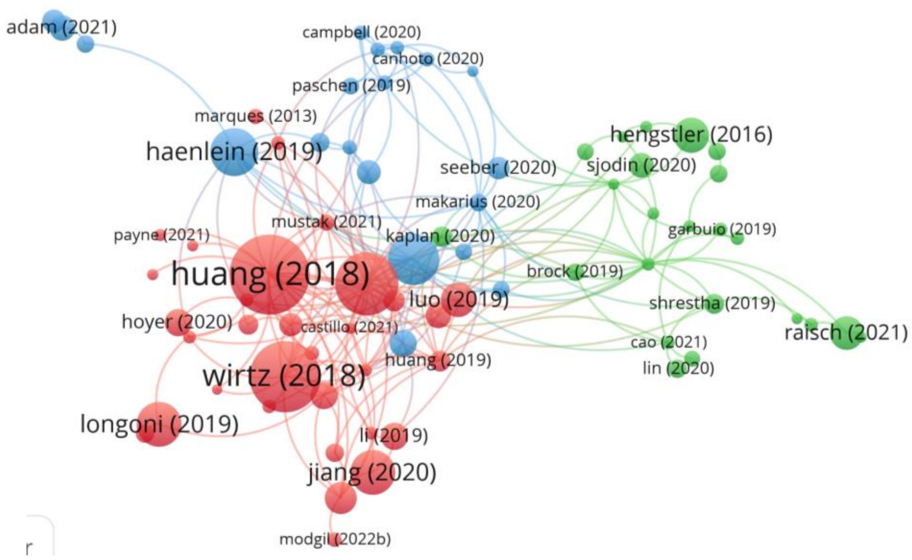

Figure 7. Links between citation level of articles
Source: Author's research using VOSViewer Software

The second citation unit was selected at the author level. With a total of 7325 authors, we applied filters of a minimum of 6 documents per author and 6 citations per author. Ninety-four authors met these criteria. Table 7 presents the classification of authors based on the strength of connections, including the number of documents and citations.

Table 7. Top of authors publication

Author	Documents	Citations	Total link strength
Jawadi Fredj	24	338	104
Cheffou, Abdoulkarim Idi	22	309	95
Jawadi, Nabila	15	153	89
Huang, Ming-hui	6	1486	85
Chatterjee, Sheshadri	9	381	71
Dwivedi, Yogesh K.	14	532	67
Malik, Ashish	9	152	61
Budhwar, Pawan	7	136	59
Grewal, Dhruv	6	579	59
Guha, Abhijit	6	579	59

In Figure 8, we graphically represented the connections between authors, using connection strength between documents, the number of documents, and the number of citations as comparison filters.

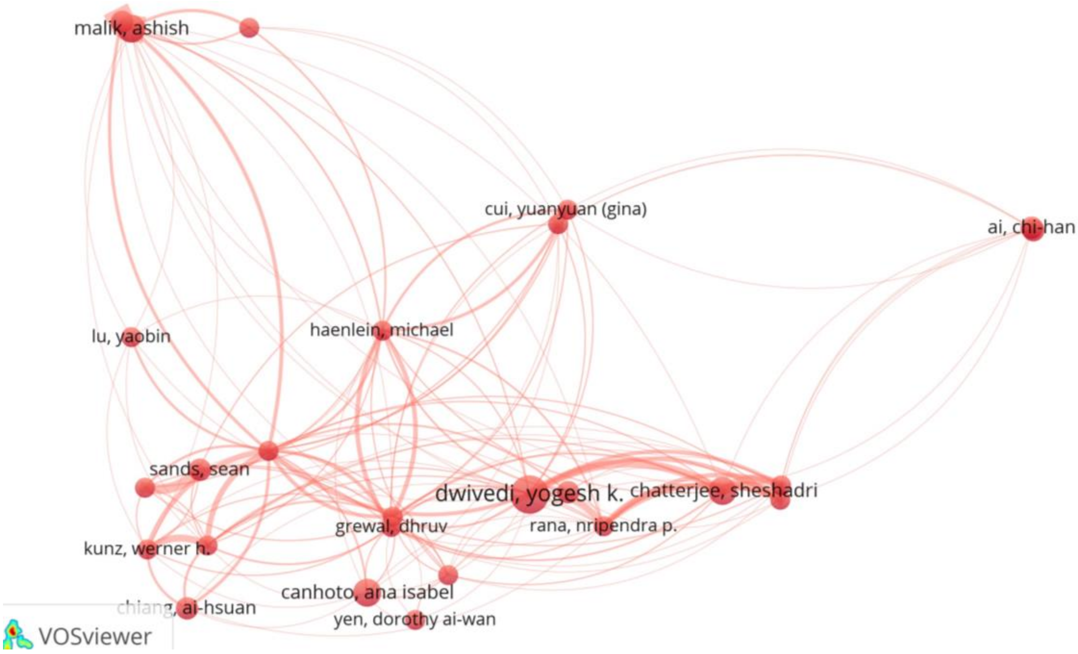

Figure 8. Links between author's publications
Source: Author's research using VOSViewer Software

The third citation unit was selected at the affiliation level. With a total of 2825 organizations, we applied filters of a minimum of 15 documents per organization and 15 citations per organization. Fifty-six organizations met these criteria. Table 8 presents the classification of affiliation institutions based on the strength of connections, the number of documents, and the number of citations.

Table 8. Top of authors organisations

Organization	Documents	Citations	Total link strength
University of Maryland College Park	24	2006	166
National Taiwan University	18	1700	159
University of Massachusetts System	19	1238	94
National University of Singapore	34	1685	92
University of Illinois System	22	441	87
New York University	23	1638	86
King s College London	17	221	76
Boston University	18	1081	75
York University	22	1149	64
Swansea University	22	623	60

In Figure 9, we graphically represented the connections between affiliation institutions, using connection strength between documents, the number of documents, and the number of citations as comparison filters.

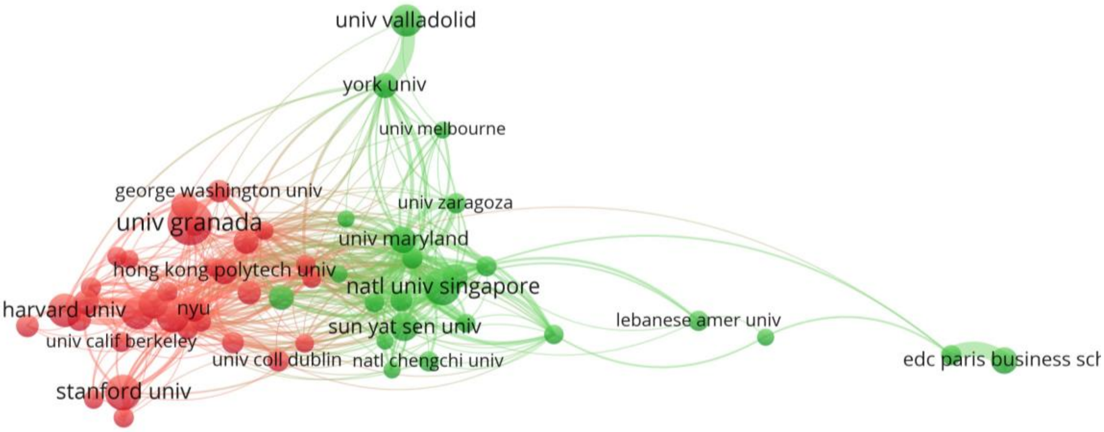

Figure 9. Links between author's organisations
Source: Author's research using VOSViewer Software

We identified a fourth citation unit at the authors' country affiliation level. Out of the 102 countries in our analysis, we utilized filters to ensure a minimum of 15 documents and 15 citations per country. Ultimately, 41 countries met our strict criteria. Our Table 9 comprehensively summarizes countries, their connection strength, total documents, and total citations.

Table 9. Top of authors country

Country	Documents	Citations	Total link strength
USA	937	30679	5112
England	386	9781	2851
China	556	9618	2587
Germany	205	5891	2006
France	204	3845	1885
Australia	172	5141	1776
India	128	2312	1382
Taiwan	125	3723	1024
Canada	151	3010	940
Italy	124	1923	862

In Figure 10, we graphically represented the connections between countries of affiliation, using connection strength between documents, the number of documents, and the number of citations as comparison filters.

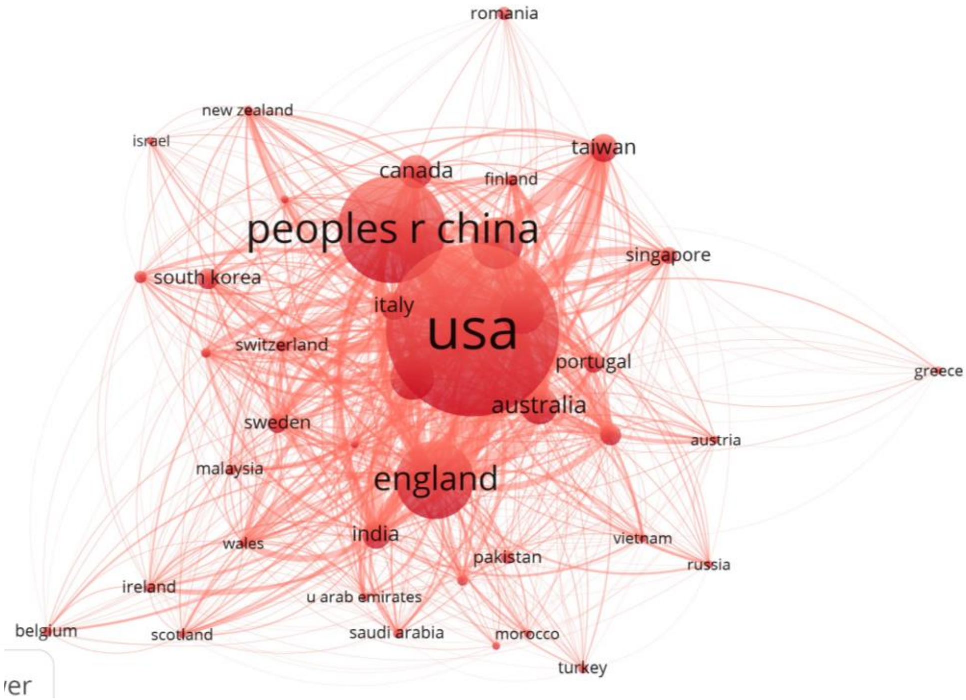

Figure 10. Links between author's country
Source: Author's research using VOSViewer Software

5. Conclusions

The analysis of scientific papers on AI and performance measurement is a critical factor in comprehending and assessing the development and influence of research in this field. With bibliometric analysis, researchers can track the progression of research over time, pinpointing trends and shifts in research focus. This analysis provides insight into the growing or declining interest in specific subdomains of AI. Furthermore, bibliometric analysis tools can reveal emerging trends and research clusters, allowing us to comprehend essential areas and connections between different subdomains of AI.

The impact of Artificial Intelligence on performance evaluation within organizations is both far-reaching and transformative. AI technologies offer a host of advantages, from streamlining operational processes and enabling informed decision-making, to providing personalized customer experiences and fostering ongoing innovation. By automating routine tasks and analyzing data more efficiently, AI frees up human resources to focus on more complex and strategic work. Moreover, AI contributes to organizational security by identifying and mitigating cyber threats. When integrated thoughtfully, AI not only enhances operational performance, but also confers a competitive edge in a constantly evolving business landscape. By embracing these technologies, organizations can cultivate an agile and innovative culture that can tackle future challenges with confidence.

Based on our analysis of current works, there has been a notable increase in articles focused on the utilization of Artificial Intelligence for measuring organizational performance. This shift is both significant and necessary in today's information landscape. By leveraging AI technologies, organizations are able to gain a more nuanced and comprehensive understanding of their performance through advanced analytics and relevant data. We firmly believe that incorporating AI into performance measurement can yield substantial benefits, ranging from improved daily operational efficiency to more informed decision-making and tailored strategic approaches. Additionally, the growing body of literature on this topic signals a move toward building agile and responsive organizational environments that can effectively navigate the complexities of an ever-evolving economic landscape.

6.References

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