What Is the Impact of Digital Transformation? A Bibliometric Analysis

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Abstract. With the rapid development of digital technology, digital transformation has brought a great impact on many aspects of human society. Based on the existing research on the impact of digital transformation, which not only helps to understand the current research progress but also can provide effective suggestions for better implementation of digital transformation. This paper analyzes the existing research on the impact of digital transformation from the perspective of biometric. First, starting from statistical analysis, the basic distribution of studies in different countries/regions, different sources of publication, different years of publication, etc., are introduced. Then, the paper shows the collaboration of researchers from the analysis of relevant citation networks, co-citation networks and collaboration networks. In addition, a thematic analysis of the relevant studies is presented, in which the relevant co-occurrence networks are shown, and then a detailed analysis of the studies is presented. On the basis of these analyses, a discussion of future research is presented, and finally, conclusions are drawn. This study shows not only the basic picture of the impact of digital transformation but also future research trends that can provide meaningful research perspectives. **Keywords:** Digital transformation, Biblio metric analysis.

1 Introduction

The impact of digital transformation exists in several ways, first of all, the changes brought about by digital transformation have had an impact on the way we think, evaluate and manage, etc. [1]. At the same time digital transformation, a hot topic in recent years, has similarly had an impact on the digital economy, changes in the social sphere, etc. [2]. Digital transformation has also attracted more and more interest and attention in academic circles [3], and more and more people are devoting themselves to the study of digital transformation in specialized fields.

In the field of environment and green energy, Truong [4] has addressed the gap in environmental research by studying the impact of digital transformation on environmental sustainability, and Gao [5] has investigated the impact of digital transformation on green energy efficiency to find out which regions or cities can benefit more from the digital transformation process. In the field of medicine: Lattouf [6] studied the impact of digital transformation on

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the future of medical education and practice. Ghosh et al. [7] studied the impact of digital transformation on the healthcare sector based on value insights and proposed the idea of healthcare process reengineering and value co-creation in parallel. Bunduchi et al. [8] studied the impact of digital transformation on the reshaping of jobs in the healthcare the impact of job reshaping in the industry. In the area of business development and people performance: Jardak et al. [9] studied the impact of digital transformation on business performance. With the potential agility and associated benefits of digital transformation, Chouaibi et al. [10] studied the risks of digital transformation on organizational performance in terms of organizational governance. Teng et al. [11] tried to identify the influencing factors that determine the sustainability of digitally transformed SMEs through an empirical analysis of their performance to provide a reference for academic researchers and industrial policymakers. Shi et al. [12] studied the impact of digital transformation on supply chain resilience of manufacturing firms, through which they found that there is no direct correlation effect between digital transformation and supply chain resilience, but digital transformation has a positive improvement effect on supply chain resilience. He [13] studied the impact of digital transformation on organizational resilience and found that in turbulent times, service firms can digitally transform to Xue et al. [14] explored the interrelationship between digital transformation and border-crossing, sustainable competitive advantage in manufacturing firms, and the findings helped firms to achieve digital transformation, achieve sustainable growth, and maintain competitive advantage. Castellar et al. [15] studied the impact of digital transformation on magazine firms, and the study showed that the digital transformation of companies led to a significant increase in the market value of the company. This is consistent with the company's expansion and increasingly better results, indicating that technology has the potential to change a company's strategy and lead to its success. In terms of customer satisfaction improvement: through a study on digital transformation in the airline industry, Heiets [16] proposed strategies for digital innovation to improve financial performance and enhance customer experience. Miguel et al. [17] studied the impact of digital transformation on customer satisfaction in the automotive services sector, and the study showed that digital means can be used to better understand customers' real needs, thus improving customer satisfaction and customer service experience. At the level of individual employee development: Qi [18] explored the impact of digital transformation on top-level turnover in enterprises and suggested that in the face of the trend of digital transformation, top-level employees need to show corresponding rapid capabilities, which provides a reference for the development direction of top-level employees in enterprises. Zhao et al. [19] studied the impact of enterprise digital transformation on individual-level innovation of employees, and the study showed that the digital transformation of enterprises and individual-level innovation of employees showed a similar pattern. Transformation showed a significant correlation with individual-level employee innovation. In other fields, there are various studies on the impact of digital transformation, Wu et al. [20] studied the impact of corporate digital transformation on the risk of stock market crash, Boyle et al. [21] studied the impact related to digital transformation in government organizations, Goncalves et al. [22] studied the impact of digital transformation on the future development of the accounting profession and explored the potential relationship between the development of digital technology tools and dynamic labor markets. Yoo et al. [23] studied the economic innovation brought about by digital transformation and its impact on social systems, trying to identify the factors that influence the acceleration of innovation in the digital economy. Merhi et al. [24] explored the impact of digital transformation on corruption and found that the enhancement of digital technology plays a crucial role in curbing the problem of corruption. Paven et al. [25] studied the impact of digital transformation on the educational and administrative fields, with a portion being tolerant of online forms of education, while another portion indicated that online forms of education and administration were unacceptable.

Scott [26] studied the impact of digital transformation on industry standards, and the study showed that the shift in industry standards brought about by the spread of digitalization is a future inevitable trend of development.

The above studies show the importance of studying the impact of digital transformation, and this paper is conducted based on the existing research on the impact of digital transformation, which not only helps to understand the current research progress related to the topic of digital transformation impact, but also can provide effective suggestions for better implementation of digital transformation.

2 General Analysis

In this section, we first introduce the idea of data collection. Then, the basic statistical characteristics of the study are introduced.

Nowadays, there are many databases that provide information about the literature, such as IEEE Explore, Springer, Google Scholar, Web of Science, etc. Considering that Web of Science is one of the most classic and commonly used databases, covering the oldest publications dating back to 1900 and providing better citation information, we choose Web of Science to collect literature information. In addition, considering that the literature provided by Web of Science can be subdivided into different categories and its core database provides relatively comprehensive and accurate information, we mainly use the core database of Web of Science for literature search.

To explore studies on the impact of digital transformation, we searched the literature through the following steps. First, we search for articles in Web of Science by topic using the subject terms in figure 1. After completing the selection of literature under each subject term, we combine the search results and remove duplicate articles. Then, the final sample could be identified.

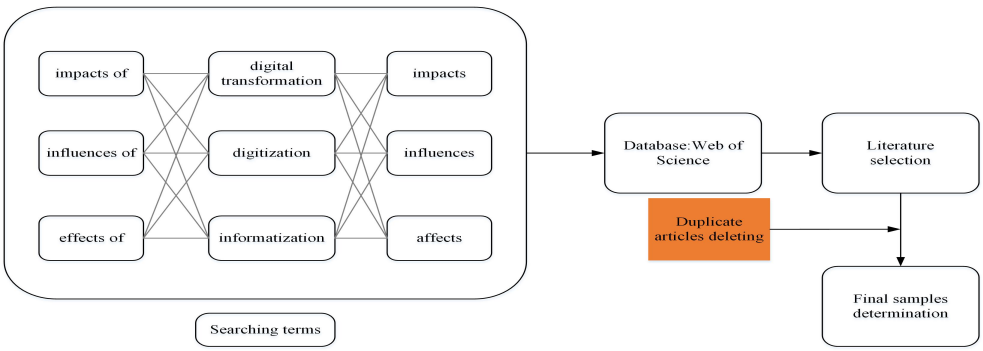

Figure 1. Digital transformation research ideas map

The distribution among publication years is shown in figure 2. The top three annual publications are: 35 related articles in 2019, 37 related articles in 2020, and 58 related articles in 2021, and the annual publication volume of papers shows a trend of increasing year by year. Classified according to the core database of Web of Science in figure 3, we can see that

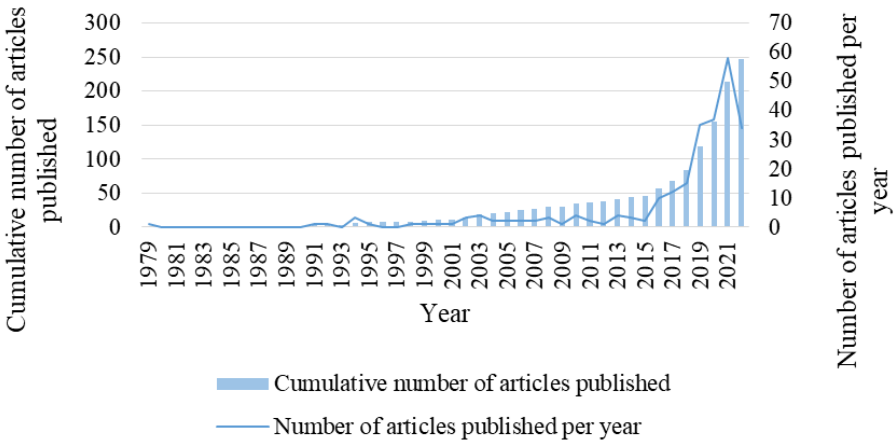

Figure 2. Statistical chart of annual publication volume and total publication volume

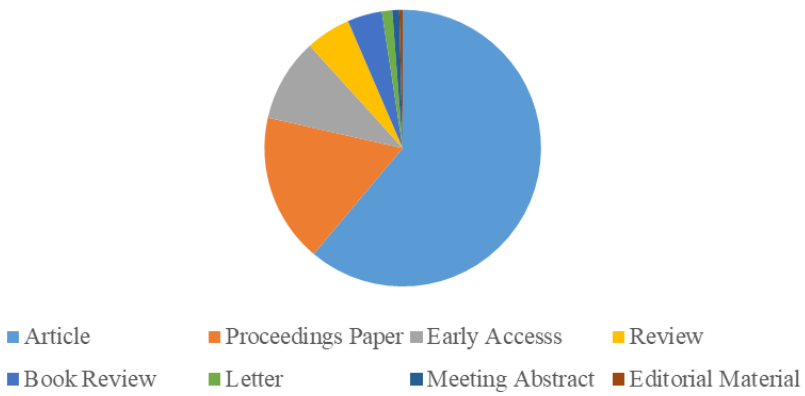

Figure 3. Graph of publication category statistics

the number of Articles is 151, which is more than 60% of all publications and occupies the largest share. After that, Proceedings Paper is in second place with 43 articles. The following is Early Access, with 24 articles, ranking third. In addition, there are 13 Reviews, 10 Book Reviews, 3 Letters, 2 Meeting Abstracts, and 1 Editorial Material, totaling 247 articles.

3 The Citation and Cooperation Analysis

In this section, we focus on the literature from the perspective of citations and co-citation situations. First, the general citation profile of the literature is presented, followed by the citation network of the literature and the co-citation network of the literature. The collaboration networks of different countries/regions, different institutions and different authors are further analyzed.

Table 1. The top-10 cited publications

Document	Citations	Links
Agarwal (2010)	383	4
Pagani (2017)	109	3
Reinartz (2019)	92	2
Kayikci (2018)	85	2
Dengler (2018)	74	3
Ritter (2020)	69	3
Matarazzo (2021)	62	6
Jenet (1998)	60	1

3.1 The Citation Analysis

Table 1 shows the number of citations and the number of links to the top 10 cited publications (Tables are in the appendix section). We can see that the publication with the highest number of citations has 383 citations, which is significantly higher than the other publications. The other publications in the list have less than 60 citations. figure 4 and figure 5 shows the citation network of the study, where the size of the nodes indicates the number of citations. In the analysis, we set the minimum number of citations for a publication to 1. The top side of figure 4 shows the citations of all documents that were cited at least 1 time. It is clear that the paper written by Agarwal (2010) et al. is the most cited.

To present the significant connections between documents, figure 5 below shows the largest sub-network of connected items, with 35 items. In the sub-network, the documents are partitioned into 9 clusters, where cluster 1 contains 5 items, cluster 2 contains 5 items, cluster 3 contains 5 items, cluster 4 contains 4 items, cluster 5 contains 4 items, cluster 6 contains 4 items, cluster 7 contains 3 items, cluster 8 contains 3 items, and cluster 9 contains 2 items. For cluster 1, the nodes are indicated in red, where the 3 papers with relatively high number of citations are by Pagani (2017), Ritter (2020), Melovic (2020). For cluster 2, the nodes are located in the middle, indicated in green, where the most cited document is by Llopois-albert et al. The citation relationships in this cluster appear to be more simply chained. The nodes in cluster 3 are in blue, where the most cited document is by Jafari-sadeghi (2021). For cluster 4, the nodes are yellow and the most cited document is by Dengler (2018) et al. For cluster 5, the node is purple and the most cited document is by Liu (2021) et al. In cluster 6, the nodes are sky blue and the most cited document is the most cited document written by Agarwal (2010). The nodes in cluster 7 are orange and the documents in this cluster are all less cited, with the most cited document being written by Heilig (2020). For cluster 8, the nodes are brown and the document written by Matarazzo (2021) et al. is the most cited. For cluster 9, the nodes are pink and the most cited document is authored by Mubarak (2019) et al.

To further explore the citation relationships of the documents, we analyzed the co-citations at the reference level, where we set the minimum number of citations of the cited references to 3. As shown in figure 6, the cited references can be divided into 7 clusters, where the first cluster has 35 items (red part), the second cluster has 21 items (green part), the third cluster has 20 items (blue part), the fourth cluster has 15 items (yellow part), 14 items in the fifth cluster (purple part), 14 items in the sixth cluster (sky blue part) and 12 items in the seventh cluster (orange part). The nodes in the graph indicate the references cited, and the more references cited, the larger the corresponding node. The top-10 cited references (all cited more than 9) are shown in table 2, where the total link strength indicates the link strength of the target reference to other references. Among the top 10 cited references, the most cited references also have the largest total link strength. In addition, these top 10 cited

Figure 4. The citations of all documents

references all have relatively large total link strengths in their corresponding clusters, which also indicates that these 10 references have important reference values in the field of digital transformation impact studies.

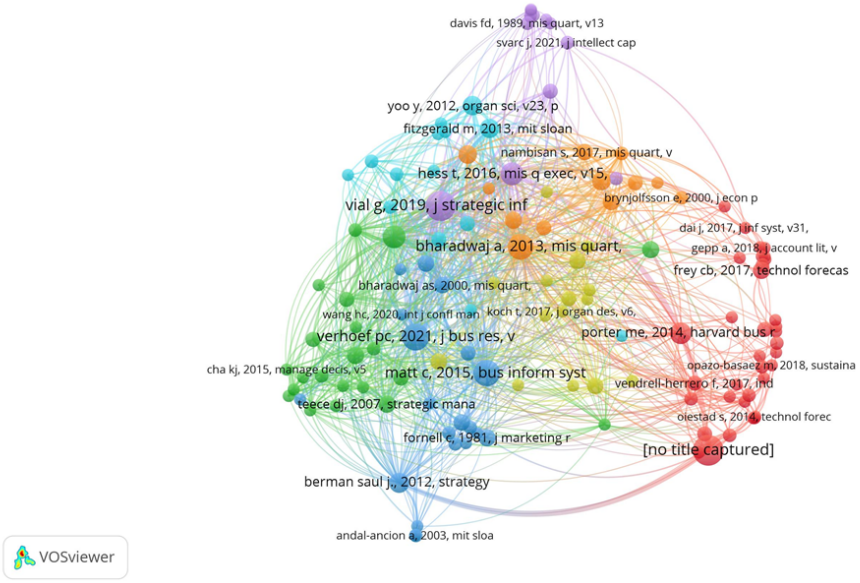

Figure 5. The largest sub-network of connected items

3.2 The Cooperation Network

After analyzing the citations, this subsection analyzes the collaborative network of related studies from the perspective of different countries/regions, different institutions, and different authors.

(1) Cooperation networks in different countries/regions

Table 3 shows the basic cooperation indicators of the top-10 prolific countries/regions. figure 7 and figure 8 shows the collaborative network at the country/region level, where we set

Figure 6. The co-citation network of the existing network

Table 2. The top10 cited references

Cited reference	Citations	Total link strength
Vial g, 2019, j strategic inf syst, v28, p118	24	254
verhoef pc, 2021, j bus res, v122, p889	19	182
Matt c, 2015, bus inform syst eng+, v57, p339	18	169
Bharadwaj a, 2013, mis quart, v37, p471	17	178
Hess t, 2016, mis q exec, v15, p123	13	162
Warner ksr, 2019, long range plann, v52, p326	13	173
Porter me, 2014, harvard bus rev, v92, p64	11	86
Berman saul j., 2012, strategy & leadership, v40, p16	10	94
Fitzgerald m, 2013, mit sloan manage rev, v54, p15	9	109
Yoo y, 2012, organ sci, v23, p1398	9	70

the minimum number of documents for a country to 1 and the minimum number of citations for a country to 0. The size of a node indicates the number of published documents in that country/region; the larger the node, the more published documents in that country/region. The left side of the figure indicates the entire collaborative network consisting of documents that satisfy the threshold, and the right side indicates the largest sub-network in the entire network, with nodes of the same color in the same cluster. In the sub-network, the 38 items are partitioned into 8 clusters with 7 items in cluster 1 (red), 5 items in cluster 2 (green), cluster 3 (blue), cluster 4 (yellow), 5 items in both cluster 5 (purple) and cluster 6 (sky blue), 4 items in cluster 7 (orange), and 2 items in both cluster 8 (brown). In addition, in clusters 4 and 5 are both European countries/regions. In cluster 6, all countries/regions are located in Asia, except Peru. The rest of the clusters show a trend of diversified cooperation. In other words, geographical location may affect the cooperation between different countries/regions, and countries/regions in the same region may seem to cooperate conveniently, but diversified cooperation is an unstoppable trend.

(2) Cooperation network of different institutions

Figure 9 and figure 10 shows the collaborative network at the institution level, where we set the minimum number of literature thresholds for an institution to 1 and the minimum number of citations for an institution to 0. The nodes indicate the number of literature

Table 3. The basic cooperation indicators of the top-10 prolific countries/regions

Country	Documents	Citations	Total link strength	Cluster
USA	33	629	11	1
Germany	22	283	4	3
France	10	274	12	5
Italy	12	174	12	5
England	17	127	16	8
Turkey	2	88	3	6
Denmark	2	80	1	8
Spain	11	66	3	3
Peoples R China	39	49	11	6
Slovakia	5	45	4	4

Figure 7. The citations of all countries/regions

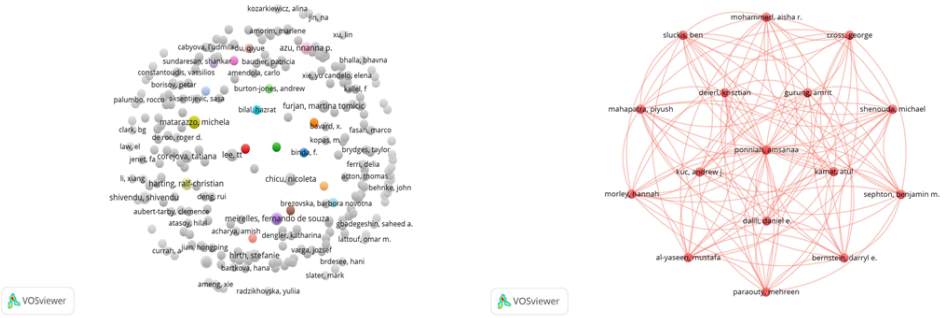

Figure 8. The largest sub-network of connected items (country/region-level)

published by the institution, with larger nodes indicating more literature published by the institution. The left figure shows the whole collaborative network, with some organizations not connected to each other. To clearly show the key collaborative networks, we show the largest collaborative sub-network on the right side of the figure. The largest collaborative sub-network has only 7 institutions and an atmosphere of two clusters, cluster 1 is shown in red and contains 4 institutions and cluster 2 is shown in green and contains 3 institutions. It

can be seen that the cooperation among various institutions is not close, and the advantages of cooperation should be given full play to promote cross-institutional cooperation, which may provide direction for the subsequent cooperation approach of digital transformation impact.

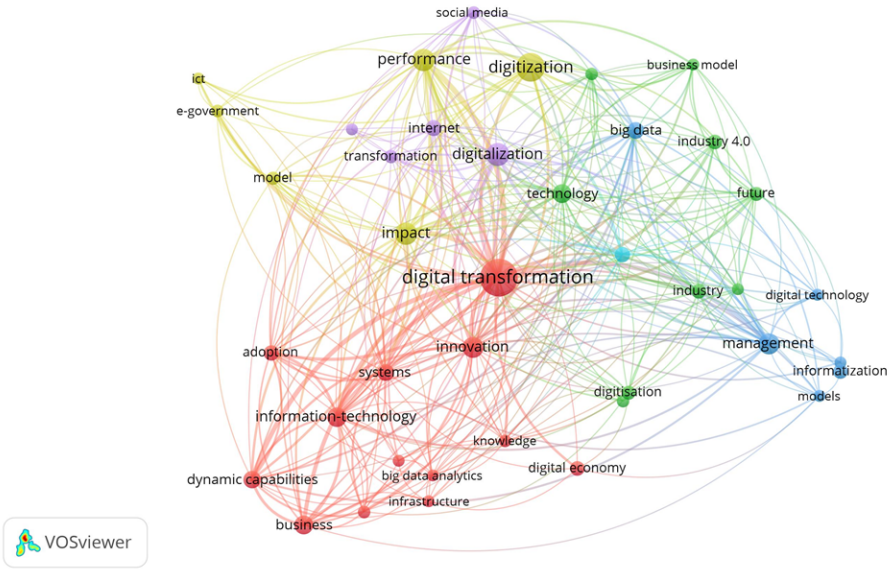

Figure 9. The citations of all institutions

(3) Cooperative network of different authors

Figure 11 and figure 12 shows the author-level collaboration network, where the minimum document count threshold for authors is 1 and the minimum citation count threshold for authors is 0. The left side of the figure shows the entire author collaboration network with 703 authors, most of whom are not connected to each other. To present the key author-level collaboration network, the right side of the figure shows the largest author-level collaboration sub-network, but the largest author-level collaboration sub-network has only one cluster, containing 16 authors, and the individual authors have closer collaborative ties with each other, and these authors work together to advance digital transformation impact research through continuous collaboration.

4 The Exploration of the Themes

In this section, we focus on the different themes of the existing studies. First, a keyword co-occurrence analysis is performed to show the basic links between studies. Then, we use biometric-based terminological analysis techniques to investigate the themes of existing studies. In addition, we divide the existing literature into different clusters based on different themes and present the main research themes under different themes.

4.1 The Keyword Co-occurrence Analysis

We first perform a keyword co-occurrence analysis using VOSviewer. In this process, we select all the keywords as the basis of the analysis, and we set the minimum number of

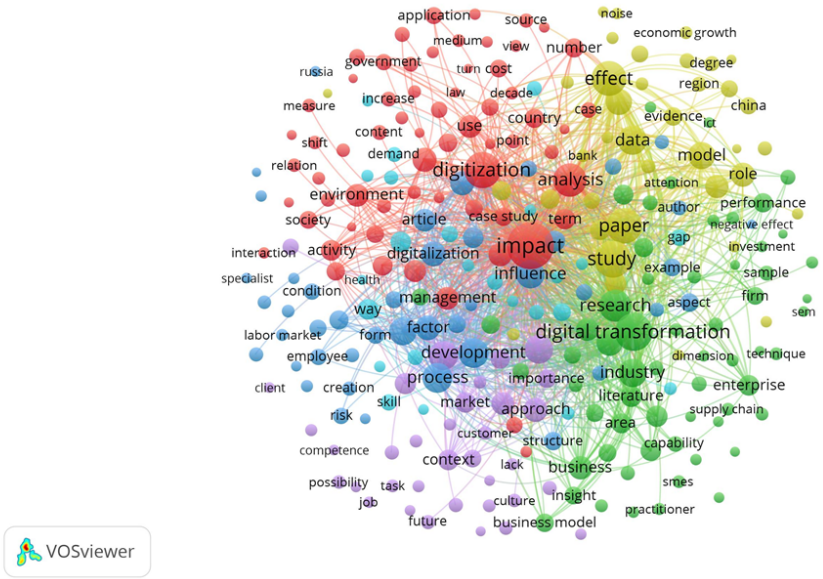

Figure 10. The largest sub-network of connected items (institution-level)

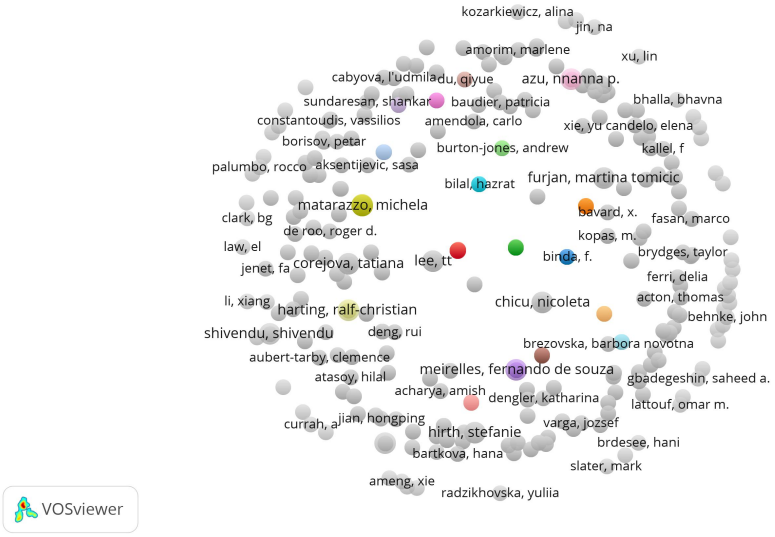

Figure 11. The citations of all authors

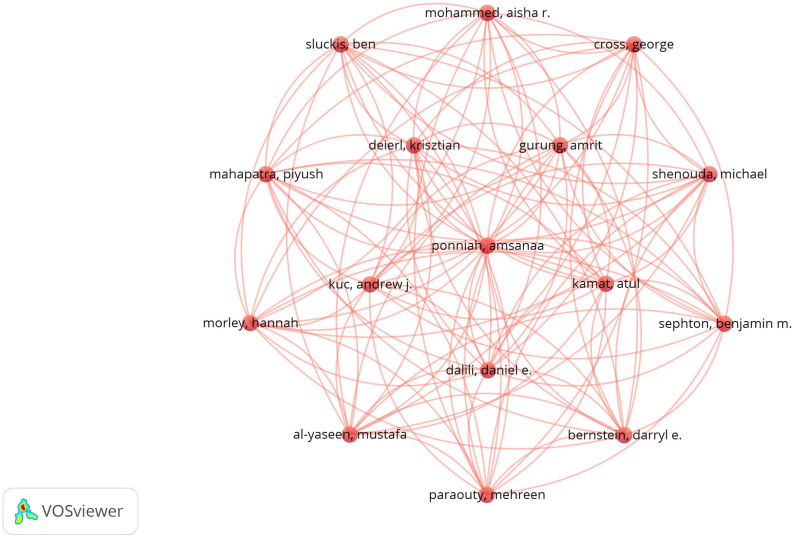

Figure 12. The largest sub-network of connected items (author-level)

occurrences of a keyword to 5. Then, we can see the keyword co-occurrence network as shown in figure 13, where the size of the nodes indicates the number of occurrences, and the larger the node, the more occurrences of the keyword. From the figure, we can see that the keywords are divided into 6 clusters, where cluster 1 contains 13 words (red), cluster 2 contains 9 words (green), cluster 3 (blue) contains 6 words, cluster 4 has 6 words (yellow), cluster 5 contains 5 words (purple), and cluster 6 contains 1 word (sky blue). We can see that the keyword "digital transformation" appears most frequently, "digitalization", " digitization", "impact", "management", "information- technology" also appeared more frequently. In figure 13, we list the keywords that appear more than 16 times. The indicator "total link strength" indicates the total number of keywords in the paper containing the target keyword and other keywords linked to the target. Investigating the results of keyword co-occurrence analysis, we found that keywords with a higher number of occurrences also have a higher total link strength. For example, in figure 13 and table 4, it can be clearly seen that the keyword "Covid-19" is linked to 74 other keywords with a total link strength of 171. It is undoubtedly the most central keyword. The keywords in table 4 show that digital transformation impact studies are mainly focused on innovation, management, and information technology.

4.2 The Term Co-occurrence Analysis

To further investigate the different topics of the existing studies, we use the VOS viewer to analyze the terms in the title and abstract fields of the existing studies, and we set the minimum number of occurrences of the terms to 5. Also, we select all the relevant terms for constructing the term co-occurrence network as shown in figure 14. In the figure, the size of the nodes indicates the number of occurrences, and the larger the node, the more occurrences of the term. In the construction of the term co-occurrence network, 266 related terms are partitioned into 56 clusters, where cluster 1 contains 64 terms (red), cluster 2 contains 61 terms (green), cluster 3 contains 44 terms (blue), cluster 4 contains 38 terms (yellow), cluster

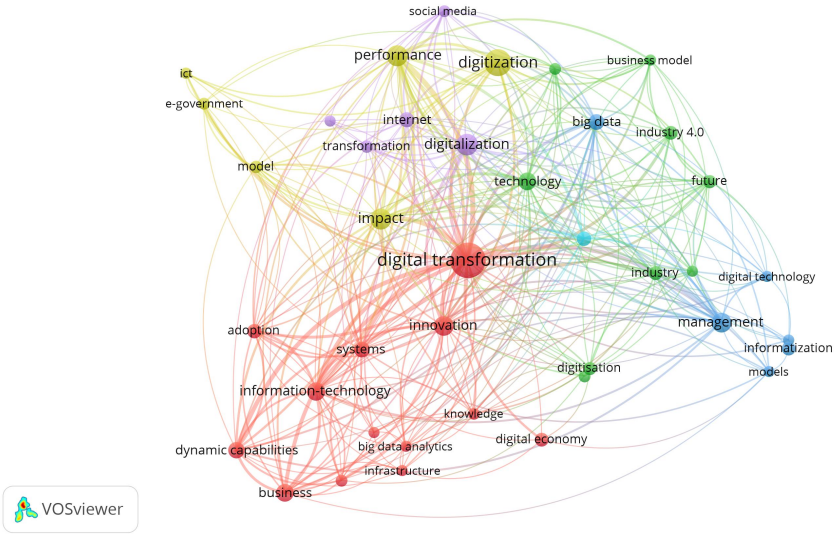

Figure 13. The keyword co-occurrence network

Table 4. The basic indicators of the keywords with more than 16 occurrences

Keyword	Occurrences	Total link strength
Digital transformation	74	171
Digitization	40	49
Digitalization	25	54
Impact	23	76
Performance	23	85
Innovation	20	69
Management	20	63
Information-technology	16	61

5 contains 35 terms (purple), and cluster 6 contains 24 terms (sky blue). The distance between terms reflects the similarity between them; the greater the distance, the greater the difference. In the figure 14, we can see that two terms are very different from the others, namely "future research" and "economic growth", which means that these two terms are slightly different from the others. In addition, we can see that some words appear more frequently than others, such as "impact", "digital transformation", "paper ", "study", "digitization", and "effect", similar to the high occurrence of keywords in the keyword co-occurrence analysis. The high occurrence of keywords in the keyword co-occurrence analysis.

Table 5 shows the top 10 terms that appear. In term co-occurrence analysis, the relevance score indicates the strength of co-occurrence connection relevance between the target term and other terms. Investigating the results, we can see that the terms with higher occurrences may not have higher relevance scores. Referring to the terms in different clusters, we believe that the terms in cluster one are more relevant to technology, including big data, blockchain, information technology, etc. The terms in cluster two may be related to business operations. It could be the impact of digital transformation on business, as there are terms

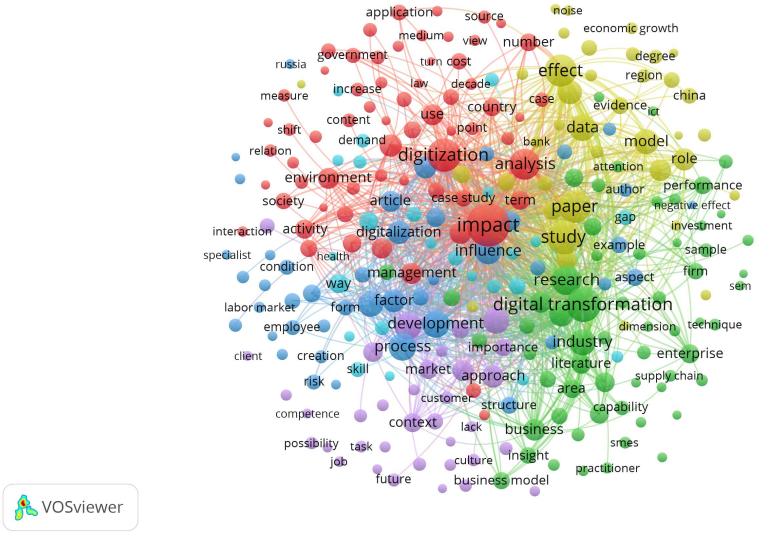

Figure 14. The term co-occurrence network

Table 5. The basic indicators of the top-10 terms on the occurrence

Term	Occurrences	Relevance score
Impact	185	0.023
Digital transformation	112	0.1014
Study	105	0.12
Digitization	104	0.1444
Paper	101	0.0782
Effect	94	0.3214
Analysis	85	0.0574
Research	78	0.1029
Development	66	0.1504
Process	66	0.1205

such as: performance, revenue, organization, manager, etc. The third cluster is mainly related to the economy as there are terms such as digital economy, economic development, and labor market. The terms in the fourth group are similar to those in the third group, as they include economic growth, panel data, etc., which reflect the economic impact of digital transformation. The terms in the fifth group are more relevant to demand, as there are terms such as client, customer, etc. The terms in the sixth group are related to the external environment as there are related terms such as pandemic, Covid, etc.

5 Conclusion

In this paper, we analyze the literature on the impact of digital transformation mainly from a biometric perspective. First, the basic statistical characteristics of publications are presented, including the basic profile of publication categories, the distribution of publication years, the

distribution of different publications, the distribution of different countries/regions, and the basic collaboration in some countries/regions. From the analysis, it is obvious that topics related to the impact of digital transformation receive a lot of attention. Then, the biometric analysis of citations and collaborations shows that we can find that the collaborations among researchers show some geographical distinctions, but there is also an overall trend of global collaboration. In addition, the main themes of the existing research are subdivided into four parts, namely the impact of digital transformation on the technological side, the impact on the economic side, the impact of digital transformation on the demand side, and the impact of digital transformation on the external environment. From the analysis of the main themes, we also present some future discussions from a period perspective that can provide meaningful suggestions for future research.

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