

Digitalization and Enterprise Innovation: Research Hotspots and Frontier Trends

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Abstract: The rapid development of digital technologies has profoundly changed the way that companies produce, create, and interact with their collaborators. Since 4G networks became widespread in 2014, the impact of the Internet, information technology, and digitalization on business innovation have received much attention from scholars. This paper uses CiteSpace software to conduct a bibliometric and visual analysis of 784 documents from the WOS Core Collection on digitalization and enterprise innovation in the last decade of research, to visualize the research collaboration network, research hotspots, and evolutionary trends of research in this field, and to summarize the hotspots and frontier trends of research in this field, with a view to providing assistance for future research.

1. Introduction

With the in-depth development of key technologies such as Artificial Intelligence, Big Data, Cloud Computing, and Blockchain, digital technologies have changed the way enterprises interact and exchange value with consumers [1]. The real economy and traditional industries urgently need to undergo digital transformation to gain a sustainable competitive advantage. In the big data era, digital technology is an important driver for the development of the digital economy and leading enterprise innovation. Thus, it is important to study digitalization and enterprise innovation to promote enterprise and economic development. In this paper, using the three main dimensions of existing literature research as keywords, 784 papers were retrieved from the Web of Science (WOS) Core Collection, and CiteSpace software was used to conduct a bibliometric and visual analysis of the above sample literature to gain insight into the current state of research and development frontiers in the field.

2. The Concept of Digitalization and Research Dimensions

From the IT perspective, digitization is the direct process of converting analog information into digital pages as units, while in the management perspective, digitization is the process of creating and harvesting value in new ways using digital technology or based on digital information. Li (2016) considers digitization as the process of using information technology or digital technology to change the existing business processes of an enterprise [2], and Ghobakhloo (2020) considers digitalization as a method of quantifying management objects and management behaviors and realizing

management activities in each of the functions through the use of computers, communications, networks, and other technologies [3]. The digital development of the enterprise is necessarily accompanied by the digital transformation of the enterprise with significant changes in technology, culture, operations, innovation, and services [4]. Verhoef (2019) divides the process of digital transformation of the enterprise into three phases: digitization, digitalization, and digital transformation [5].

Current research on digitalization and enterprise innovation focuses on three main dimensions. First, information technology or information systems and enterprise innovation. Advances in information technology reduce transaction costs, improve management efficiency, and contribute to the coordination between knowledge asset management, innovation production, and inter-organizational, which in turn increase the speed and efficiency of firm innovation [6]. And information systems help enterprises quickly and efficiently analyze, publish, and record large amounts of information [7], increasing the breadth and depth of information flow [8], as a result of which business innovation is facilitated [9]. Second, the Internet and enterprise innovation. The Internet promotes inclusive innovation in developing countries [10], through achieving deep integrative innovation between the Internet, big data, artificial intelligence, and the real economy, to promote the innovation capacity of enterprises. Third, digitalization and digital transformation, and enterprise innovation. Digital technology facilitates the flow of innovation at the spatial, technological, and organizational levels, creating complex and dynamic dependencies between innovations and products or services [11], and contributes to the effective integration of internal resources and enhanced collaboration with other organizations [12], as well as facilitating the diffusion of knowledge within the enterprise, updating business models, and thus achieve innovation [13].

Accordingly, this paper argues that the digitization of enterprises includes the use of early technological foundations and preparations such as the utilization of information technology and the Internet by enterprises, as well as the digitization and digital transformation processes using digital technologies nowadays. And four dimensions including Information Technology, Internet, Digitalization, and Digital Transformation are used as keywords to retrieve the research literature on digitalization and corporate innovation.

3. Data and Methodology

3.1 Data Source

This paper presents a visual analysis of the sample literature from the WOS Core Collection for the last decade (2012-2021). Retrieved keywords were “Internet and Enterprise innovation” or “Information technology and Enterprise innovation” or “Digitalization and Enterprise innovation” or “Digital transformation and Enterprise innovation”, and refined the research direction in the field of “Management or Business or Economics or Business Finance or Operation Research Management Science”. 1448 documents were searched in total, and after eliminating duplicate documents, 784 valid documents were finally obtained, the search deadline was December 3, 2021.

3.2 Research Methodology

This paper uses CiteSpace analysis software to conduct a bibliometric and scientific knowledge mapping visualization analysis of 784 papers from the WOS Core Collection that have studied digitalization and corporate innovation over the last decade. CiteSpace helps scholars to understand emerging trends in a particular knowledge area through a precise review process that overcomes the subjective bias of narrative-based literature reviews [14]. Through literature co-citation and keyword

co-linear analysis, the hot topics and trends in the research field can be visually identified, which will help scholars to quickly find out and grasp the research progress and trends in a specific field. Therefore, bibliometric analysis using CiteSpace can help scholars gain insight into the current research status and research frontiers of digitalization and enterprise innovation.

4. Bibliometric and Visual Analysis

4.1 Trend Analysis of Issuance

The change in the trend of literature publication is an important measure of the development status of the research field. According to the annual distribution of research publications in digitalization and enterprise innovation in the last decade (see Figure 1), it can be seen that since 2014, research in this field has gradually received wide attention from scholars, constantly showing a steady growth trend and witnessing the first and second growth in 2014 and 2020, respectively. The possible reason is that the adoption and popularization of 4G network in 2014 have closely integrated the production and living activities of human society with information technology, and with the in-depth development of key technologies such as Artificial Intelligence, Big Data, Cloud Computing, Blockchain, etc., human economy and society are moving into a new era with digital as the core feature. For the year 2020, during the fight against the COVID-19 epidemic, the application of big data tools such as health codes, place codes, and itinerary codes on various network platforms in China, and the in-depth application of spatio-temporal concomitant identification by telecommunication positioning have demonstrated the powerful power of Big Data and accelerated the development process of digitalization and digital economy.

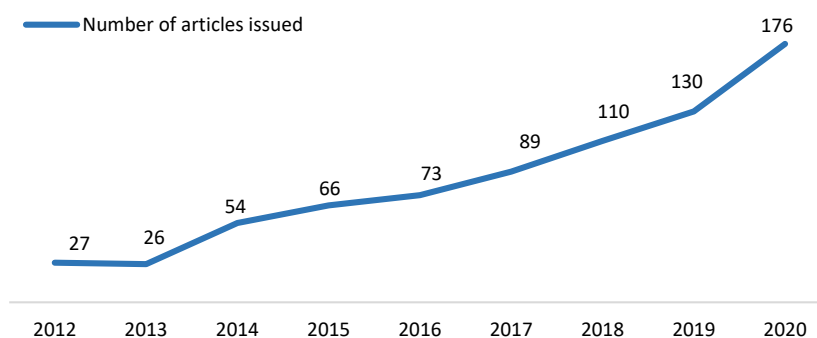


Figure 1: Annual Distribution of Research Publications

4.2 Research Collaboration Network Analysis

4.2.1 Analysis of Country/Regional Cooperation Networks

According to Figure 2 and Table 1, China currently has the highest number of 102 documents, accounting for 13% of the total sample literature, and the USA has the highest centrality of 0.43, indicating that it plays a strong intermediary hub role among the countries or regions studying in this field. In addition, the nodes in the UK, Spain, and Italy are also more significant, with prominent outer ring color and centrality greater than 0.1, indicating that as key nodes, these five countries are the core research groups in the field of digitalization and enterprise innovation. In the global economic competition, enterprise innovation is an inevitable requirement to help national development, and the digitalization process of enterprises is a necessary transformation of enterprises in the wave of the digital era. The economic development and scientific research level of the above-mentioned countries are among the top in the world, and they are bound to reveal the importance of digitalization for

enterprise innovation with scientific researches and conclusions, provoking reflections and attention of entrepreneurs and managers.

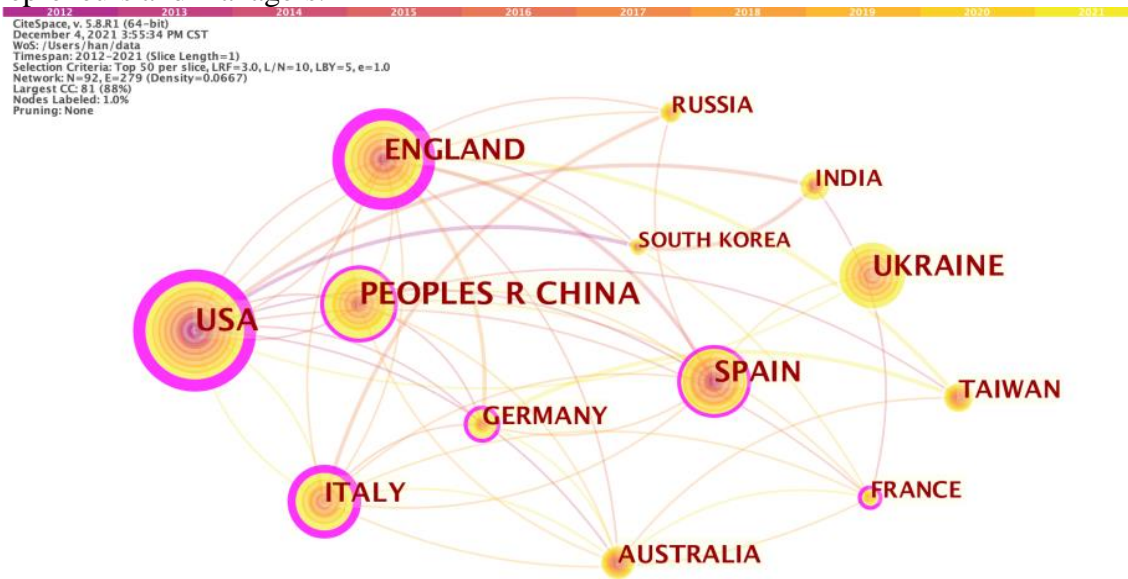


Figure 2: Mapping of Country/Region Cooperation Networks

(In the above figure, different nodes represent different countries or regions, the size of the nodes reflects the number of articles issued, the connecting lines and thickness between the nodes respectively indicate the cooperation and intensity between countries, and the outer purple circle represents the centrality of the country.)

Table 1: Countries/Regions by the Number of Articles Issued Top 10

No.	Number of articles issued	Centrality	Issuance Percentage	Countries
1	102	0.15	13%	CHINA
2	95	0.43	12%	USA
3	81	0.41	10%	ENGLAND
4	69	0.01	9%	UKRAINE
5	66	0.10	8%	SPAIN
6	62	0.23	8%	ITALY
7	37	0.07	5%	AUSTRALIA
8	35	0.11	4%	GERMANY
9	34	0.01	4%	TAIWAN
10	29	0.05	4%	RUSSIA

4.2.2 Journal Co-citation Analysis

Journal co-citation refers to the citation of two or more journals simultaneously in a single document, and usually reflects the relationship between journals and the distribution of the knowledge base. The 20 most cited journals are shown in Figure 3 and Table 2, concentrating on business studies, strategic management, information science and library science, and computer science and information systems, which with high impact factors and authority. Among them, ADMIN SCI QUART, HARVARD BUS REV, ACAD MANAGE REV, ACAD MANAGE J, STRATEGIC MANAGE J, MANAGE SCI, J MANAGE, and J BUS RES are the top journals in management research.

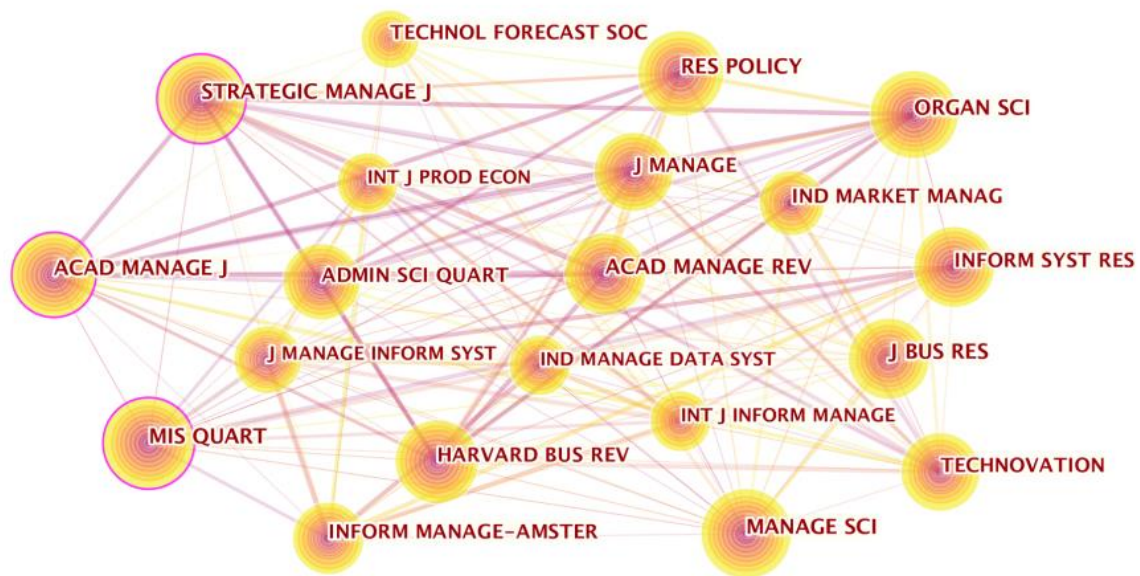


Figure 3: Journal Co-citation Network

(Each node represents a journal, and the line between nodes indicates the co-citation relationship between journals.)

Table 2: Journal Co-citation Top 20

No.	Frequency of citations	Centrality	2020 Impact Factor	Cited Journals
1	335	0.13	8.641	STRATEGIC MANAGEMENT JOURNAL
2	327	0.11	7.198	MIS QUARTERLY
3	296	0.06	4.883	MANAGEMENT SCIENCE
4	271	0.03	8.110	RESEARCH POLICY
5	269	0.05	7.550	JOURNAL OF BUSINESS RESEARCH
6	269	0.06	12.638	ACADEMY OF MANAGEMENT REVIEW
7	264	0.14	10.194	ACADEMY OF MANAGEMENT JOURNAL
8	249	0.10	5.000	ORGANIZATION SCIENCE
9	243	0.09	6.870	HARVARD BUSINESS REVIEW
10	235	0.04	6.606	TECHNOVATION
11	227	0.04	11.790	JOURNAL OF MANAGEMENT
12	209	0.06	5.207	INFORMATION SYSTEMS RESEARCH
13	193	0.08	7.555	INFORMATION & MANAGEMENT
14	183	0.01	8.593	TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE
15	179	0.06	11.113	ADMINISTRATIVE SCIENCE QUARTERLY
16	179	0.07	6.960	INDUSTRIAL MARKETING MANAGEMENT
17	168	0.04	14.098	INTERNATIONAL JOURNAL OF INFORMATION MANAGEMENT
18	165	0.05	4.224	INDUSTRIAL MANAGEMENT & DATA SYSTEMS
19	164	0.04	7.885	INTERNATIONAL JOURNAL OF PRODUCTION ECONOMICS
20	164	0.07	7.838	JOURNAL OF MANAGEMENT INFORMATION SYSTEMS

4.3 Research Hotspots and Evolutionary Trends Analysis

4.3.1 Research Hotspots

A research hotspot is a perspective or theme that is commonly valued by a group of literature with a strong correlation over a certain period. Keywords are a high-level summary and refinement of the research topics and contents of an article, and visual analysis of keywords can contribute to the discovery and acquisition of research hotspots. High-frequency keywords in the recent decade of research on digitalization and enterprise innovation are shown in Figure 4, and the top 10 keywords with high frequency and high centrality are shown in Table 3.

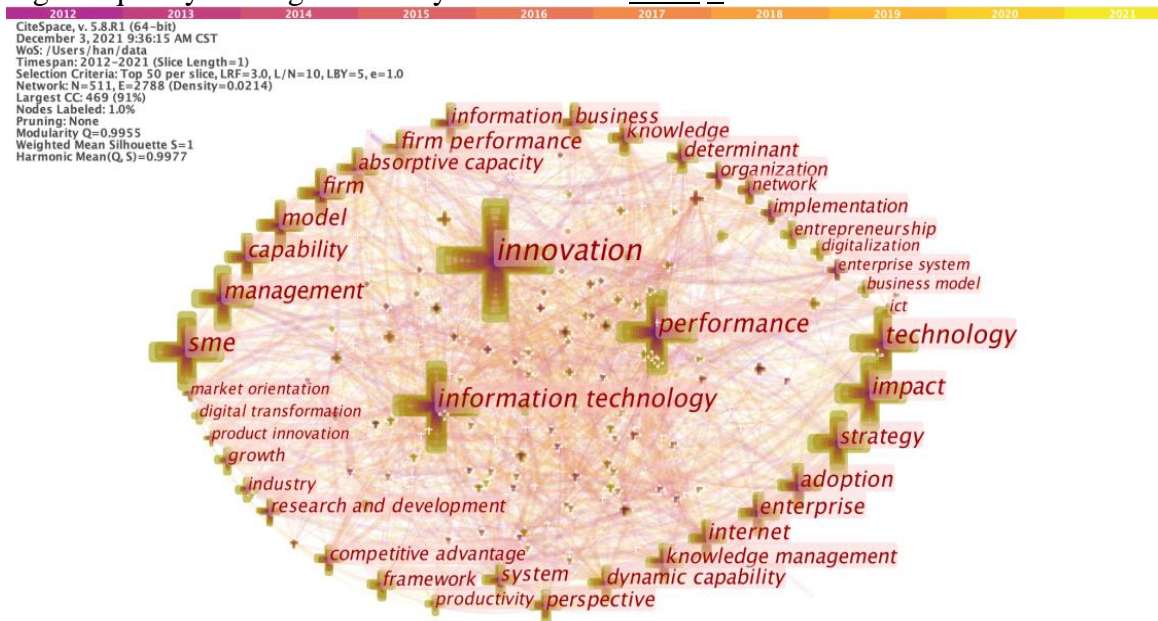


Figure 4: Keyword Co-occurrence Mapping

(Different nodes in the figure represent different keywords, and the larger the node, the higher the frequency of occurrence, the line between the nodes indicates the co-occurrence of keywords, and the thickness of the line indicates the co-occurrence intensity.)

Table 3: Keyword Top 10

No.	Frequency	Centrality	Keyword
1	354	0.11	innovation
2	172	0.06	performance
3	162	0.05	information technology
4	131	0.06	SME
5	129	0.04	technology
6	124	0.05	impact
7	100	0.09	management
8	89	0.02	strategy
9	77	0.01	capability
10	73	0.02	model

4.3.2 Evolutionary Path and Trend Analysis

Timeline mapping depicts clusters that evolve along a horizontal timeline [14]. The timeline diagram can describe the trends and evolutionary paths of the studied fields. CiteSpace has clustered nearly a decade of research on digitalization and enterprise innovation into 19 clusters, and the

Timeline mapping (see Figure 5) shows only the first 11 clusters. From the Timeline mapping, keywords related to enterprises, such as innovation, enterprise system, and business value have been studied by scholars for a long time, while keywords related to digitalization have started and gradually been widely focused at different times following the development of information technology, for example, Information Technology ushered in a research hotspot in 2012, Information System in 2013, Digitalization and Digital Transformation in 2019, and Artificial Intelligence in 2021.



Figure 5: Timeline Mapping of Keyword Co-existence Network

CiteSpace judges the mapping effect of the graph based on the Modularity Q and the Weighted Mean Silhouette S , and when $Q > 0.3$ and $S > 0.7$, the mapping effect of the graph is very significant. From the keyword clustering mapping (see Figure 6), the mapping $Q = 0.626$ and $S = 0.8431$, indicating significant clustering. Three of the clusters, #0 dynamic capabilities, #8 industry 4.0, and #10 artificial intelligence, are in lighter colors which have been widely noticed by scholars recently, so this paper concentrates on analyzing and interpreting the above three clusters.

#0 Dynamic Capabilities. The period is 2012-2021. The keywords are Information Technology Performance, Innovation, Knowledge Management, Information Technology Capability, Competence, Big Data, Digitalization, Digital Transformation, etc. The clustering is mainly based on dynamic capability theory to study the relationship between digitalization and enterprise innovation. Dynamic capabilities promote the continuous building and renewal of resources and assets through the ability of opportunity perception, opportunity control, revolution, and reorganization to quickly respond to changes in the external market environment [15]. Under the perspective of enterprise capabilities, dynamic capabilities contribute to the construction of digital-specific capabilities such

as information technology capabilities and digital platform capabilities [16]. Under the perspective of knowledge and resource management, dynamic capabilities can help enterprises effectively manage data knowledge, coordinate and integrate data resources, efficiently train digital talents, etc., and realize effective collaboration of digital knowledge and resource combination of enterprises [17].

#8 Industry 4.0. The period is 2012-2020. The keywords are Medium-Sized Enterprises, Industry, Digital Technology, Competitiveness, Continuous Learning, Information Technology Infrastructure, etc. This cluster focuses on the relationship between digitalization and innovation in manufacturing enterprises, especially small and medium-sized enterprises. With the rise of the fourth industrial revolution, manufacturing firms are increasingly focusing on the application of information technology to improve their manufacturing capabilities. Entrepreneurial SMEs can improve their performance through the combination of digital platform capabilities and development orientation [18]. Facing the challenges of Industry 4.0, high-technology and knowledge-intensive companies should pay more attention to the application of modern digital technologies, matching digital economy capabilities with their financial, material, human, and productive resources, and improving the way they operate in the areas of product development, innovation, and commercialization [19].

#10 Artificial Intelligence. The period is 2012-2021. The keywords are Information System, Sustainability, Enterprise Architecture, Artificial Intelligence, etc. This cluster focuses on the relationship between Artificial Intelligence which emerged in recent years and business innovation. With the explosion of artificial intelligence, companies of all types are rapidly adopting new technologies collectively named Intelligent Automation, such as automation, logical analytics, and artificial intelligence, to drive digital transformation. At the same time, enterprises are under unprecedented pressure for driving innovation. In today's fast-paced business operations model, enterprises continue to struggle with expanding AI due to organizational barriers such as the lack of proper data architecture, underestimation of the scientific data lifecycle, the absence of a clear strategy to operationalize the model, and the missing engagement of business leaders and support from executives [20].

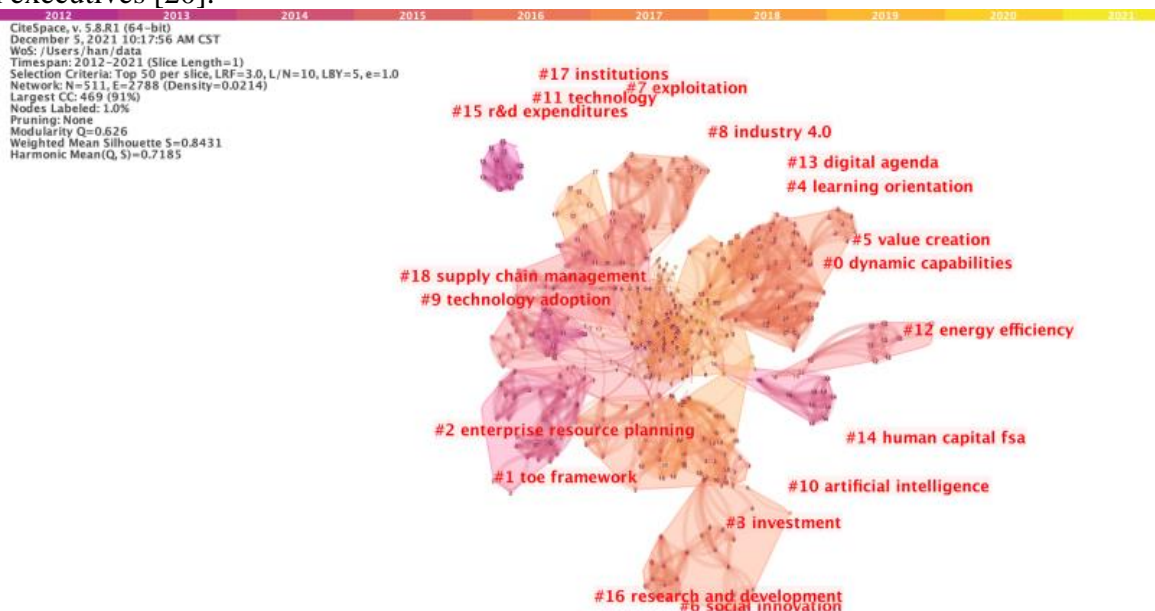


Figure 6: Keyword Clustering Mapping

5. Conclusion

At present, the number of publications on digitalization and enterprise innovation research shows

a steady growth trend. At present, the number of publications on digitalization and enterprise innovation research shows a steady growth trend. According to the results of the literature visualization analysis of CiteSpace, the analysis of countries or regions shows that among the core research groups, China, USA and England are in the leading position in terms of research level and scientific capability, but China is in the low impact centrality and needs to strengthen international academic communication and cooperation. The analysis of journal co-citation shows that the journals cited in this field are concentrated in business research, strategic management, information science, computer science, and information systems, all of them having greater authority. Moreover, from the analysis of hotspots and evolutionary trends, the research frontiers of digitalization and enterprise innovation can be drawn as follows.

First, Research from the perspective of dynamic corporate capabilities. Although digital technologies such as Big Data have provided opportunities for enterprise development, it is still a challenge to unleash the effectiveness of Big Data and transform the data-driven effects into enterprise performance. Dynamic capability theory provides a theoretical basis for explaining how enterprises can use digital technologies to improve their performance, and at the same time, studying the modes and paths of digitally enhanced enterprise innovation from a dynamic capability perspective can develop and broaden the boundaries of dynamic capability theory.

Second, Research focused on high-tech and knowledge-intensive enterprises. Digitization and science and technology innovation are important driving forces for the development of the digital economy and innovation. Digitization has become a necessary path to realize intelligent manufacturing, and a new industrial system with data as the core driving factor is gradually taking shape. As an important pillar of national essential technology research and development, it is important to research the impact of digitization and innovation of high-tech and knowledge-intensive enterprises, which is important for their key technology breakthrough and innovation.

Thirdly, research keeps up with the development of digital technology. In recent years, emerging digital technologies such as Cloud Computing, Big Data, the Internet of Things, Blockchain, and Artificial Intelligence have developed rapidly, and research in this field has continued to change with the evolution of those technologies. Future research can focus on emerging technology directions such as Machine Learning, Augmented Reality Technology, Robotic Process Automation, 5G networks, etc.

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