Digital Innovation Ecosystem: Research Context, Research Hotspot and Research Trends -- Knowledge Mapping Analysis Using Citespace

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Abstract: As the product of digital economy era, digital innovation ecosystem is also the main research direction of collaborative innovation in the future. However, the summary and analysis of the new research object is limited. This paper conducts analysis of co-citation and co-occurrence keywords cluster with 373 literatures on the theme of digital innovation ecosystem from 2003 to 2019 in the core database of Web of Science using CiteSpace. It is found that there are four theoretical foundation and four major research topics in the related research. It is still the main research trend in the future to research the digital innovation ecosystem which integrates the service dominant logic.

1. Introduction

Digital revolution extends the boundary of enterprises from supply chain and value chain system to value network system, promotes the development of new cooperative organization network and forms a Digital Innovation Ecosystem (DIE).

DIE has many definitions in academia, such as: interaction and relationships between organizations and stakeholders that use digital technologies to create new products and services to create value [1]; a complex network composed of heterogeneous social and technological elements [2] [3]. And the research of digital innovation ecosystem is the extension of the innovation ecosystem, focusing on the impact of digital transformation on the innovation ecosystem, among which digital technology is both the object of innovation and the promoter of innovative activities [4, 5]. This paper defines DIE as a complex network of collaborative and competitive relationships among individuals, organizations and digital technologies that jointly create value for innovation. And DIE is an open, complex ecosystem driven by innovation and development and composed of different innovation roles, in which each role operates autonomously and participates in the collaborative innovation in the ecosystem with the support of digital technology.

The main purpose of this paper is to find the current research situation, analyze the research context, summarize the theoretical framework, clarify the research hotspots and discuss the research trend.

The key contents of this paper are organized as follows: Firstly, DIE and related concepts are sorted out and analyzed, and the research purpose of this paper is proposed. The second section elaborates the research methods and data used. The third section analyzes the distribution of research literature. In the fourth section, the research context and theoretical system of the field are sorted out. The fifth section analyzes the research hotspots in this field. The sixth section analyzes and forecasts the research trends and problems. The seventh section summarizes and discusses.

2. Research Method

2.1 Selection of Research Methods and Analysis Tools

This study adopts a new method of scientific metrology – Mapping Knowledge, which is one method that integrated visualization technology, applied mathematics, graphics, computer science, information science, citation analysis and co-occurrence analysis in metrology. The research object is the knowledge domain and the research result is visual graphics which display the development and structural relationship of scientific knowledge.

This study uses Citespace which is a commonly used tool of the scientific knowledge and is developed by American Drexel university professor Chaomei Chen. It is a JAVA based visualization software and can be used to conduct co-occurrence analysis of literature, authors, institutions, countries, terminology, and keywords, co-citation analysis and coupling analysis of literature, authors and journal [6].

2.2 Data Resource

The data used in this paper comes from the core database of WOS, and the search theme is selected as "Digital innovation ecosystem". Since "innovation ecosystem" was first proposed by the American Competitiveness Council in 2004 and the research on innovation ecosystem is carried out around "open innovation", a concept first proposed by CHESBROUGH in 2003. Therefore, in order to improve the recall ratio, the retrieval period set in this paper is from 2003 to 2019. Finally, a total of 373 records and 14541 valid citations were obtained, as shown in Table 1.

Table 1 Search rules and results

Retrieval setting item	Retrieval settings and results
Database	SCI –EXPANDED, SSCI, A&HCI, CPCI-S, CPCI –SSH, CCR-EXPANDED, IC
Retrieval way	TS=(digital innovation ecosystem)
Literature	Article, Proceedings Paper, Review
Language	English
Time period	2003-2019
Retrieval time	2020 年 1 月 1 日
Retrieval result	373 条记录
Valid citation	14541

3. Research Status

3.1 Distribution of Time

Figure 1 is a trend chart of the volume of literature published in the field from 2003 to 2019 obtained by WOS. It can be found from the figure that the number of literature related to the research on the digital innovation ecosystem has been increasing rapidly in the past 17 years. And 2015 is the turning point in the research. The highly cited article of 2015 is one which authors are Lush and Nambisan and it is published in the MIS QUARTERLY. This article mainly introduces service innovation from the perspective of service-led logic and proposes a three-party framework of service-led logic: service platform, value co-creation and service ecosystem, which provides a new research perspective for the study of DIE.
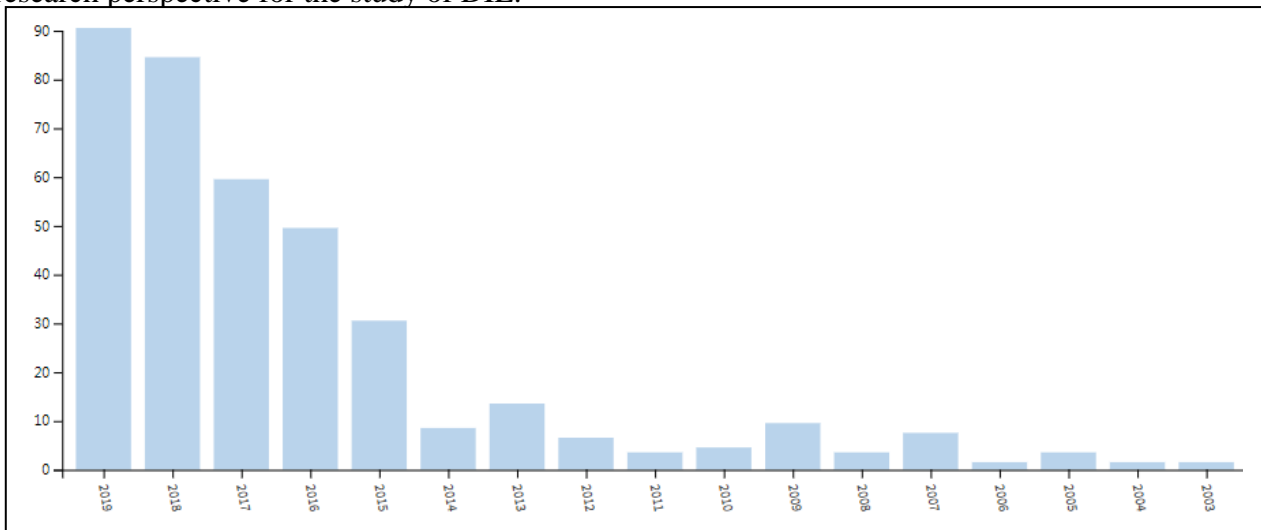

Figure. 1 Distribution of research time

3.2 Distribution of Subject

It can effectively grasp the key points of the research in field to analyze the distribution of subject of literature. Figure 2 is the distribution of subject of DIE. As the figure shows, the main subject of all literature of DIE is economic and management, followed by computer science and engineering. And these three disciplines intersect with each other, which indicates that academic achievements in this field are characterized by discipline integration. The research on "digitization" and "innovation" has gradually penetrated from economics and management to computer and engineering.
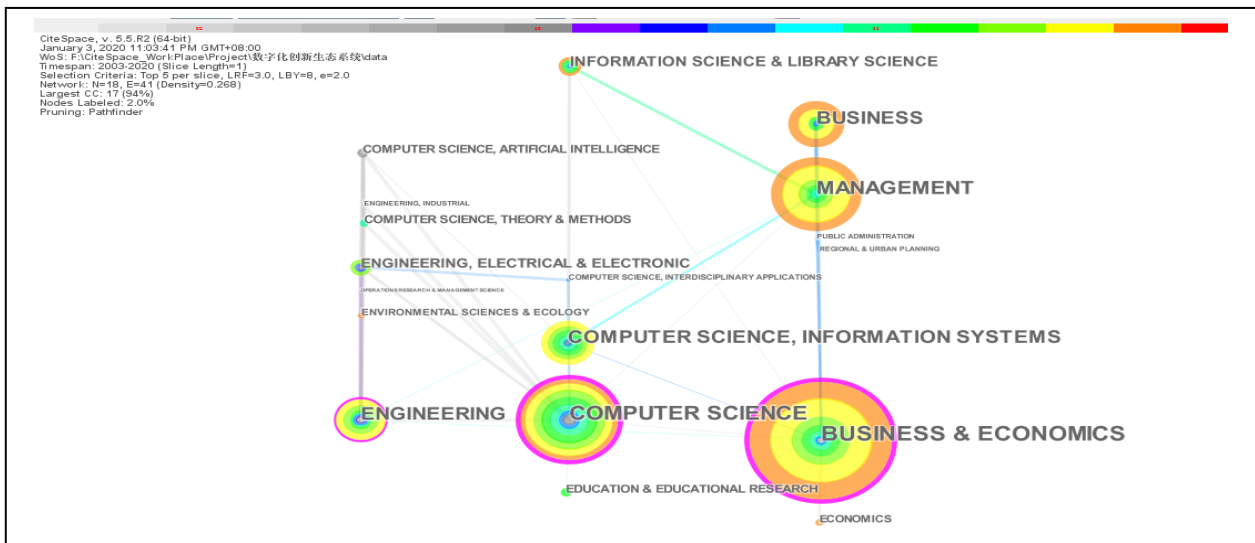
Figure. 2 Distribution of research subjects

3.3 Distribution of Country

Figure 3 shows the distribution of research countries in DIE. As the figure shows, the United States and the United Kingdom are the main countries, followed by Germany, China, Finland, Italy, Australia, Sweden and other countries in this research field. Moreover, according to the purple circle on the periphery of the node, which represents intermediary centrality, it is found that the United States, the United Kingdom, Finland and Australia have the most cooperation in this field. However, China has a low degree of intermediary center and its main partners are the United States, the United Kingdom, Australia, Finland, Sweden and Singapore.
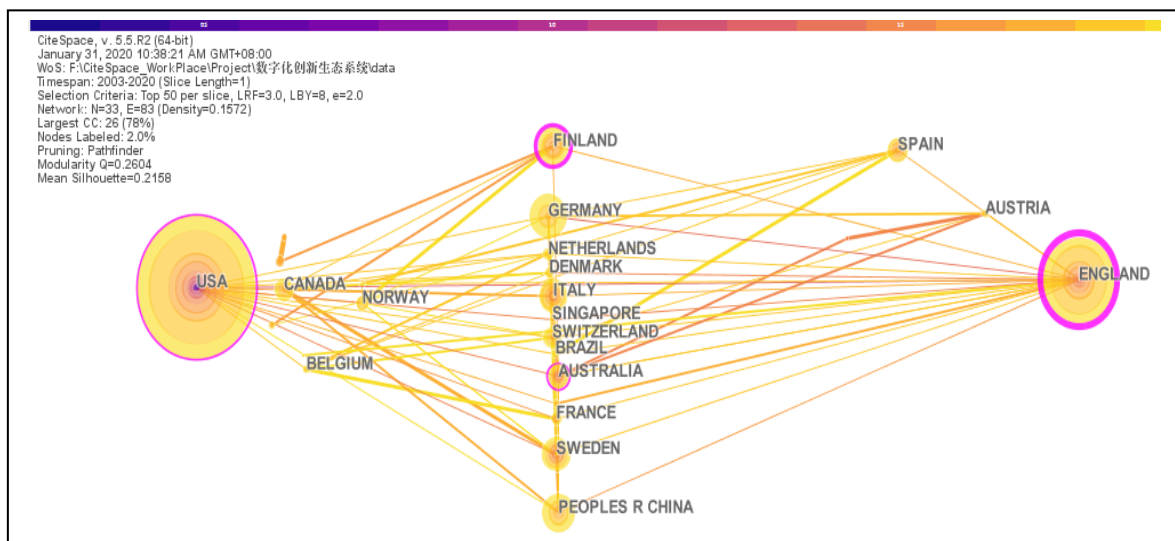

Figure. 3 Distribution of research countries

3.4 Distribution of Institution

Figure 4 shows the distribution of research institutions, of which the top three are the University of Cambridge in the United Kingdom, the University of Queensland in Australia and the Council for Scientific and Industrial Research (CSIR), and the Beijing University of Aeronautics and Astronautics in China in seventh place.
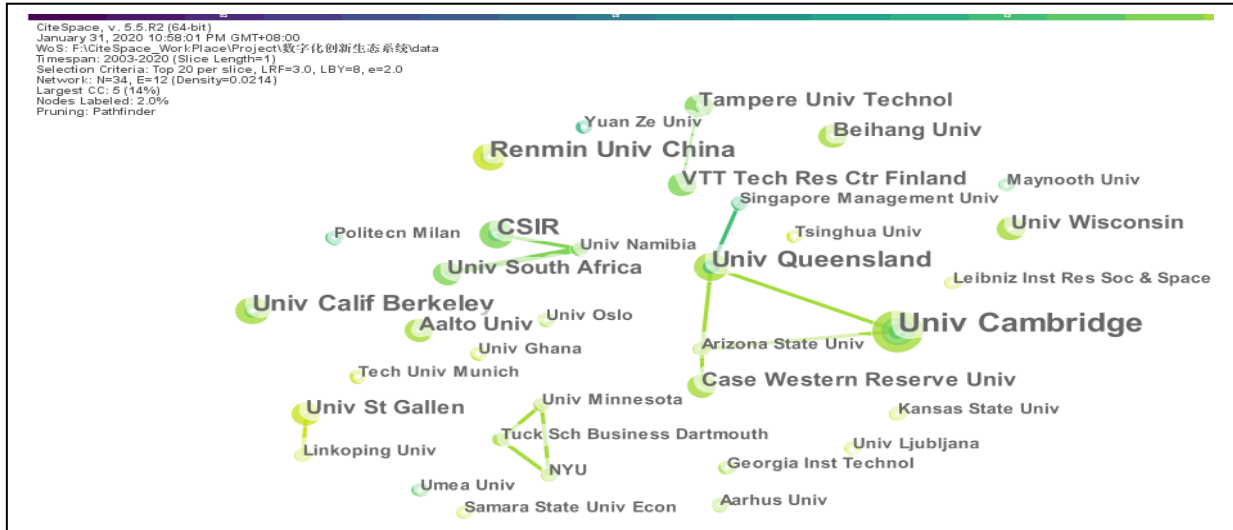

Figure. 4 Distribution of research countries

3.5 Distribution of Journals

By using Citespace, top 10 high- frequency cited journals are obtained and summarized in the Table 2. Seventy percent of the journals are in JCR partition Q1 area, which are core journals of organization and management, business management, policy, product innovation and information system management. Besides, MIT SLOAN MANAGE REV, a highly cited journal on digital transformation, which in Q3. It indicates that the research in this field has high-quality references in organizational management, while the literature in the combination of digital transformation and innovation is not of high quality.

Table 2 List of frequently cited journals

Order	Journal	Frequency	JCR
1	HARVARD BUS REV	126	Q1
2	RES POLICY	113	Q1
3	MIS QUART	112	Q1
4	STRATEGIC MANAGE J	102	Q1
5	ORGAN SCI	90	Q2
6	ACAD MANAGE REV	82	Q1
7	INFORM SYST RES	82	Q2
8	MANAGE SCI	69	Q1
9	MIT SLOAN MANAGE REV	67	Q3
10	J PROD INNOVAT MANAG	63	Q1

4. Evolutionary Path and Theoretical Framework of Research

Due to the timeliness of research, scholars are more willing to cite recent articles for reference. However, there is a kind of long-published but frequently cited article, which is often the earliest and most representative findings in the field and called by ground-breaking articles. Besides, high centrality is one concept of Citespace, which represents the key role of citation in the research field[7]. Evolutionary path of research can be obtained by analyzing the key and ground-breaking articles. And this paper analyzes 14541 valid citations in Citespace and gets the time zone diagram of citations, as shown in Figure 5.
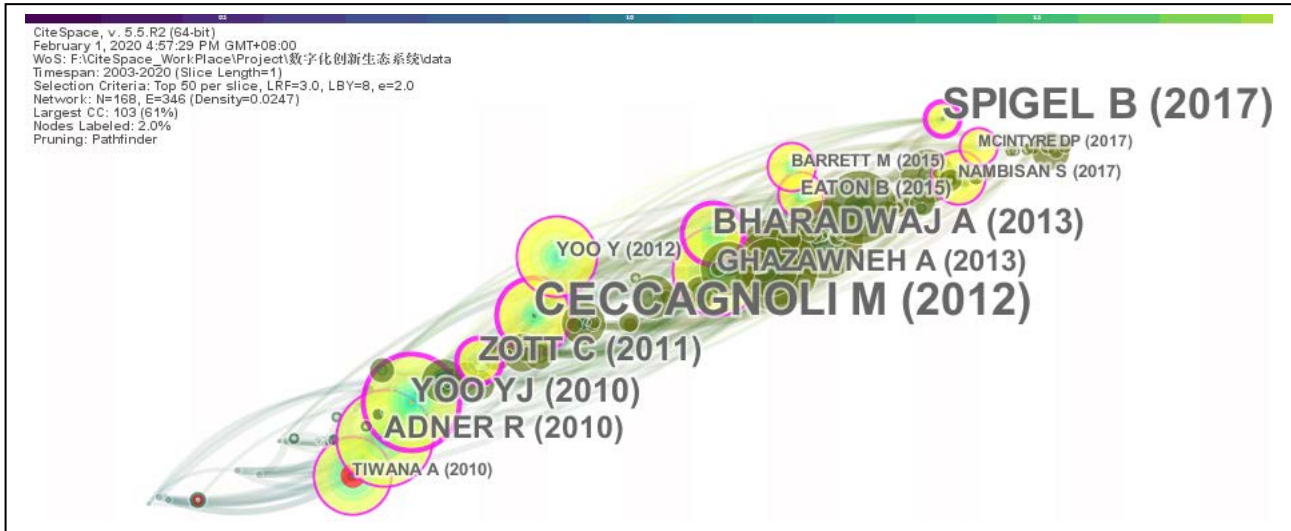

Figure. 5 Knowledge mapping of key citation

A collection of all cited literature constitute the knowledge foundation in the research field. It is found that the core knowledge foundation of DIE includes four parts: theory of digital technology, platform innovation, innovation ecology and business model. And the theoretical frame diagram is shown in the Figure 6. The distributed characteristics of digital technology promote the development of software platform innovation and the concept of platform innovation is generalized, which is defined by that cooperative innovation among innovation object relying on "public space". With the development of the open innovation and ecological theory, the competition between enterprises turned into ecological competition, which request enterprises innovate not only on technology but also on business model. From the perspective of technological innovation, innovation ecosystem is transforming to digital, distributed, platform, cross-border and diversified. From the perspective of business model innovation, more and more attention has been paid to users' demand. Users participate in the design and production of innovative products to create value together with other participants and promote the development of technological innovation. These four theories are the knowledge foundation of DIE, support the development of research of DIE and promote and support each other.
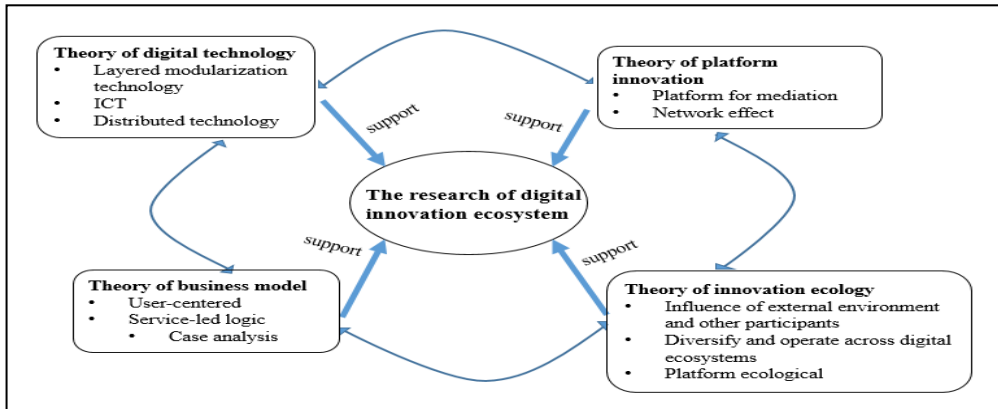
Figure. 6 Knowledge mapping of key citation

5. Research Hotspots

Keywords in the paper are summaries of the paper. If certain keywords appear frequently in the paper during a period of time and they are strong related to each other, then these keywords often represent the research hotspots in the field during this period of time. In this paper, keyword co-occurrence of Citespace is used to analyze research hotspots. Figure 7 is the cluster mapping of keywords. It can be known that the clustering result is effective according that the Mean Silhouette equals to 0.6061 (>0.6) and Medularity Q equals to 0.4435 (>0.3). In the end, 12 keywords with high centrality are listed in Table 3, which can reflect the research hotspots in the field.

From the Figure 7 and Table 3 show, it is found that the research hotspots can be summarized to four aspects: enterprise digital transformation and upgrading[8, 9], digital service ecosystem [10] [5, 11] and digital business ecosystem[12, 13], digital innovation platform and platform ecosystem[14-16], and governance of enterprise digital system[17, 18].
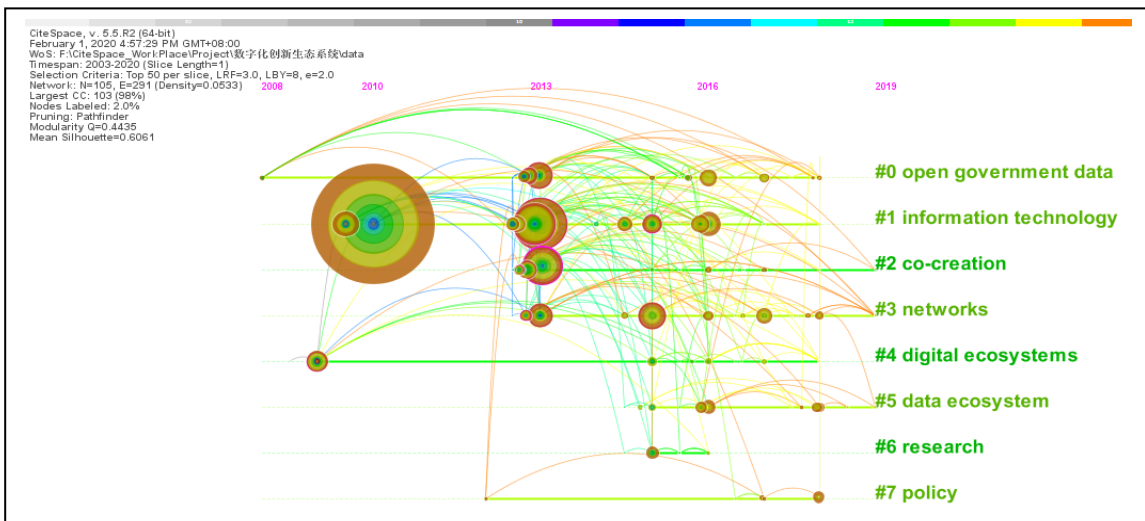

Figure. 7 Knowledge mapping of key citation

Table 3 Information of keywords

Keywords	Frequency	Centrality	Keywords	Frequency	Centrality
technology	44	0.25	industry	12	0.14
competition	22	0.2	strategy	47	0.13
digital ecosystem	28	0.19	model	14	0.13
firm	21	0.17	system	33	0.12
platform	31	0.14	network	28	0.12
open innovation	24	0.14	capability	19	0.11

6. Frontiers and Trends of Research

The latest research topics or those change suddenly in a period of time are called research frontiers, which are represented by emergent words in Citespace. This paper detects three emergent words of DIE: digital ecosystem, service and service innovation, shown in the Table 4. This paper suggests that building an innovation ecosystem integrating digital and service-led logic concepts is still the main research direction in DIE in the future, and it is also worthy of further discussion.

Table 4 Emergent keywords of DIE

Keywords	Frequency	Strength	Year	Article data
Digital ecosystem	28	5.344	2009-2013	
Service	6	3.74	2014-2015	
Service innovation	7	2.98	2016-2017	

7. Conclusion

Digital innovation ecosystem (DIE) has become a new organizational form of enterprise innovation and inter-enterprise competition in the digital era. Since 2003, scholars have made beneficial explorations in DIE from different research perspective. In this paper, Citespace is used to conduct citation analysis, keyword co-occurrence and cluster analysis on existing literatures in DIE. And systematically summarizes the research status, research context, theoretical framework, research hotspots and research directions of DIE. It is found that:

Firstly, theory of digital technology, platform, innovation ecology and business model support the research in the DIE, and the four theories also promote and support each other.

Secondly, there are four major research hotspots: enterprise digital transformation and upgrading, digital service ecosystem and digital business ecosystem, digital innovation platform and platform ecosystem, and governance of enterprise digital system.

Thirdly, digital innovation ecosystem has new characteristics different from traditional collaborative innovation, which requires scholars to expand research ideas and explore new research issues on the basis of traditional collaborative innovation research, including constructing digital innovation ecosystem integrated with SDL, whether the factors of traditional collaborative innovation still play a role in DIE, whether the diversity and fluidity of innovation subjects will

affect the competition and cooperation among innovation subjects, the choice of system strategy and related research of platform ecology.

Fourthly, Literature distribution: since 2003, the literature related to DIE has been increasing year by year. Lush and Nambisan in 2015 introduced the service ecosystem from the perspective of service-led logic, which has accelerated the research of DIE. The United Kingdom and the United States are main countries in DIE, and China ranks top seven in the number of publications in this field. Among the research institutions, the University of Cambridge in the UK is the most prolific, while Beijing University of Aeronautics and Astronautics in China ranks seventh. From distribution of subject and high-frequency cited journals found in DIE, it is found that subject integration and the main subject are economic management, engineering and computer science, there are much more reference of high quality in the organization and management, information systems management and innovation management, but the literatures of digital transformation are not of high quality.

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