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## Mapping Knowledge Domains of Digital Labor Research: Current Status, Hotspot and Frontier



**Abstract:** - With the rapid development of digital technology, the mode of production has been transformed into digitalization, virtualization and technologization. The labor has been changed from the real world to the virtual digital world, and digital labor has become an important part of the labor form in modern society. According to bibliometrics and Mapping Knowledge Domains, this study aims to reveal the research status, hot spots and future development trends in the field of digital labor. Based on this, this study takes the relevant core literature from 1990-2023 includes Web of Science Core Collection and Chinese CNKI as the database, and uses CiteSpace visualization software to conduct comparative analysis. The results of this study show that: the number of publications on digital labor in China is lagging behind that of the international community; the research on digital labor in China started late, and the influence of the literature is weaker than that of the international community; the growth rate of relevant literature in Chinese is faster, and the distribution of disciplines is concentrated, while the literature in English is increasing year by year and is relatively stable, and the distribution of disciplines is wide; there is a partial overlap between Chinese and international digital labor research hotspots, with digital labor being studied under the perspectives of computer science, communication studies, education, and so on; Chinese research still focuses on general theoretical discussions, while international research has been widely conducted in the fields of social media, deep learning, digital labor education, artificial intelligence, computer science and information systems. This study not only provides a theoretical perspective for understanding the interaction between digital technologies and labor, but also offers new perspectives for future research and labor education to address the challenges of digital transformation.

**Keywords:** Digital Labor, Research Status and Hotspots, Cite Space, Digital Technology, Digital Labor Education.

### I. INTRODUCTION

Nowadays, human beings are living in digital form. As a new type of labor under the development of the digital economy, digital labor has shown rapid development and become an important issue in the new era. Digital labor is also called "playbour", "prosumption labor on the Internet and social media" or "immaterial labor 2.0". Generally speaking, digital labor refers to the activities of Internet users who produce, exchange, distribute, consume the subject's emotions, cognition, experiences, etc., and generate related content on the Internet (especially peer-to-peer collaborative/P2P and social networking sites) supported by digital technology [1]. This definition can summarize some of the core features of digital labor: not only does it involve the use of technology and tools, but more importantly it represents a new economic and social activity in which people interact and create value in digital space. In the process, "digital laborers" use digital technology to create, distribute, and consume various forms of content, including text, images, audio, and video. At the same time, these contents affect people's emotions, cognition, and experience.

Digital labor is called a new type of economic and social activity, mainly because it differs from traditional economic and social activity in the following ways: firstly, in terms of technical support, Digital labor is supported through digital technologies, such as the Internet, mobile devices, cloud computing and artificial intelligence, which enable people to work, communicate and create value over a wider range of space and time; secondly, in terms of working methods, Digital labor usually does not require a fixed office space and can be performed anywhere, such as at home, in a coffee shop or in a public library, which provides people with more autonomy and choice, and at the same time enables enterprises and individuals to utilize their resources more efficiently; Thirdly, in terms of economic models, digital labor usually involves new economic models such as sharing economic platforms, online marketplaces and freelancing, which make transactions between service providers and service consumers more flexible and efficient, while also providing individuals with more employment opportunities and sources of income; and fourthly, in terms of social models, Digital labor also changes the way people socialize and socialize. People can communicate and collaborate with people around the world through the Internet and social media, which provides new possibilities for people's social circles and social values. In summary, digital labor is an economic

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and social activity with new types of technologies, work styles, economic models, and social models. It involves not only the use of technology and tools, but also a shift in the way human beings interact and create value, which has a significant impact on individuals, businesses, and society as a whole, and provides useful lessons and reflections for exploring new economic and social models.

With the rapid development of digital labor research, more and more related research results have emerged. How to systematically sort out these research results, mine their inspiration for future research, and predict the frontier direction and development trend of digital labor research has triggered the attention of Chinese scholars. For example, Feng [2] reviewed the research on international digital labor; Han [3] reviewed the literature on digital labor with theoretical economics as the analytical framework; Kong & Huang [4] made a literature review and commentary on international digital labor in the connotation, form, and outlook of digital labor; and Wang [5] made a visual analysis of the research hotspots and development trends of digital labor. All these have made necessary contributions to the literature study of digital labor, but there are still limitations. From the point of view of research contents, most of them are literature reviews, and few of them analyze the hot spots and frontiers of digital labor research; from the perspective of research, most of them are unilateral analyses of Chinese or international digital labor research, and few of them are visual comparative analysis of digital labor research; from the perspective of research methods, most of them are subjective content interpretation, and few of them are objective analysis with scientific measurement tools. Given this, this paper adopts the bibliometric method and uses CiteSpace as a research tool to conduct a visual analysis of digital labor research from a comparative perspective, aiming at objectively presenting the differences and similarities of digital labor research, as well as the hotspots and progress of digital labor research, so as to provide new ideas and perspectives for the innovative development of the field of digital labor and the research paradigm.

## II. RESEARCH DESIGN

### A. *Research Methods and Tools*

The research method of this paper is mainly based on bibliometrics and the Mapping Knowledge Domain. Mapping Knowledge Domain is a modern theory that combines the theories and methods of applied mathematics, graphics, information visualization technology, and information science with the methods of citation analysis and co-occurrence analysis in metrology, and uses the visualized atlas to display the core structure, development history and frontier fields of the discipline vividly [6]. The research tool is CiteSpace. It is the abbreviation of Citation Space and is the information science knowledge graph visualization software developed by Dr. Chaomei Chen of Drexel University, USA. This paper uses the latest version of CiteSpace, version 6.1.r6 (released in January 2023).

### B. *Data Sources*

The science of knowledge mapping is rooted in the database, i.e., how to accurately and comprehensively retrieve the entire literature on the topic to be studied is the key issue [7]. According to Bradford's law of literature dispersion, most of the key literature is generally concentrated in core journals. Therefore, this paper used the representative and authoritative core journal database as the source of information. The English literature came from the Web of Science Core Collection Database (WOS), and the Chinese literature came from China National Knowledge Infrastructure (CNKI). To completely include the core documents in the field of digital labor research, after several retrieval attempts, the following methods are proposed to be adopted: In the Web of Science core aggregation database, the English expression "digital labor" and "digital labour" closely related to "digital labor" in a wide sense were used as the subject search words. The search formula was: TS = (digital labor or digital labour), and 5,436 papers of digital labor collected from 1990 to 2023 had been retrieved. In order to improve the accuracy and scientificity of the data while expanding the breadth of the research as much as possible, it is necessary to clean up the data of the literature obtained from the initial search, and manually exclude the conference papers, reviews, and other nature of the literature and then search again accurately, and get the effective data information (English samples) of 3,591 pieces of information. In the CNKI academic journal database, with "subject word = digital labor" as the search formula, limiting the source category to the Chinese Social Sciences Citation Index (CSSCI), 373 journal articles were retrieved. To reduce the research error, this paper carried out manual screening of the 373 sample data, eliminating reviews, conference papers, yearbooks, news reports, foreign literature, secondary reprints, and literature not related to digital labor, and finally obtaining 342 valid data for analysis.

C. Research Process

The research process of this paper is shown in Figure 1. Firstly, it introduced the concept of digital labor and the limitations of current research on digital labor literature. Then the WOS core database and CNKI database were used as data sources and the data were screened and de-duplicated. Thirdly, we compared the research foundation of digital labor with the annual publication statistics, development stage analysis, and disciplinary distribution analysis of digital labor research, followed by mining the research hotspots of digital labor using keyword co-occurrence, high-frequency word analysis, and secondary literature exploration, and finally exploring the research fronts and trends of digital labor by using keyword clustering, mutant word analysis, and timeline charts, to make a systematic compilation summary and review of digital labor research.

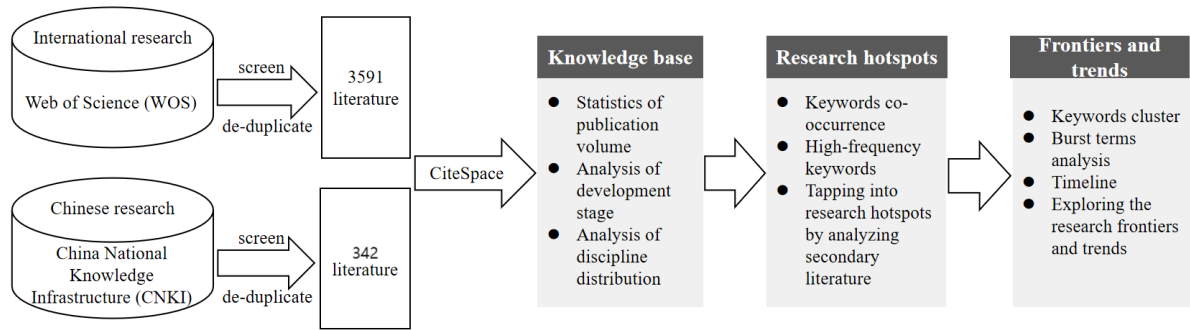


Figure 1: Research Process

III. COMPARATIVE STUDY OF DIGITAL LABOR IN CHINA AND INTERNATIONALLY

A. Comparative Analysis of the Basic Situation

In order to understand the changes in the number of publications and the disciplinary basis of digital labor research as a whole, this paper conducted statistics and comparisons on the annual distribution of the number of publications and research disciplines for 342 Chinese literature and 3,591 English literature. This is shown in Figure 2 and Table 1.

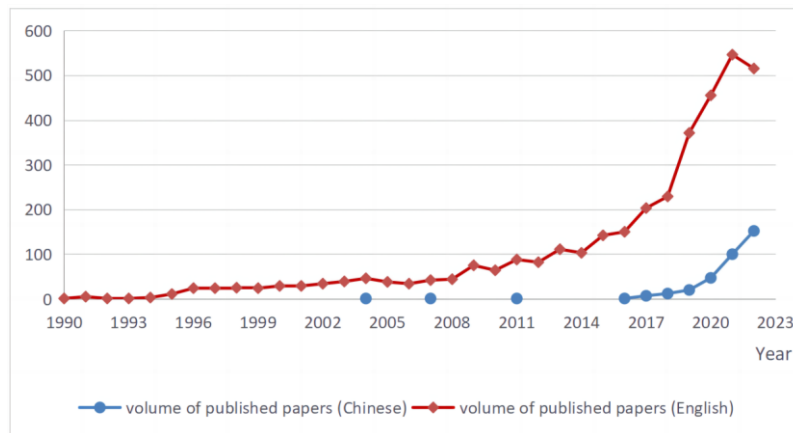


Figure 2: Comparison of Annual Publications in the Core Literature of Digital Labor Research (1990-2023)

Table 1: Comparison of the Distribution of Digital Labor Research Disciplines

Chinese		English	
research course	Documentation	research course (top ten)	Documentation
Philosophy	125	Communication	376
Journalism and Communication	99	Obstetrics & Gynecology	347
Economics and Management	71	Sociology	201
Sociology	30	Engineering, Electrical & Electronic	193
Computer Science	8	Economics	192
Education	5	Engineering, Biomedical	185
Law	4	Management	175
		Computer Science, Interdisciplinary Applications	133
		Environmental Sciences	127
		Computer Science, Information Systems	121

### 1) *Comparison of annual publications*

The number of publications is an important indicator to measure the development trend of a certain field in a specific period, which can also be more intuitive to see the change in the research intensity of the field, which is of great significance to analyze the development trend of a certain field and predict the future development trend of the field [8]. As can be seen from Figure 2, international research on digital labor predates China and can be traced back as far as the 1990s in the field of computer science, when the main focus was on the impact of digital technology on the workflow or work organization, such as the 1990 study on Intelligent Tutoring Systems (ITS) conducted by Angelides & Doukidis [9], which suggested that the direction of the development of intelligent tutoring systems was likely to be a labor-intensive industry. And the earliest literature on digital labor in China appeared in 2004 when Fan Huang published *Digital Labor Security Spawning a New Type of Labor System*. Before 2008, the academic circles paid little attention to digital labor, and the research on digital labor was in its infancy. After 2008, benefiting from the popularization of the Internet and the commercialization of 4G, many countries (especially the United Kingdom and the United States) gradually entered the era of mobile Internet, and digital labor began to gradually gain importance. Therefore, from 2008 to 2016, international digital labor research slightly increased, while China's digital labor research is still slowly developing, the relevant research results are very limited. With the optimization of personal smartphones, computers, and the Internet and the improvement of digital technologies, more and more forms of digital labor are derived, and digital labor is constantly penetrating into various fields. From 2018 onwards, the research on digital labor has ushered in the spring of development, and the overall number of publications has increased rapidly, especially internationally, with very rapid development, and the relevant literature of 2021 has reached the peak of the phase (546 articles). After 2021, although the international literature has slightly decreased, the number of annual publications remains above 500; the total number of Chinese literature is also increasing, with 152 publications in 2022.

With the deepening of digitization, informatization, and intelligence, digital labor has become one of the most important forces for economic development in today's world. Although there are some differences in the research development of digital labor in different countries, the research significance and value of digital labor as a new type of labor form in the era of digital economy is self-evident. In general, in terms of the total number of publications, Chinese digital labor publications were small but on the rise; in terms of development stages, international digital labor research had experienced a budding exploration period (before 2008) - a slow development period (2008-2016) - a rapid development period (2018-present); Before 2018, Chinese digital labor research was in a nascent exploratory period, and after 2018, there was a rapid development trend, which was mainly due to the fact that the 19th National Congress of 2017 proposed to "promote the deep integration of the Internet, big data, artificial intelligence, and the real economy", and the number of policies related to digital labor has gradually increased. The evolution of related policies has promoted the development of theoretical research on digital labor in China, and theoretical research is often systematic and forward-looking. With the development of theoretical research on digital labor, it can also provide support for the continuous improvement of policies related to digital labor, and further deepen and strengthen the rationality and scientificity of the policy system.

### 2) *Comparison of subject distribution*

To a certain extent, the distribution of subjects can reflect the researcher's research methodology, research perspective, and the field to which the research results belong, so a comparison of the distribution of subjects for digital labor research can tap into the differences between the two research perspectives and fields of study, and so on. From Table 1, it can be found that digital labor has formed a multidisciplinary common concern and multi-perspective cross-analysis research field, reflecting the complexity and importance of digital labor. Perspectives and approaches from different subjects can provide a richer and more comprehensive understanding and interpretation of digital labor studies.

In terms of the specific composition of the distribution of subjects in digital labor research, the study of digital labor in China involves seven subjects: philosophy, journalism and communication, economics and management, sociology, computer science, education, and law. Literature in the category of philosophy ranks first with 36.55%, which indicates that philosophy has an important role in the study of digital labor. Philosophy can provide frameworks and methods for in-depth exploration of the value logic and philosophical foundations of digital labor, thus promoting the development and regulation of digital labor. Secondly, the proportion of literature on journalism and communication, economics and management is also high, which is because the development of digital labor cannot be separated from the support of new technologies and the exploration of business models, and the research of journalism and communication, economics and management can provide theoretical support and practical guidance for digital labor in the areas of marketing, operation and management. In addition, sociology and

computer science have an irreplaceable role in digital labor research. Finally, education and law have a low percentage of literature, but this does not mean that they are not important in digital labor research. Pedagogy can explore the impact of digital labor on education and "how it is possible" to educate labor in the digital age, while jurisprudence can provide a legal framework and solutions for the regulation of digital labor.

The international digital labor research literature has a wide range of subjects, with communication studies dominating, accounting for 10.47% of all literature. In addition to communication, there are many other subjects dealing with digital labor. For example, the literature on obstetrics and gynecology is relatively large, which may be related to the popularization of digital medical services. Digital healthcare services can improve healthcare efficiency and service quality, while also increasing the digital labor intensity of medical staff. Sociology is also one of the important subjects in digital labor research. The continuous development of digital labor has brought about many changes in society, with far-reaching impacts on social structure and social relations, and has also brought about new social problems, such as "digital child labor" and "gender inequality in digital labor for childcare", and so on. In addition, there is a relatively large amount of literature on economics in digital labor research. The application of digital technology makes the digital labor market present new characteristics and laws, and digital labor as a new form of labor also provides great opportunities for the development of the digital economy.

In contrast, the disciplinary foundations of digital labor studies are the same: both involve directions in communication, sociology, computer science, economics, and management. The difference is that the subject distribution of digital labor research in China is more concentrated while international research is relatively extensive. An analysis of the distribution of the subjects that ranked in the top five reveals that in addition to the three disciplines that are commonly involved in communication, economics, and sociology, Chinese research focuses more on the directions of philosophy, and computer science, while the international focus is more on the exploration of digital labor in the fields of obstetrics and gynecology, and electrical and electronic engineering.

## *B. Digital Labor Research in China: Hot Spots, Frontiers and Trends*

### *1) Research hotspots*

Research hotspots refer to the research theme that is widely concerned by academics or has greater influence, through an in-depth understanding of the research hotspot, you can grasp the current cutting-edge dynamics of the field, and grasp the direction and focus of future research. The keywords are a high degree of generalization of the research topic, reflecting the research focus of the literature, therefore, high-frequency keywords often reflect the research hotspots in a certain field. In the visualization analysis based on CiteSpace, the combination of keyword co-occurrence Mapping Knowledge Domain and high-frequency keywords is usually used to reveal the knowledge structure or research paradigm. In addition, Centrality is a key indicator for analyzing the importance of keywords, and keywords with higher mediational centrality indicate a higher frequency of co-occurrence with other keywords, which can be used to predict the research hotspots in a certain field [10]. Nodes with centrality above 0.1 are central nodes, indicating that they are more important and influential in the research area.

In this paper, we analyze the co-occurrence of keywords in 342 digital labor literature in China and draw a keyword co-occurrence Mapping Knowledge Domain of digital labor research in China, which has a total of 529 nodes, 1,256 connecting lines, and a network density of 0.009. By listing the data information of the top ten keywords (Table 2), it can be found that "digital labor" has the highest frequency of 171 times, and its intermediary centrality is also the highest; "Digital economy", "digital capital", "digital labor", "platform economy", "digital technology", etc. all appear more than 10 times, and the intermediary centrality of "digital economy" and "digital labor" is also relatively high. "digital technology" and so on all appear more than 10 times, and centrality of mediation between the "digital economy" and "digital labor" is also relatively high. The emergence of "digital technology" shows that the nature of digital labor is based on digital technology, and digital technology is the key to the realization and development of digital labor. The emergence of "digital labor" emphasizes the place and role of digital labor in the labor market, and the role of digital labor in the digital and platform economies is also in the spotlight. In addition, the study of digital labor has expanded from the perspective of pure labor to the perspective of macro-economy, and the digital economy has become an important background and development environment. At the same time, the constant innovation of digital capital, digital technology, and platform economy has a far-reaching influence on the form and ecology of digital labor. Combined with the analysis of the keyword co-occurrence mapping knowledge domain, Table 2, and the secondary literature, the research focus of digital labor in China mainly focuses on three aspects:

a) *Definition of the concept and scope of digital labor:* The definition of the concept and category of digital labor has been one of the core issues of digital labor research in China. Due to the special nature of digital labor, such as intangibility, virtuality, and high degree of intelligence, how to define digital labor has received a lot of attention. In the process of defining digital labor by Chinese researchers, a number of scholars have based their conceptualization on Fox's viewpoints, while a number of authors have focused on the difference between digital labor and traditional labor, the content and characteristics of digital labor, as well as the relationship between digital labor and concepts such as the digital economy and the sharing economy. For example, Zhou & Wang [11] defined the concept of digital labor in a way that was more in line with Fox's point of view, and in their study, they constructed and explained Fox's critical theory of digital labor, which provided Chinese scholars with a new way of thinking about reconstructing the labor theory of value in the age of Internet social media; Ping [12] considered digital labor to be all kinds of labor that could be included in the capital value-added system by leaving traces of data and forming abstract data under the domination of the value form under the social conditions of the universalization of digital technology and smart devices; Chen [13] outlined the concept of digital labor as a new form of labor that accompanied the development of information technology on the Internet, but there were many new changes compared with the general production process in traditional industries, such as the object of labor was dominated by data, and labor materials were closely related to information technology. Wu & Lu [14] mainly referred to Fox's definition of digital labor, proposing that digital labor referred to both data commodities formed by general intelligence, as well as closely related activities such as agriculture, industry, etc.; they also specifically explored the concept of digital labor in three dimensions: complex labor, informational labor, and diversity of forms [15]. It can be seen that the definition of digital labor in China has not yet been unified, and different researchers have proposed their own definitional perspectives from different angles, which provides multidimensional ideas and directions for digital labor research.

b) *Studying digital labor from the perspective of the labor theory of value:* It mainly involves popular themes such as the dispute between data commodities and data products [15-16], the dispute between productive and unproductive labor [17-18], the digital economy and digital capitalism [19], and digital labor education [20-22]. The rise of the digital economy and the new changes in productivity and production relations brought about by digitization have brought digital labor a whole new space for reflection and development. Studying digital labor from the perspective of the labor theory of value can help us deeply understand the value significance of digital labor as a new type of labor form.

c) *Studying digital labor in the context of the communication studies:* Although the communication studies has absorbed and borrowed some contents of information and communications technology, their main research object is still "communication". So scholars who study digital labor in Chinese academia include not only scholars of information and communications technology but also many scholars of communication. On the whole, Chinese academics study digital labor in the context of the communication studies, mainly staying in the translation of international research results [23], as well as the use of the concept of "digital labor" in the field of communication to analyze the specific cases of the digital economy, such as Yuan [24] studied the labor of young players in the field of mobile games, which was the most important factor in the development of the digital economy in China; Zhang [25] studied digital labor from the perspective of subtitle groups and youth culture; Jiang & Huang [26] took the digital labor of network writers as the object of their study, focusing on the transformation of network writers' identity from "literary youth" to "digital laborer"; Taking "food delivery" as an empirical case, Shu [27] explored the dissemination of the material practice of digital labor in the context of mobile Internet through fieldwork and in-depth interviews, and found that "food delivery" under the platform economy is a material network of digital labor consisting of digital laborers, technological artifacts, intermediary labor organizations, and Internet platforms.

Table 2: High-frequency Keywords of Digital Labor Research in China (Top10)

Serial number	Keywords	Frequency	Centrality	Year of first appearance
1	Digital labor	171	1.31	2016
2	Digital economy	38	0.29	2019
3	Digital capital	22	0.08	2018
4	Digital labour	19	0.15	2018
5	Platform economy	14	0.03	2019
6	Digital platform	13	0.04	2018
7	Digital technology	12	0.05	2019
8	Labor process	12	0.05	2020
9	Exploitation	11	0.04	2019
10	Digital age	10	0.04	2021

11	Gig economy	9	0.04	2017
12	Data commodity	9	0.02	2019

2) *Research frontiers and trends*

The analysis of the evolution trend of research hotspots in the field of digital labor research can make researchers more clear about the development of research hotspots, and based on the evolution trend, the research frontiers of digital labor can also be predicted. The "Timeview" function of CiteSpace can be used to visualize and analyze this evolutionary trend, as well as to perform thematic clustering of keywords [28]. In this paper, the keywords of the papers related to digital labor were first clustered, and the average silhouette value of the clustered network (Mean Silhouette)  $S=0.92 (>0.7)$ , which indicates that the clustering results have a high degree of confidence [7]; the modularity value of the clustered network (Modularity  $Q$ )  $Q=0.65 (>0.3)$  indicates a significant modular structure of the delineated modules. Then, a timeline map of our digital labor research area was drawn and the clustering results and timeline map were converted to Table 3 using Excel tools.

Table 3: Cluster and Continuous Research Schedule of Digital Labor Research in China

Cluster	number	Keywords	Average year*
Digital Labor in the Perspective of Labor Value Theory	# 0 Digital Labor	Social Conditions; Platform Users; Dialectical Analysis; Ethical Reconstruction; Digital Capitalism	2020
	# 2 Digital Capital	Digital Labor; Common Prosperity; Digital Welfare; Distributive Justice; Capital Logic	2020
	# 4 Proletariat	Left-wing thinker; excluded person; social time; labor time; labor process	2021
Digital Labor in the Perspective of the Communication Studies	# 1 Digital Economy	Digital Labor; Uncertainty; Platform Labor; New Employment Form; Digital Platform	2020
	# 5 Platform Economy	Digital labor; Value realization; Value formation; Value distribution; Data commodity	2020
	# 3 Digital Labour	Mobile Games; Intangible Labor; Platform Exploitation; Social Media; Network Governance	2020
Alienation of Digital Labor	# 6 Labour & Technology	Social basic contradiction; Machine paradox; Intelligence paradox; Leisure labor; Labor leisure.	2019
	# 7 Digital Age	Other Exploitation; Alienated Labor; Self-exploitation; Data Regulation; Labor Education	2020
	# 8 Labor control	Digital Labor; Digital Capitalism; Time Change; Integration of Production and Expenditure; Creative Labor	2020

(\* Notes: In papers in the field of scientometrics, researchers have borrowed the term "average year" to reflect the temporal characteristics of the emergence of a particular topic and to facilitate the highlighting of the persistence of a research topic.[29]. For example, if a keyword appears twice in 2016 and three times in 2022, the average year is  $(2016*2 + 2022*3)/5 = 2019.6$ , which is the average year of the keyword's appearance. The closer the average year is, the more recent the topic is as a research hotspot).

In a timeline map, literature in the same clusters is placed on the same horizontal line, with more literature in the cluster representing the more important the area clustered [28]. Cluster labels show 9 categories, including digital labor, digital economy, digital capital, digital laborer, the proletariat, platform economy, labor technology, digital age, and labor control. Combined with Table 3, it can be seen that China's digital labor research started late, the average year is concentrated in 2019-2021, and the research hotspots in the last three years are mainly focused on the theoretical study of digital labor, including digital labor under the view of the labor theory of value, digital labor under the view of the communication studies, and the alienation of digital labor. The research related to testing the value utility of digital labor theory through case studies and the application of digital labor in different fields is less.

a) *Cluster I: digital labor in the perspective of labor theory of value*

Among the research themes of digital labor from the perspective of the labor theory of value, the following points are noteworthy: First is digital capitalism and the logic of capital. Digital labor, as a new productive force and production relation, has impacted and transformed the traditional capitalist logic and capitalist mode of production. By analyzing the formation mechanism of digital capitalism and the impact of digitization on capitalist relations of production, we can understand the social changes in the context of digitization and globalization. The second is the relationship between digital labor and social time, labor time, and the labor process. With the acceleration and popularization of digitalization, the time and space of digital labor become more and more unlimited, which brings new challenges and possibilities to labor time, labor process and social time. The third is digital labor and distributive justice. Digitization and globalization have accelerated the concentration of wealth

and opportunity, leading to a widening gap between digital and non-digital labor. By exploring the relationship between digital labor and distributive justice, including income distribution, social security and labor rights in digital labor, a more just and inclusive digital society can be built. The last is digital labor and ethical reconstruction. The rapid development of digital society has brought about entirely new moral and ethical challenges for individuals and society, such as privacy protection, personal information security, and algorithmic fairness. Digital labor research should pay attention to the relationship between digital labor and ethical reconstruction, and explore how digital labor should be carried out under the premise of personal and social interests. In conclusion, the study of digital labor under the labor theory of value can help us better understand social changes and issues in the context of digitization and globalization, and contribute to the construction of a more just, inclusive and sustainable digital society.

*b) Cluster II: digital labor in the perspective of the communication studies*

In the study of digital labor from the perspective of the communication studies, digital economy and platform economy are the most prominent and cutting-edge topics. Digital economy refers to the impact of digital technology on the entire economic activities, including digital industry, digital business, digital finance and other aspects, and the development of these digital economic fields has largely promoted the emergence and development of digital labor. The platform economy, on the other hand, is one of the most typical manifestations of digital labor. Platform companies, as intermediary platforms, provide online services and products while charging a certain amount of platform service fees, which often come from the labor value of digital labor. Platform labor and new employment forms are also important directions for digital labor research. With the development of digital economy and platform economy, more and more people choose to earn income through digital platforms, thus forming new employment forms, such as online car-hailing drivers, delivery riders, and self-media creators. These new employment forms also bring a lot of social problems, such as the protection of the rights and interests of platform laborers, platform exploitation, etc., which are also hot topics of researchers' attention.

In addition, data merchandise and mobile games deserve attention. Data commodity is an important field in the digital economy, such as personal information, preference data, and so on. These data are collected and processed by digital platform and transformed into data commodity for sale. Mobile games, as the representative of the digital entertainment industry, also play a significant role in the emergence and development of digital labor, a lot of digital labor, and mobile games.

Finally, the digital labor research frontier also includes social media and online governance. Social media has become an inevitable part of people's daily lives and work, and more and more digital laborers carry out content creation, publicity, and promotion activities through social media, which makes social media an important direction for digital labor research. Network governance, on the other hand, is an important background for the study of digital labor. With the development of the digital economy and the platform economy, the creation and development of digital labor have also brought many new issues and challenges to network governance, such as the protection of the rights and interests of digital laborers and the regulation of platform enterprises.

*c) Cluster III: alienation of digital labor*

From Table 3, we can see that the study of digital labor alienation mainly focuses on the following aspects: First, the study of digital labor alienation needs to consider the basic contradictions between digitalization and mechanization. Although digitalization and robotization provide more convenience and efficiency, they also bring new problems and contradictions, such as artificial intelligence paradox and machine paradox. Secondly, digital labor alienation research needs to pay attention to the problem of labor leisure. With the popularization of digital, people's lives and work have changed, the combination of digital labor and leisure is higher and higher, and the boundaries between the two are becoming increasingly blurred. Third, Digital labor alienation research needs to explore the impact of digital capitalism. Changes in the ways of labor and relations of production in the digital age and the emergence of digital capitalism have brought new pressures and challenges to labor. In the context of digital capitalism, workers face increased control and regulation, and their personal information and privacy may be violated. Finally, research on digital labor alienation needs to focus on the status of creative workers. The digital age offers more opportunities and platforms for creative workers, and while digital labor frees people from being objectified, it may also expose them to more risk and uncertainty.

*C. International Research on Digital Labor: Hotspots, Frontiers and Trends*

*1) Research hotspots*

We imported 3591 foreign language samples of digital labor into Cite Space, set the node type as "keyword", selected the keywords with the top ten frequency, and drew the keyword co-occurrence map of international digital



labor research (Figure 3). There are 933 nodes, 4005 lines, and a network density of 0.0092. The size of the keyword node indicates the frequency of keyword occurrence. The larger the node is, the higher the frequency of keyword occurrence. The diameter of each node in Figure 3 is different, which indicates that the frequency of keywords is different. Among them, "labor", "digital inspection", "technology" and other keywords corresponding to the larger node, more nodes connected with it, indicating that these keywords often appear together in the same literature, playing a significant role as a bridge.

The keywords ranked in the top ten in frequency are listed, as shown in Table 4. It can be seen that "labor" has the highest frequency of 431 times, and its intermediary centrality is also the highest; the frequency of "work" and "social media" are 179 and 138 times respectively. Social media" are 179 and 138 times respectively. "technology" "system" and "impact" also appear more than 100 times, but The centrality of "technology" and "impact" are both below 0.1, with relatively low research importance and weak impact. Among the top ten high-frequency keywords of international digital labor research, "labor", "system" and "management" have a centrality of more than 0.1. Integrating and categorizing the high-frequency keywords and further tracing their related literature, it was concluded that the hotspots of international research are respectively:

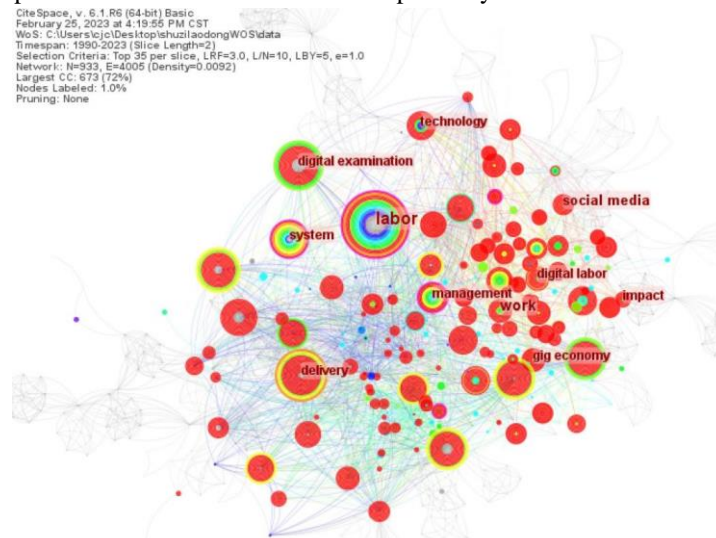


Figure 3: Keywords Co-occurrence Knowledge Graph of International Digital Labor Research

a) *Research on digital labor based on fox theory:* Fox was an important representative of the international academic circle in analyzing digital labor. He had published a series of research results. For example: with the help of the social model of three subsystems (economic, society, and cultural) and three forms of power (economic, society, and cultural), he put digital labor on social media into context and explored the digital labor of social media in the context of the capitalist system [30-31]; he combined the analysis of patriarchy and slavery, which enriched the theoretical study of digital labor. Many scholars had subsequently criticized or added new perspectives to Fox's digital labor research [32-34].

b) *Studying digital labor in the context of the communication studies:* The current research on "digital labor" in the international academic community generally traces its origin to the field of the communication studies, mainly represented by Dallas Smythe and others. Smythe was the first to put forward the concept of "audience commodity" [35], and his main object of analysis was the "audience" in traditional mass media (e.g., television), and "audience" was the main object of analysis in traditional mass media (e.g., television). "Audience" had become a kind of "commodity", and the media often sold the audience's "attention" as a "commodity" to advertisers. The media often sold the audience's "attention" as a "commodity" to advertisers, and when the audience focused its attention on the "advertisement", it constituted a kind of "audience labor", which constituted a kind of "digital labor". This "audience labor" constituted the earliest prototype of "digital labor". After that, the research results on digital labor in the field of the communication studies mainly focus on the commodification of media content, audience, and labor, the change of communication space and time, as well as class, social movement, hegemony and other practical processes [36-38].

c) *The value embodiment and influence of digital labor in different fields:* Combined with Figure 3 and Table 4, international digital labor studies not only focus on the theoretical level but also focus on its value and impact in different areas. Before the 21st century, the international academic discussion of digital labor was still based on the theoretical perspectives of Fox Theory and the communication studies, as well as on the value of

embodiment in computer science, electrical and electronic engineering, and medicine; since the 21st century, the international academic community has paid more attention to the embodiment of digital labor in the fields of social media, economics, artificial intelligence, etc., that is to say, the international research on digital labor has gone from focusing on the theory to focusing on the practice, and from focusing on the macroscopic to focusing on the microscopic, some topics characteristic of the digital age have also been proposed, such as "gig economy", "digital labor for childcare", "new domestic labor", "digital housewife", "digital labor for people with disabilities" and so on [39-43].

2) *Research frontiers and trends*

Tracking research frontiers and development trends can help researchers grasp the research direction and provide new ideas and guidance for the innovative development of research. In this paper, Web of Science data was imported into Cite Space to establish the corresponding data project, selecting 1990-2023 and taking two years as the time slice, selecting the node type as "keywords", setting the threshold as Top35, and continuing to run Cite Space on the basis of the keyword cluster network ( $S=0.85 > 0.7$ ,  $Q=0.65 > 0.3$ ). After using the "Citation Burst" and selecting the top 10 keywords in terms of mutation intensity, we drew the keyword mutation graph in the field of digital labor research (Figure 4).

Table 4: High Frequency Keywords of International Digital Labor Research (Top10)

Serial number	Keywords	Frequency	Centrality	Year of first appearance
1	Labor	431	0.17	1995
2	Work	179	0.03	2003
3	Social media	138	0	2014
4	Technology	109	0.03	2000
5	System	109	0.13	1991
6	Impact	105	0.08	1998
7	Digital labor	94	0	2014
8	Delivery	91	0.02	1996
9	Gig economy	90	0	2018
10	Digital examination	86	0.02	1994
11	Management	85	0.13	1996

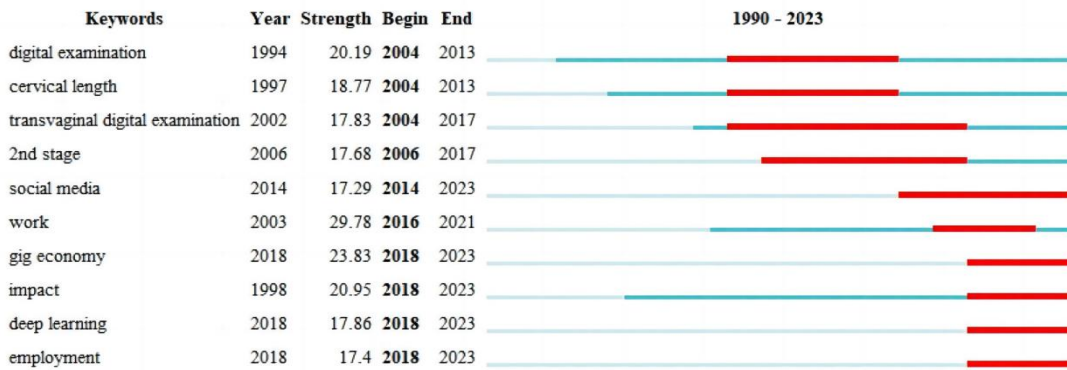


Figure 4: Top 10 Keywords with Strongest Citation Bursts

As keywords with a sharp increase in citation frequency over a period of time, burstness can be used to show changes in research trends in a field. Words with high mutation intensity in Figure 4 include "digital examination", "work", "casual economy", and "impact". From 2004 to 2013, the strongest words in the digital labor field were related to medicine, and by tracing the relevant literature, it was found that most of them were about how to perform medical examinations or treatments with the help of digital technology. From 2004-2017, "2nd stage" became a strong term, where "2nd stage" refers to the second phase of global WAN technology (Web 2.0). Web 2.0 is the typical embodiment in the Internet field of the future-oriented, human-centered innovation 2.0 model brought about by the network revolution triggered by the development of information technology. With the proposal and application of Web 2.0 technological forms, the combination of digital labor with play, leisure, and consumption has become higher and higher, and the boundaries between the two have become more and more blurred, making it difficult to distinguish "who is the producer", "who is the consumer", "who are the workers (digital proletariat)", or "who are the capitalists (digital capitalists)". From 2014 to 2023, "social media", "casual labor economy", "deep learning" and "employment" have become strong words in the field of digital labor. have become strong words in field of digital labor, in which the burst word "social media" has continued since 2014, which on the one hand

indicates that the international research trend of digital labor is diversified and multi-disciplinary, and on the other hand indicates that digital labor on social media is a topic of sustained international attention in the past decade.

Combined with Figure 2 in the previous section, it can be seen that international digital labor research has entered a period of rapid development since 2018, with an explosive growth in the number of articles published, while Figure 4 shows that "gig economy" "impact" "deep learning" and "employment" have become burst terms since 2018. The "gig economy" refers to short-time, flexible forms of work that can be quickly matched between supply and demand using the Internet and mobile technology. The advantages of this form of employment are flexibility and autonomy, but the disadvantages are instability and unreliability. There are also issues of platform exploitation and social security. Therefore, we need to further explore how to balance the development of the economy and the protection of workers' rights and interests. The burst term of "impact" emphasizes the fact that the development of digital labor has had far-reaching social, economic, and cultural effects. For example, digital labor has changed the landscape of the media and entertainment industries, and digital labor patterns have changed the way traditional industries operate. In this process, the development of digital labor brings challenges and opportunities to labor relations, employment and income distribution. Therefore, the impact of digital labor needs to be explored in depth in order to better respond to these changes. Deep learning is an artificial intelligence technology that can automatically acquire new knowledge and skills through machine learning to achieve more accurate and efficient task processing. In the field of digital labor, deep learning technology can help people to complete some repetitive and tedious work, so as to improve efficiency and productivity. However, the use of deep learning techniques also brings some problems, such as opacity of machine algorithms and data privacy issues. So there is a need to study the impact of the use of deep learning techniques on digital labor. The burst term of "employment" reflects the impact of the digital economy on the demand and supply of the labor market. In the digital economy, the relationship between workers and employers has changed. Employers have more flexibility to hire workers, and workers have more autonomy to choose their jobs. However, the change has also brought about some challenges, such as how to protect workers' rights and interests, how to rationalize labor relations, and how to use digital technology for labor education.

All in all, these burst terms reflect the cutting-edge topics of international digital labor research: focusing on research on the impact of digital labor in different fields, including the social media, deep learning, digital labor education, artificial intelligence, computer science, and so on.

#### IV. FINDINGS

Based on the core journal documents of WOS and CNKI, this paper makes a visual analysis of digital labor research from 1990 to 2023 by scientific measurement methods, summarizes the basic status quo, research hotspots, research frontiers and trends of digital labor research, and makes a comparative analysis of digital labor research on this basis. The results show that there are certain similarities and differences between Chinese and international research, which can be summarized into the following points:

Firstly, in terms of the number of publications, the total amount of digital labor literature in China is relatively small, and the research started late, relatively lagging behind the international. Although China's digital labor research has developed relatively rapidly in the past five years, the pace of research has accelerated, and certain results have been achieved, but compared with the international, both in terms of research breadth and research depth, there is a gap, and there is still a lot of room for growth in Chinese digital labor research.

Secondly, in terms of disciplinary distribution, the disciplinary distribution of digital labor research involves the direction of communication, sociology, education, computer science, economics and management, etc. Chinese research is more concentrated (mainly involving seven disciplines) and international research is relatively extensive (involving dozens of disciplines). Chinese research pays the most attention to the direction of philosophy, while international research has been widely conducted in the fields of social media, deep learning, digital labor education, artificial intelligence, computer science and information systems.

Thirdly, in terms of research hotspots, frontiers and trends, there is partial overlap between Chinese and international digital labor research. For example, all of them have conducted research on digital labor in the context of the communication studies and educational perspectives, which indicates that the direction of Chinese research on digital labor is generally consistent with that of the international community, and that it has basically grasped the essence of the research on digital labor. However, there are also significant differences, for example, most Chinese scholars have studied digital labor in terms of its concept, form, alienation, exploitation, etc., while other countries paid more attention to this in the early days, but in the past decade, they have paid more attention to the

value embodiment and impact of digital labor in different fields, such as social media, gig economy, deep learning, artificial intelligence, and digital labor education.

## V. RELEVANT IMPLICATIONS

Digital labor research in our country has made many research results and has been catching up rapidly in recent years, but compared with international digital labor research still has a great room for improvement. Based on the visual comparison and analysis of digital labor research, this paper draws the following enlightenments to further expand and deepen the study of digital labor in China.

### A. *Research Context: Promoting "Convergence of Perspectives" between Chinese and International Studies*

Chinese digital labor research started late and its theoretical foundation is relatively weak, so it is more dependent on or biased toward international digital labor theories, even if there are differences, it has not really put forward Chinese contextual digital labor theories of great significance, and it has not really developed its own research themes. Therefore, as a developing country that has attracted much attention in the digital era, China can put forward more digital labor theories and concepts that can solve real problems. For example, it can explore the influencing factors and new representations of digital labor, as well as the ethics of digital labor, digital labor education, and so on.

### B. *Research Areas: Enhancing "cross-border integration" between subject areas*

Digital labor, as a combination of "Internet" and "labor", has its own characteristics of cross-field. International digital labor research involves a wide range of disciplines, such as communication, medicine, economics, computer science, education, electronic information engineering, and so on. However China has not yet stepped out of the traditional research framework, and the research theory is more conservative, the research perspective is relatively single. Therefore, China's digital labor research should expand the extension, break the disciplinary boundaries, widely absorb the theories and research paradigms of various disciplines, explore the possibility of interdisciplinary, find new breakthroughs and focus, and explore a new direction of digital labor research by multi-track and multi-synergistic path, so as to promote the innovative development of digital labor research and better deepen digital labor research.

### C. *Research issues: realizing the "dynamic integration" of theoretical research and practical exploration*

International digital labor research not only focuses on theory but also on practice and problem solving. However, at present, the research on digital labor in China still focuses on theoretical research, with relatively little research on practice. Practice is fundamental to promoting continuous in-depth research on related issues, so it is necessary to deeply analyze the impact and practical exploration of digital labor in different fields, including but not limited to the digital labor education, digital divide, digital ethics, blended labor education and so on. At the same time, the forms, characteristics, and laws of digital labor should be fully grasped, so as to realize the organic combination of theory and practice, and to provide a scientific basis for the research of related issues, to cope with the challenges brought about by digital transformation.

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