A Review of Carbon Emission Reduction Cost Research in China—Based on CiteSpace Knowledge Mapping Analysis

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Abstract: *With the continuous severity of the global environment, people are aware of the importance of protecting the ecological environment, China assumes the status of a major country in the world, actively responds to the global call, and puts forward the goal of achieving carbon peak by 2030 and carbon neutrality by 2060. As a result, all industries in our country must carry out carbon emission reduction and reduce pollutant emissions. Therefore, we are more concerned about the cost of carbon emission reduction, in order to have a more detailed understanding of the development of carbon emission reduction costs, comb through the scientific research and development trends of scholars in this field in recent years, so as to provide guidance and reference for beginners to clarify the formation stage, development context and hot frontiers of carbon emission reduction costs. In this paper, the literature in the CNKI core database with the theme of "carbon emission reduction cost" is used to compare and analyze the visual data based on the perspectives of core journals, scientific research strength, authors and their research fields, core literature and keywords.*

Keywords: bibliometrics; CiteSpace; carbon reduction costs

1. Introduction

Climate change today is having a very significant impact on a global scale. For example, extreme weather has caused many inconveniences to people's production and life; global warming has led to threats to food production; sea-level rise has led to an increasing risk of catastrophic flooding, and cities and countries near the sea are facing a huge existential crisis; and the global ecological balance has been disrupted by the decline in biodiversity. Therefore, climate change is a major challenge to the future and destiny of humankind, and we need to join hands to deal with it. In view of this, the Paris Agreement states that the ecological risks posed by climate change to the Earth and the existential crisis brought about by human beings can be reduced only if the world realizes the peaking of greenhouse gas emissions as soon as possible and achieves net-zero greenhouse gas emissions in the second half of this century. To address the issue of climate change, China has played its role as a great power, with General Secretary proposing the goal of achieving carbon peaking by 2030 and carbon neutrality by 2060. In order to actively respond to the country's call, various industries in China have begun to pursue green, low-carbon and sustainable development. As a result, carbon reduction has become a hot topic. Therefore, in order to understand more about China's carbon abatement cost related policies and the current status of academic research, this paper takes carbon abatement cost as the keyword, searches for the literature in the Knowledge Network, and conducts a visual analysis with the help of CiteSpace, so as to understand the current status of its research as well as the future development trend[1-6].

2. Research design

CiteSpace's study of carbon abatement costs consist of three main parts: data preparation, data analysis, and visualization and analysis. The first is to determine the research content, the theme of this paper is the cost of carbon emission reduction; the second is to determine the data, according to the research theme to determine the data source, the processed data will be stored in the database; the third is to carry out the visualization and analysis; and the last is to draw conclusions based on the analysis and put forward the recommendations or the future research direction in conjunction with the actual situation.

2.1 Data sources

The literature data of this paper comes from CNKI database. In CNKI database, select advanced search, literature type selects journal, subject is carbon abatement cost, and source category is CSSCI. The literature of the paper is from 2013 to 2022. A total of 461 journal papers were retrieved.

2.2 Research methods

This study mainly uses CiteSpace software to analyze the relevant literature.CiteSpace is a mathematical and statistical method to describe, evaluate and predict the current status and development trend of the literature through various features of the existing literature. It is currently widely used in a variety of fields, and is accurate, convenient and efficient in analyzing and visualizing co-citation networks, and is able to identify new future trends and dynamics in this direction. The software usually uses two levels, descriptive statistical analysis and cluster analysis, to make a study on the current development and future trends of a field. Among them, descriptive statistical analysis describes the current status of research development, including the overall analysis of publications and citation distributions during the sample period, the analysis of research regions of published journals, and the analysis of issuing organizations and collaborative networks; the basic idea of cluster analysis refers to the analytical process of grouping a physical or abstract collection into multiple classes consisting of similar objects, so that objects in the same cluster have a great deal of similarity, whereas objects between different clusters have great differences. Based on this, this paper analyzes the bibliometric analysis in the field of carbon emission reduction cost by using CiteSpace software, aiming to show the current status, hotspots and trends of this research through data analysis and information mining[7-11].

3. Visualization of carbon abatement costs

In this paper, carbon emission reduction cost is visualized and analyzed by CiteSpace software to explore the development process of carbon emission reduction cost as well as future research hotspots. It mainly analyzes the analysis, cluster analysis and trend analysis of the number of articles, keywords, authors of articles, and institutions of articles.

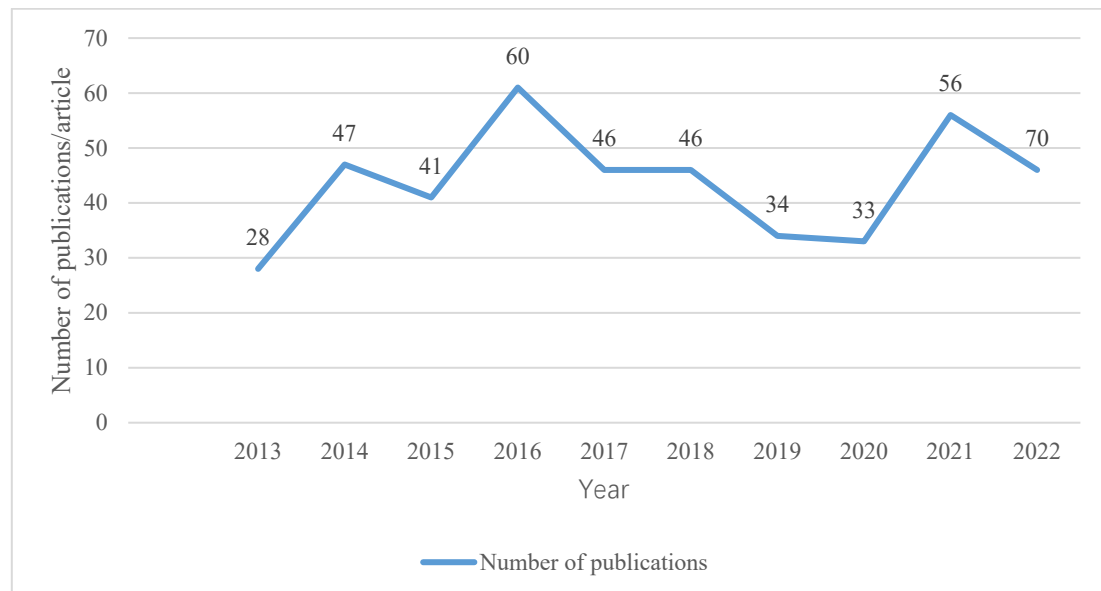*3.1 Analysis of the annual number of communications*

Figure 1: Temporal distribution of the number of literature on carbon abatement costs.

According to the number of literature counted from CNKI full text database, Excel was used to draw the time distribution graph of the number of articles issued in the study of carbon emission reduction cost. From the overall point of view of the number, it is gradually and slowly rising. Among them, the highest value in the statistical graph was obtained in 2016, which was due to the signing of the Paris Agreement in 2016: the goal is to control the increase in global average temperature within 2 degrees Celsius

compared to the pre-industrial period, and to strive to limit the temperature increase to 1.5 degrees Celsius. Therefore, the significant number of publications in this year is also particularly due to the fact that the increase starts after 2020 due to President's important speech at the 75th General Debate of the United Nations General Assembly, in which he pointed out that it is necessary to accelerate the formation of a green mode of development and way of life, to build an ecological civilization and a beautiful planet, and that carbon dioxide emissions should strive to reach a peak by 2030, and strive to achieve carbon neutrality by 2060. As a result, the amount of carbon emission reduction cost issuance will increase year by year after 2020, as shown in Figure 1.

3.2 Author profiling

Statistics on authors with 3 or more publications in the field of carbon abatement cost during the period of 2013-2022 are shown in the table 1 below.The authors with 3 or more publications totaled 26, and the top three authors were Wang Zheng, Tian Yun, and Xia Liangjie.

Table 1: Statistics of authors with high frequency of publications from 2013 to 2022.

Number	author	Number of publication	Author's unit	Number	author	Number of publication	Author's unit
1	Wang Zheng	5	Henan University	14	Liu Yu	3	University of Chinese Academy of Sciences
2	Tian Yun	5	Zhongnan University of Economics and Law	15	Tang Ling	3	Beijing University of Chemical Technology
3	Xia Liangjie	5	Tianjin University of Finance and Economics	16	Xia Yan	3	Chinese Academy of Science
4	Fan Ying	4	Beihang University	17	Zhao Wenhui	3	Shanghai Electric Power University
5	Zhang Tongbin	4	Dongbei University of Finance and Economics	18	Bao Qin	3	Chinese Academy of Science
6	Liu Mingwu	4	Chongqing Jiaotong University	19	Qiao Xiaonan	3	Nankai University
7	Li Youdong	4	Inner Mongolia University of Finance and Economics	20	Lou Gaoxiang	3	East China University of Science and Technology
8	Zhao Lixiang	4	Beijing University of Technology	21	Zhang Xinhua	3	Changsha University of Science and Technology
9	Zhou Dequn	3	Nanjing University of Aeronautics and Astronautics	22	Wang Mingxi	3	University of International Business and Economics
10	Zhao Daozhi	3	Tianjin University	23	Cui Lianbiao	3	Anhui University of Finance and Economics
11	Fan Tijun	3	East China University of Science and Technology	24	Gu Gaoxiang	3	East China Normal University
12	Xu Yingzhi	3	Southeast University	25	Chen Liyun	3	Tianjin University
13	Nie Jiajia	3	Southwest Jiaotong University	26	Wang Qinpeng	3	Hebei University of Economics and Business

In CiteSpace, the network node is set as the author (Author), the threshold (c, cc, ccv) is set as (2, 2, 15) (2, 2, 15) (3, 2, 15) in the three partitions of the data at the beginning, middle, and end of the data, respectively, and the time slices are set to 1 year. The literature from 2013-2022 was analyzed by author collaboration network visualization and the obtained results are shown in Figure 2. From the figure, we can conclude that Tian Yun cooperated closely with Wu Xianrong and Zhang Junbiao, and there was close cooperation between Xia Liangjie and Li Youdong[12-17].

Figure 2: Author collaboration network diagram.

3.3 Analysis of Institutional Characteristics

We analyzed the selected 461 papers in CNKI by metrological visualization and got the main distribution of the author institutions. The following table 2 mainly contains the institutions with 6 times and more than 6 times of publications, the highest number of publications is the Chinese Academy of Sciences, and the second is Tianjin University, which can be seen that some of the teachers in this institution have a strong research interest in this area with more publications, or the institution as a whole is more concerned about the cost of carbon emission reduction, which leads to a higher number of publications.

Table 2: Statistics on high-issue-frequency institutions from 2013 to 2022.

Number	Institution	volume of publications	Number	Institution	volume of publications
1	Chinese Academy of Science	12	14	Central University of Finance and Economics	8
2	Tianjin University	11	15	Shandong University	8
3	Xi'an Jiaotong University	10	16	Wuhan University	7
4	Peking University	10	17	Central South University	7
5	Zhongnan University of Economics and Law	10	18	Jiangsu University	7
6	East China Normal University	10	19	Renmin University of China	7
7	Jinan University	10	20	Dongbei University of Finance and Economics	7
8	Tsinghua University	10	21	Jilin University	7
9	University of Chinese Academy of Sciences	10	22	Beijing Normal University	6
10	Southeast University	9	23	Zhejiang Gongshang University	6
11	Tianjin University of Finance and Economics	9	24	Southwest Jiaotong University	6
12	Chongqing University	9	25	University of International Business and Economics	6
13	Nanjing University of Aeronautics and Astronautics	8	26	East China University of Science and Technology	6

3.4 Keyword analysis

Keywords are words or terms extracted from the literature to distinctly and intuitively reflect the subject matter of the literature, and the study of keywords helps to analyze the hot issues of research in a certain scientific field. Therefore, in this paper, the keywords of the sample literature were statistically analyzed to find out the keywords that appear more frequently in the literature. The following table shows the keyword co-occurrence analysis of the research data literature. From the figure 3, it can be concluded that carbon emission reduction, carbon emissions, carbon trading and emission reduction cost appear more frequently. Another list of the top 10 high-frequency keyword terms is listed, which is shown in Table 3.
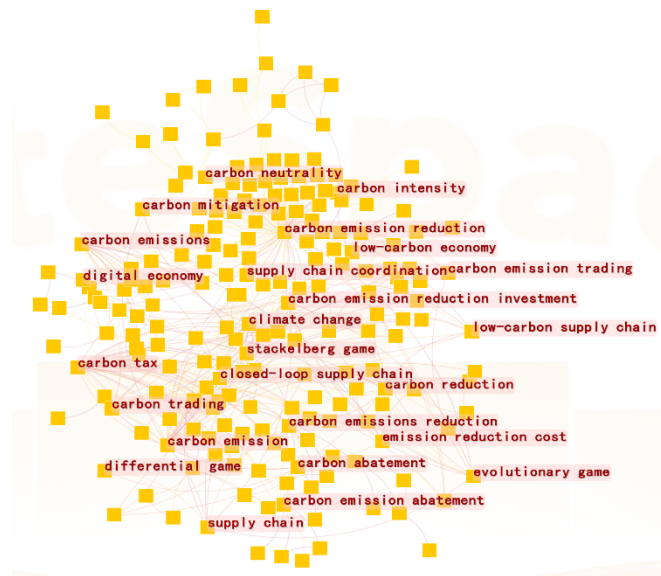

Figure 3: Keyword co-occurrence network graph.

The node size indicates the key frequency, and the highest frequency is for carbon abatement, right next to our search topic. In addition, carbon emissions, carbon taxes, and carbon trading appear slightly more frequently, suggesting that carbon abatement cost articles are primarily associated with these.

Table 3: Top 10 high-frequency keywords in the sample literature from 2013 to 2022.

Number	frequency	centricity	keyword
1	155	0.92	reduce carbon emissions
2	47	0.27	carbon emission
3	43	0.12	carbon tax
4	32	0.15	carbon trade
5	21	0.12	Emission reduction costs
6	16	0.07	climate change
7	16	0.06	low carbon economy
8	16	0.03	evolutionary game
9	14	0.05	carbon neutral
10	13	0.04	supply chain

Based on the keyword co-occurrence mapping, 7 sets of cluster clusters for carbon abatement research were derived from the cluster analysis of co-occurrence relationships and linkage strength between keywords via CiteSpace. These 7 cluster labels show the research focus of scholars in the field of carbon emission reduction cost during the statistical period[18-22].
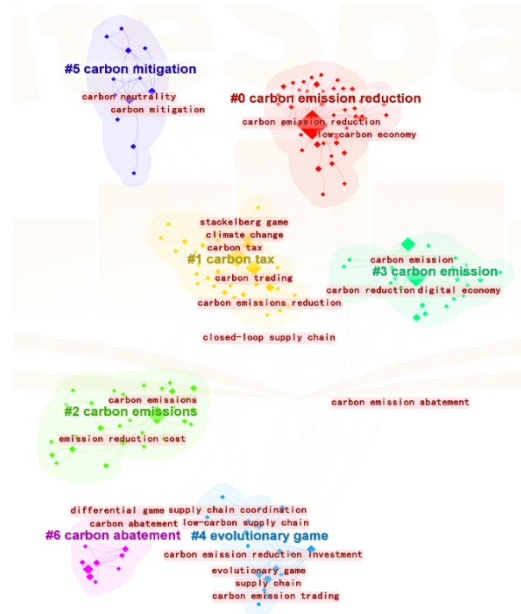
Figure 4: Keyword clustering label mapping.

On the basis of the keyword co-occurrence network to generate the keyword time zone graph, the time zone graph can indicate the knowledge evolution of a research field in time, where the size of the nodes in a time zone in the keyword time zone graph represents the total number of times the keyword appears in the research time period, the number of nodes reflects the number of research results within the time zone, and the connecting line between the nodes indicates the co-occurrence relationship. Due to the denser generation of node typography, the points are adjusted up and down within the same time zone so that the nodes do not cover each other. The above emergent keywords are thematically divided in the time dimension. From this time zone, we can clearly and explicitly conclude that the concepts of carbon emission reduction, carbon emissions, carbon tax, etc. have appeared in 2013; in 2014, it was combined with supply chain as well as focusing on emission reduction in the power industry, and the shadow price calculation method was used in the writing; in 2015, it was mainly studied in conjunction with intermediary effect and industrial agglomeration; in 2016, it was mainly studied together with concepts of technological innovation and carbon leakage; in 2017, it was mainly concerned with the concept of carbon leakage; and in 2017, it was mainly studied with the concept of carbon leakage. In 2017, it mainly focused on implied carbon, which is a relatively new perspective; in 2018, it was combined with altruistic preference, low-carbon publicity, decision optimization, and the algorithm of differential game; in 2019, it mainly focused on path optimization and effectiveness evaluation; in 2020, it started to study it by linking it with green finance and green innovation; in 2021, it was mainly studied by combining it with carbon peaking, carbon neutrality, and emission credits; in 2022, it was mainly studied by combining it with carbon emissions reduction and carbon neutrality, and emission credits. credits; and in 2022, digital finance, carbon shifting and low cost are studied more closely, as shown in Figure 4[23-25].

4. Conclusion

Carbon emission reduction has become a hot topic nowadays, and the first and foremost concern of implementing carbon emission reduction in various industries is the cost issue. In this paper, with the help of CiteSpace software, we have systematically sorted out and visualized the relevant literature on the topic of "cost of carbon emission reduction" in the CNKI database from 2013 to 2022, and reached the following conclusions by exploring the field and research hotspots through multi-faceted and multi-level analyses.

First, the cost of carbon emission reduction is a more comprehensive concept, the implementation of green low-carbon sustainable development of various industries are essential to analyze the cost of carbon emission reduction, but also because of the diversity of the research object, the characteristics of each are different, and every year there are new hot spots. Therefore, this research is more sustainable.

Second, the carbon abatement cost systems are vast and rich in content, through the analysis of the core authors, core literature, keyword clustering, and other perspectives to summarize the findings, the

carbon abatement cost of the research content is very diverse, more and more industry carbon abatement cost is scholars concerned about, scholars on the carbon abatement cost of the calculation of the method is also constantly updated and enriched, and for today's industries have a very strong reference significance and value.

Third, we can also conclude from the various analyzed statistics that there is relatively little cooperation among various authors as well as institutions, and there have been a few authors from one school working together all the time, and an interdisciplinary and inter-regional research platform has not yet been established to strengthen academic cooperation among various scholars and to carry out academic exchanges and innovations.

Fourth, the knowledge map represented by carbon emission reduction, emission reduction cost, carbon emission, carbon trading, carbon tax and evolutionary game is being formed, and some scholars' research is combined with the supply chain, but in general, when analyzing the sample literature, it is found that the current carbon emission reduction cost and the logistics related writing literature is less, and the carbon emission reduction cost can be combined with the logistics industry in the future to become an innovation point. Provide theoretical reference for the logistics industry to reduce emissions.

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