

Research Trend and Hot Spot Analysis of Carbon Emission Reduction in China based on Citespace

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Abstract

This paper uses CiteSpace software to draw a knowledge map of authors, institutions and keywords, analyzes 913 academic journals related to "China's carbon emission reduction" published in the core and CSSCI literature databases of Peking University from 2002 to 2021 by CNKI, and combs the research hotspots and trends related to "China's carbon emission reduction". The results show that: (1) the research on carbon emission reduction in China first appeared in 2002, and the number of published documents increased sharply between 2009-2011 and 2019-2021. The school of economics of Zhongnan University of Finance and economics and the Institute of science and technology policy and management of the Chinese Academy of sciences are important institutions studying "China's carbon emission reduction". Wang Zheng, he Jiankun and other experts have significant influence in the field of carbon emission reduction research. (2) China's carbon emission reduction research includes such major topics as "emission reduction cost", "carbon trading", "carbon peaking" and "emission reduction technology". From the perspective of hot spot evolution, the period from 2002 to 2008 belongs to the basic stage of carbon emission reduction research. Scholars began to pay attention to the research on the impact of climate change on carbon emission reduction; From 2008 to 2010, scholars paid more attention to the research of "low-carbon economy" and "low-carbon development"; From 2010 to 2015, scholars paid more attention to the research on "energy intensity" and "hidden carbon"; From 2015 to 2021, scholars paid more attention to the research on carbon trading on the basis of previous studies.

Keywords

Carbon Emission Reduction; Knowledge Map; Visual Analysis; Citespace.

1. Introduction

As the world's second largest economy and a large carbon emitter, China's measures in improving the environment and energy conservation and emission reduction have become an issue of keen international concern. On October 24, 2021, the CPC Central Committee and the State Council issued the opinions on fully, accurately and comprehensively implementing the new development concept and doing a good job in carbon peak and carbon neutralization. The opinions pointed out that by 2030, the comprehensive green transformation of economic and social development will achieve remarkable results, and the energy utilization efficiency of key energy consuming industries will reach the international advanced level; By 2060, a green, low-carbon and circular economic system and a clean, low-carbon, safe and efficient energy system will be fully established, the energy utilization efficiency will reach the international advanced level, and the proportion of non fossil energy consumption will reach more than 80%.

Under such circumstances, it is very important to analyze the research hotspot and evolution of carbon emission reduction, which can provide reference for China to better carry out low-carbon economy

and fulfill its commitments[1].Based on the 913 academic journals on "China's carbon emission reduction" published in the core and CSSCI literature databases of Peking University from 2002 to 2021 by CNKI, this paper analyzes the current research status, hot spots and evolution of "China's carbon emission reduction" by using the knowledge map, and provides reference for the research in the field of carbon emission reduction.

2. Data Result Analysis

2.1 Basic Statistics

2.1.1 Distribution of Documents Issued by Year

China's research on "carbon emission reduction" began in 2002 with the book "China's CO2 emission reduction resources for implementing CDM projects: evaluation of a CGE model under the conditions of economy technology energy environment" written by Shen keting and he juhuang. By using the CGE model of economy technology energy environment, China's CDM project cooperation is studied to reduce the national emission reduction cost[4].It can be seen from Fig. 1 that from 2002 to 2004, the number of research documents related to China's "carbon emission reduction" gradually increased: in 2002, Premier Zhu Rongji announced that China had approved the Kyoto Protocol, and began to specify the specific measures and indicators of emission reduction policies. In 2003, the state proposed the "low carbon economy", and carbon emission reduction entered the national vision; From 2009 to 2010, the number of research documents related to China's "carbon emission reduction" surged, reaching a peak in 2011: in 2009, Premier Wen Jiabao announced at the Copenhagen climate conference that China's carbon dioxide emissions per unit of GDP in 2020 would be 40% - 45% lower than that in 2005. It can be seen that the government has set a hard target for carbon emission reduction, and China is increasingly paying attention to the issue of carbon emission reduction; Although the number of documents has decreased since then, the number of relevant documents has shown an upward trend from 2015 to 2016: in 2015, China participated in the signing of the Paris Agreement; From 2019 to 2021, the number of relevant papers increased sharply: with the increasingly prominent environmental problems in China, China has paid more attention to carbon emission reduction. Especially in September 2020, when the "double carbon" target was first proposed, the research on carbon emission reduction has become increasingly important. At present, China is the country with the largest carbon emissions in the world, and faces major challenges in energy conservation and emission reduction. With the deepening of extreme weather and greenhouse effect, coupled with the high barrier and high threshold of high-end low-carbon technology, how to formulate regulations and plans for carbon emission reduction from technology, regulations, management and other aspects has gradually become the focus of academic research.

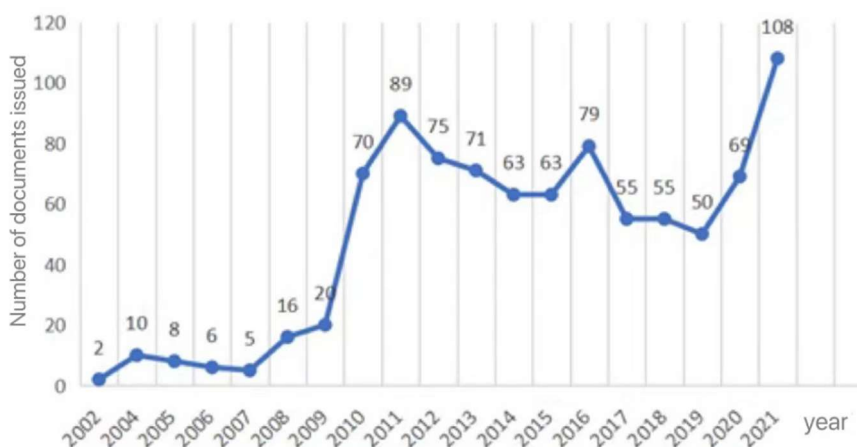


Figure 1. Annual publication of Chinese carbon emission reduction literature

2.1.2 Distribution of Issuing Agencies

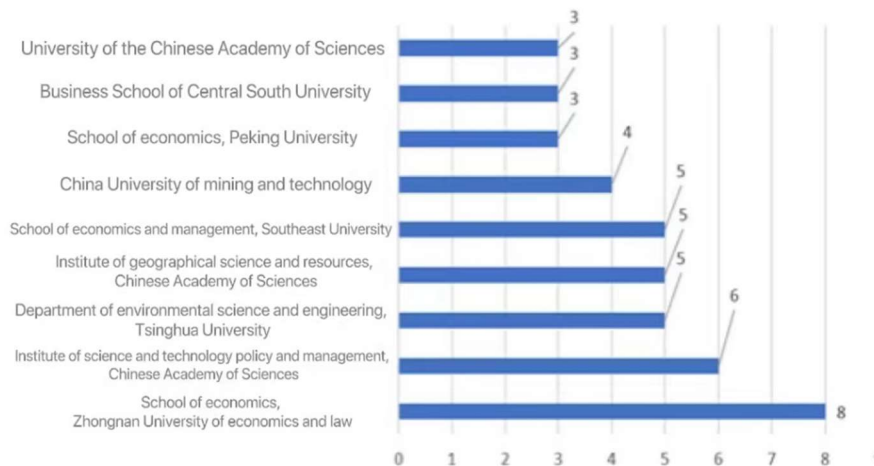


Figure 2. Main research institutions in the field of carbon emission reduction in China

It can be seen from Fig. 2 that among the top 9 research institutions on "China's carbon emission reduction", the school of economics of Zhongnan University of economics and law has published the largest number of papers, with a total of 8 papers on "China's carbon emission reduction", followed by the Institute of science and technology policy and management of the Chinese Academy of Sciences, the Department of environmental science and engineering of Tsinghua University, the Institute of geographical science and resources of the Chinese Academy of Sciences, and the school of economics and management of Southeast University. Among the nine institutions, except for the Institute of science and technology policy and management of the Chinese Academy of Sciences and the Institute of metal resources strategy of Central South University, other institutions are domestic institutions of higher learning.

Run CiteSpace to get the knowledge map of institutional co-occurrence network as shown in Figure 3. It can be seen that the school of economics of Zhongnan University of economics and law, the Institute of science and technology policy and management science of the Chinese Academy of Sciences, the Department of environmental science and engineering of Tsinghua University, the Institute of geographical science and resources of the Chinese Academy of Sciences, and the school of Economics and management of Southeast University have issued a large number of papers and strong academic and scientific research strength in the research of "China's carbon reduction". In addition, it can be seen that the research on "China's carbon emission reduction" is mainly distributed in several university disciplines such as economics, management and environmental science. On the whole, China's carbon emission reduction research is mainly based on the professional background of economic management and combined with the professional advantages of various research institutions, which promotes the formation of high-level scientific research achievements. However, as shown in the figure, there is only one connection between each node. The number of connections indicates the connection between nodes, and the more the number of connections indicates the closer the connection between nodes. Therefore, it can be seen that there is almost no connection between various institutions and there is no sense of cooperation. China's carbon emission reduction research institutions should carry out active academic exchanges with each other and with their international counterparts, promote the optimal allocation of scientific research resources, and accelerate the output of China's carbon emission reduction scientific research achievements.

2.1.3 Distribution of High-yield Authors

It can be seen from table 1 that the top 10 high-frequency authors published 74 articles, accounting for 8.11% of the total (913), of which Wang Zheng published 17 papers, he Jiankun published 10 papers, and Chen Wenying published 8 papers, ranking the top three.

Fig. 4 shows the author's co-occurrence network knowledge map, in which Wang Zheng is the scholar with the largest number of nodes, followed by he Jiankun, Chen Wenyong and Wu Jing. Among the high-yield authors, he Jiankun, Li Zheng and Chen Wenyong are shown in the figure; There are many academic exchanges and contacts between Wang Zheng and Wu Jing, but there is less cooperation with other scholars with large amount of papers; In addition, it can be seen that although Xue Huaqing, pan Songqi, Wang Ying and others do not have the largest number of articles, they have more cooperative research. Nevertheless, generally speaking, Chinese scholars have insufficient awareness of communication and cooperation in the research of carbon emission reduction in China, and academic exchanges and cooperation among scholars need to be strengthened.

Table 1. Arrangement of high-yield authors of carbon emission reduction research in China

Number	Auther	Number of documents issued	Starting time
1	Zheng Wang	17	2004
2	Jiankun He	10	2004
3	Wenyong Chen	8	2004
4	Jing Wu	7	2006
5	Can Wang	7	2005
6	Zheng Li	7	2004
7	Huanbo Zhang	5	2007
8	Jining Chen	5	2005
9	Qiang Liu	4	2010
10	Ying Fan	4	2013

2.2 Research Hot Topic Analysis

2.2.1 Keywords Cluster Analysis of Carbon Emission Reduction Research in China

The research hotspot reflects the research focus and direction of a certain research field, which is of great significance for in-depth understanding and analysis of the research content in this field. Keywords are the core condensed content of a document. The high frequency of keywords in a certain field reflects the research hotspot in this field[5]. Keyword clustering analysis is based on keyword co-occurrence analysis, which simplifies the network relationship of keyword co-occurrence into a relatively small number of clusters through clustering statistics[6]. This paper summarizes the main research topics concerned by China's carbon emission reduction research institute from 2002 to 2021 by means of keyword cluster analysis to explore the hot topics of China's carbon emission reduction research.

Run CiteSpace, set the node type as the key word, and the parameter settings are the same as those of the organization to get the keyword clustering network atlas. The color blocks represented by different colors in the map show nine clusters of "carbon emission reduction", "carbon emissions", "emission reduction costs", "carbon dioxide", "emission reduction effects", "carbon trading", "carbon peaking", "economic growth" and "emission reduction technologies", reflecting the research focus in China's carbon emission reduction field in the past two decades.

2.2.2 Analysis of Time Line Map of China's Carbon Emission Reduction Research

The cluster label of cluster # 0 is carbon emission reduction. The cluster first appeared in 2004. The cluster mainly includes such keywords as "energy utilization in a well-off society", "carbon emission reduction", "hidden carbon", "circular economy" and "low carbon pilot". In the initial year, i.e. 2004, special attention was paid to the research on "carbon emission reduction", and the number of articles issued increased sharply. Moreover, the number of research on "carbon emission reduction" is on the rise.

The cluster label of cluster # 2 is "emission reduction cost". Since the emergence of this cluster, the results of this cluster have been increasing in the following three years (2006-2008). It mainly includes such keywords as "emission reduction measures", "emission reduction market", "carbon intensity", "carbon market", "carbon quota" and "carbon peak". In recent years, the cost of carbon

emission reduction in the transportation industry, chemical industry and public services has also attracted more and more attention.

The cluster label of cluster # 4 is "carbon trading". The cluster started in 2009, and the main keywords are "carbon trading", "carbon emission rights", "carbon finance", "carbon tariff", etc. the related research on this cluster has received great attention since 2009. In 2009, Premier Wen Jiabao announced at the Copenhagen climate conference that China's carbon dioxide emissions per unit of GDP in 2020 will be reduced by 40% - 45% compared with 2005. On October 29, 2011, Beijing, Tianjin, Shanghai, Chongqing, Hubei, Guangdong and Shenzhen launched carbon emission trading pilot projects. It can be seen from this that the research on carbon trading in China has become a research hotspot and is constantly evolving. In recent years, "green finance" has also received great attention.

The cluster label of cluster # 6 is "carbon emission". When the cluster appeared, a large number of studies were produced. These studies mainly focus on carbon emission related issues from the aspects and perspectives of "output value structure", "low carbon policy", "Chinese manufacturing industry" and "industrial upgrading".

The cluster label of cluster # 7 is "carbon peak". Research on this cluster has appeared as early as 2002. The main keywords of this cluster include "emission reduction scheme", "carbon neutralization", "carbon tariff", "new energy" and "carbon peak". The first reference document of this cluster is the article "CO₂ emission reduction resources for implementing CDM projects in China: evaluation of a CGE model under economic technology energy environment conditions" written by Shen keting and others. They proposed to use the CGE model of economy technology energy environment to study the cooperation of CDM projects in China, so as to propose a plan to reduce the national emission reduction cost. In addition, "carbon neutrality" is also a hot topic. Carbon neutralization, also known as carbon compensation, refers to the calculation of total carbon dioxide emissions, and then the absorption of emissions through afforestation (increasing carbon sink), carbon dioxide capture and storage, so as to achieve the purpose of environmental protection[7]. With the continuous maturity of carbon compensation mechanism, methodology and carbon market, carbon neutralization, as an important environmental management tool to deal with the global greenhouse effect, has gradually gained the support of more and more governments, enterprises and people, and the trend of global voluntary carbon reduction action has changed.

The cluster label of cluster # 9 is "emission reduction technology". This cluster appeared in 2002. The main keywords include "carbon tax", "power industry", "emission reduction effect" and "emission reduction tools". In 2002, Premier Zhu Rongji announced that China had approved the "Kyoto Protocol", and began to specify the specific measures and indicators of emission reduction policies. Therefore, the research on emission reduction tools and emission reduction effects has gradually attracted people's attention. The CGE model of carbon tax and carbon dioxide emission reduction, written by he juhuang and others in 2002, adds an environmental module on the basis of the general equilibrium model to analyze the policy effect of carbon tax on macro-economic development [8].

2.2.3 Analysis on Hot Spot Evolution of Carbon Emission Reduction Research in China

Emergent words are keywords with a sudden increase in citation frequency in a certain period of time, which can be used to reflect the research trend in a certain period of time. In view of this, in order to further study the development trend of China's carbon emission reduction research, CiteSpace was run with TopN=50, $\gamma=0.6$, MinimumDuration=2, get the keyword emergence graph. The results show that the prominent words in 2005-2008 include "emission reduction technology", "scenario analysis" and "climate change", of which "climate change" has the longest emergence cycle, indicating that the issue of climate change has received high attention during this period;

During the period from 2008 to 2010, the prominent words include "low-carbon economy", "low-carbon development", "clean production", "carbon market", "carbon finance" and "low-carbon technology". Among them, the emergence cycle of "low-carbon economy" and "low-carbon

development" is long, which indicates that during this period, the research on low-carbon is a hot issue;

During the period 2010-2015, there were "energy intensity", "carbon emissions", "low carbon", "energy saving and emission reduction" and "hidden carbon". Among them, the emergence period of "energy intensity" is the longest, followed by "carbon emissions" and "hidden carbon". This indicates that during this period, researchers pay more attention to the relationship between energy intensity and carbon emission reduction;

During the period 2016-2021, the emerging words include "emission reduction path", "power industry", "double difference", "technological progress", "emission reduction cost", "carbon quota" and "synergistic effect". Except for "emission reduction cost", the emergence cycle of other emerging words is very long and has strong continuity, which indicates that "emission reduction path", "evaluation of emission reduction policy effect", "emission reduction problem of power industry", "emission reduction cost", "emission reduction cost" and "synergistic effect" The relationship between carbon emission reduction and technological progress, "carbon quota" and other topics are not only the research hotspots in recent years, but also may become the hot topics in China's carbon emission reduction research in the next few years. Therefore, the research in these aspects is worth paying attention to.

3. Research Conclusions and Suggestions

With the help of the CiteSpace visualization tool, this paper analyzes the research time, institutions and distribution of high-yield authors of China's carbon emission reduction according to 913 articles on "China's carbon emission reduction" in the core of Peking University and CSSCI database of China HowNet from 2002 to 2021. Through keyword clustering analysis, time line map analysis and keyword emergence analysis, it analyzes the main topics and hot spot evolution trends of China's carbon emission reduction, and draws the distribution of relevant research Research topic clustering network map, timeline map and keyword emergence map, and draw the following research conclusions:

From the perspective of research distribution, among the selected documents, the research on carbon emission reduction in China first appeared in 2002, and the number of published documents increased dramatically between 2009-2011 and 2019-2021. The school of economics of Zhongnan University of economics and law, the Institute of science and technology policy and management science of the Chinese Academy of Sciences, the Department of environmental science and engineering of Tsinghua University, the Institute of geographical science and resources of the Chinese Academy of Sciences, and the school of economics and management of Southeast University have published a large number of papers. The Institute of science and technology policy and management science of the Chinese Academy of Sciences in the form of 10 Chinese and African universities is an important institution to study "carbon emission reduction". Among the high-volume authors, Wang Zheng, he Jiankun, Chen Wenyong, Wu Jing, Wang can, Li Zheng, Zhang Huanbo, Chen Jining, Liu Qiang, Fan Ying and other experts have significant influence in the field of carbon emission reduction research.

From the perspective of the main topics, China's carbon emission reduction research includes "carbon emission reduction", "carbon emission", "emission reduction cost", "carbon dioxide", "emission reduction effect", "carbon trading", "carbon peak", "economic growth" and "emission reduction technology". From the perspective of hot spot evolution, the period from 2002 to 2008 belongs to the basic stage of carbon emission reduction research. Scholars began to pay attention to the research on the impact of climate change on carbon emission reduction; From 2008 to 2010, the focus of scholars' research turned to the research on "low-carbon economy" and "low-carbon development"; From 2010 to 2015, scholars paid more attention to the research on the relationship between energy intensity and carbon emission reduction and the "hidden carbon"; From 2015 to 2021, scholars paid more attention to the research of emission reduction path and the evaluation of the effect of relevant carbon emission reduction policies. In addition, the carbon emission reduction of the power industry has also received

greater attention. As carbon trading is an effective policy tool to deal with global climate change at this stage, it will have a profound impact on all aspects of China's economic and social life, so the trading of carbon quotas and carbon emission rights deserves in-depth study, Carry out top-level design as soon as possible to seize the commanding height of future world economic and social development.

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