Exploring the research fronts of low carbon and energy-efficiency in economic environmental development: a scientometric analysis from a multidisciplinary literature

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Abstract. In the increasingly severe global economic environment, low-carbon and energy efficiency have become a hot topic in contemporary times. In order to provide low-carbon and energy efficiency at the forefront of economic and environmental development, this article is based on 192 data retrieved from the Web of Science (WoS) database. This article conducted a comprehensive data and visualization analysis on keywords such as "low-carbon economy" and "low-carbon development".

1. Introduction

In 2003, the term "low-carbon economy" first appeared in the British government's "Energy White Paper" and attracted international attention [1]. To curb greenhouse gas emissions and develop a low-carbon economy, Jiankun, He, Y. Zhiwei, and Z. Da in 2012 mentioned that many countries and international organizations have taken measures [2]. With the joint efforts of various countries and international organizations, the average reduction rate of CO2 intensity of global GDP in the 20 years from 1990 to 2010 reached 15% [3]. But at the same time, the development of a low-carbon economy still faces greater challenges. The development of a low-carbon economy is conducive to exploring a new green and low-carbon development model for eco-cities and lifestyles, guiding consumption behavior to a healthy and appropriate low-carbon consumption model, and conducive to the realization of energy, environmental, economic and social coordination. In 2014 many scholars thought Sustained development is conducive to achieving the coordinated development of carbon footprint and economy [4] and alleviating the major challenges caused by climate change [5].

2. Data and methods

This article first starts from the "advanced search" in the WoS database to search for relevant documents related to a low-carbon economy, environmental economy, energy utilization, and energy development, and then explains the mapping protocol and strategy, as follows:

\[ \text{TS} = ("Low Carbon Economy" \ OR \ "Low Carbon City" \ OR \ "Low Carbon Development") \ AND \ \text{TS} = ("Co-evolution" \ OR \ "Ecological Economics" \ OR \ "Environmental Economy" \ OR \ "Energy Efficiency" \ OR \ "Energy Strategy" \ OR \ "Energy Development") \]

Various literacy terms were selected from the Oxford bibliography. The result is that 192 articles were retrieved in July 2020, and they were mapped using VOSviewer and the Python
3. Research the mapping results

3.1. Annual trends
According to data, articles on this topic have shown a tortuous and increasing trend since they were published in 2007, and the number of citations has also shown an exponential increase since 2009 and reached a peak in 2019. This shows that people have paid great attention to the research on this topic in the past ten years, and the interest in research is rising.

3.2. WoS categories and research fields

| Table 1. Top WoS categories | Table 2. Top Research Areas |
|-----------------------------|-----------------------------|
| **Category**                | **Article (53 total)**      |
| Environmental Sciences      | 20.1%                       |
| Environmental Studies       | 16.4%                       |
| Energy & Fuel               | 13.9%                       |
| Green & Sustainable Science | 13.1%                       |
| Economics                   | 7.1%                        |
| Engineering, Environmental  | 6.5%                        |
| Public Administration       | 2.0%                        |
| Thermodynamics              | 1.5%                        |
| Meteorology & Atmospheric   | 1.5%                        |
| Management                  | 1.5%                        |
| Construction & Building Technology | 1.5% | 120 articles | 30.0% |
| Environmental Sciences & Ecology | 44 articles | 11.0% |
| Energy & Fuel-Other Topics  | 43 articles | 15.3% |
| Science & Technology-Other  | 63 articles | 15.3% |
| Engineering                 | 64 articles | 15.3% |
| Business & Economics        | 38 articles | 9.5% |
| Public Administration       | 14 articles | 3.5% |
| Construction & Building Technology | 7 | 1.8% |
| Thermodynamics              | 7 | 1.8% |
| Meteorology & Atmospheric    | 7 | 1.8% |
| Urban Studies               | 5 | 1.3% |
| Transportation              | 4 | 1.0% |
| Development Studies         | 4 | 1.0% |
| Others                      | 26 | 6.2% |

The classification of WoS is shown in Table 1. Only materials that account for more than 1.5% are listed. The top 3 are environmental science, environmental research, energy, and fuel. The top 3 publications account for about 1/2 of the total number of publications, and the number of publications is relatively concentrated, while the latter rankings are relatively scattered, indicating that the clusters in the related fields of environmental science, environmental research, energy, and fuel are very significant, other categories including green sustainable technology, economics.

Table 2 lists the analysis of 12 research areas, including more than 4 articles. The top 5 fields accounted for 81.6% of the total number of published papers, which shows that environmental science and ecology, energy, and fuels are more concentrated. The research field is roughly the same as the WoS category, but the ranking has been changed. For example, the second place in energy and fuel is the same as the third place in WoS. Also, compared with the WoS category, different research fields have emerged, such as urban research, transportation, and development research.

3.3. Top organizations
This study analyzes the distribution of institutions involved by the author. Table 3 lists the countries accounting for more than 3%. Among them, the top three are China, the United Kingdom, and the United States. The total proportion of the three is nearly 71.4%. The strong position of the first three also reflects the importance of energy sustainability in the region. Also, in the 10 countries listed in Table 3, the number of European countries accounted for 50%; although the total proportion is still less than that of China, which ranks first, it shows the European plate's regional coverage.
3.4. Keyword Map and Source Cluster

Figure 1 shows the visualization results of the author's keyword analysis. In the legend, there are 7 large clusters. The size of the node indicates the number of times the keyword has been cited, that is, it reflects the degree to which the keyword is concerned. The more obvious ones in the figure are the five nodes of "energy efficiency", "low-carbon economy", "renewable energy", "climate change" and "china", which are located at the center of the blue, red, orange, green, and purple groups. Among them, "energy efficiency", located in the center of the map, is the center of keyword research. It has built a green and sustainable research framework while occupying the largest citation rate. And "China", as the only node in the graph representing the country, has a relatively close relationship in terms of low carbon and energy efficiency.

Figure 2 shows the results of the citation source analysis. The figure shows that the main source journals are "journal of cleaner production", "energy policy" and "renewable & sustainable energy reviews", and the three are closely related to each source in the cluster. Most of them are journals related to the ecological environment, energy resources, and sustainability. Journals linked to the economy are relatively rare, indicating that there is still a lot of room for the development of this topic in the field of economic integration.

In Figure 3, the red cluster is the cluster with the most nodes and is dominated by North China Electric Power University. The nodes of the red, yellow, purple, and light blue clusters are all composed of Chinese scientific research organizations, which reflects China’s attention to the low-carbon economy. Higher. Moreover, the total number of citations received by all articles published by the blue cluster far exceeds that of other clusters, reflecting the certain recognition of other organizations' research work. At the same time, it also reflects that in the research on this subject, the contribution of developed countries to low-carbon economy research appears to be somewhat insufficient, and there is still huge room for saturation in research in the field of the low-carbon economy globally.
4. Conclusion
With the huge impact of extreme weather on human life, such as the floods on the mainland, the economy has been hit hard, causing the supply chain to be disrupted again. Climate change is being paid more and more attention, and topics such as energy efficiency and sustainable development of low-carbon economies have received unprecedented attention in the economic field. This article integrates research trends, popular publications, and organizational data analysis, and discusses current research hotspots and possible research development directions in academia through data visualization. China, the United Kingdom, the United States, and other countries are likely to continue to constitute the key organization and cooperation system in this field in terms of their existing research breadth and progress. In this way, it has played a powerful role in the development of low-carbon, energy efficiency, and economic environment.

References
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