Environmental Cost Research Hotspots and Frontier Analysis —Visual Analysis Based on CiteSpaceV

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Abstract. Using the core collection library of web of science as the data source, we obtained 996 documents related to environmental cost in the core collection of web of science from 1986 to 2019, and then used the information visualization software CitespaceV to draw scientific knowledge map. We found that: the research group is characterized by large dispersion and small concentration, and no academic community has been formed among core scholars; research institutes are concentrated in universities; the research has gone through two processes of germination and development, mainly focusing on the mechanism and accounting method of environmental cost impact and environmental cost management;new energy, new materials, resource consumption and multi-objective optimization have become popular word frequency in recent years. Under the guidance of the new economic development model of advocating green environmental protection and sustainable development, accounting is the constant theme of environmental cost research, and the development and utilization of clean production and renewable energy is the leading direction of environmental cost research in the future.

1. Introduction

The environmental cost was first defined internationally by the United Nations International Committee of Accounting and Reporting Standards (ISAR) as the cost of using materials and energy and its impact on the environment, including the cost of the impact of the organization's operations on the environment information[1]. From the perspective of environmental management accounting, Jasch defines environmental costs as all internal and external costs related to environmental protection [2]. There are also opinions that the purpose of researching environmental cost management is not only to improve the environment, but also to reduce costs and improve corporate efficiency.

In this paper, the web of science core collection library is used as the statistical source of the literature. The title is "environmental cost" as the search field and the document type is used for the fuzzy search of all subject areas. Finally, 996 related articles are retrieved, and the retrieval time was June 20th, 2019. We use Excel and CiteSpaceV, a document processing tool, to make statistics and charts, and then use qualitative methods to analyse the visual charts, so as to explore and evaluate the current research status and trend of environmental costs at home and abroad, which will be conducive to provide references for subsequent studies.

2. Bibliometric analysis of literature data

2.1 Document time distribution

In order to investigate the changes in the number of documents over time, this paper will compare the literature related to environmental costs and use Excel to make a line chart. As shown in Figure 1, the overall trend of the literature volume has increased from less to more year by year, and can be roughly divided into the following stages: from 2007 to 2015, the environmental cost study is in the initial period, with less than 80 articles published each year; from 2016 to 2019, the study of environmental costs was in a period of growth, and the volume of publications at this stage grew at a faster rate. This shows that people's concern about environmental costs is rising.
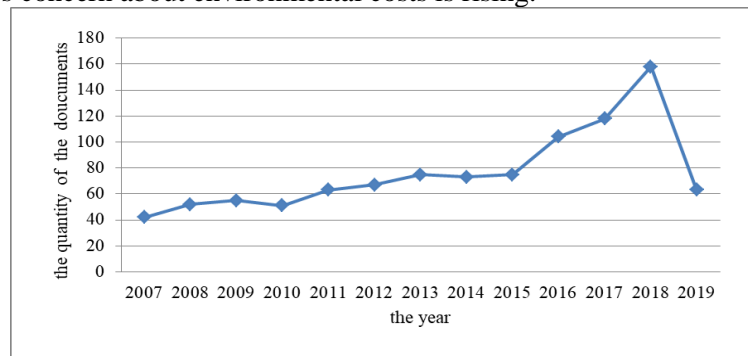

Figure 1.The change curve of related literature of environmental cost.

2.2 Document subject distribution

Environmental cost studies are involved in many areas, showing interdisciplinary and cross-domain characteristics of environmental cost research. But in general, "Environmental sciences ecology" and "Engineering" are the core of the research, followed by "Business economics", "Business economics", "Science technology", "Energy fuels", "Agriculture", "Chemistry", etc. The theme, which has formed a multi-angle, multidisciplinary research environment cost trend, also reflects the concern about environmental costs in various industries in recent years.
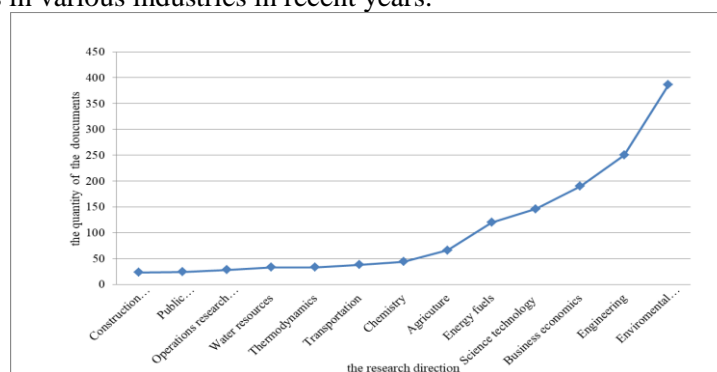

Figure 2.The distribution of disciplines related to environmental cost.

2.3 Author distribution analysis

High-impact authors can always lead the depth and breadth of their research activities in specialized fields, and also show the epitome of the research essence of a certain field. Through the visual analysis of the authors in the field of environmental costs, the core authors are Anonymous, Azapagic A, Lee JS and so on. Among them, Anonymous mainly focuses on the connection between human daily life and environmental costs, such as food and energy production[3]; Azapagic A's research mainly evaluates the development and utilization of natural resources from the perspective of life cycle, trying to be the government Policy formulation and consumer decision-making provide an environmentally friendly reference[4]; Lee JS mainly uses South Korea as a research object to propose accounting and quantification methods for environmental costs incurred in the implementation of multiple projects. The choice of experimental methods can provide policymakers with useful information to help them assess and plan relevant environmental policies[5]. From the perspective of the cooperation network,

there is little cooperation between the authors in the field of environmental cost research, which further confirms that the research in the field of environmental costs is relatively fragmented and has not yet formed a strong cohesive research group.

Figure 3. Author's network of environmental cost studies.

2.4 Institutional distribution analysis

The core academic teams and institutions in the field of environmental cost research were examined, and ten of them had more than 8 sources (Table 1). Among them, the top three in terms of the number of publications are the University of California system, The National Center of Scientific Research, and Stanford University. Foreign universities are the main positions in environmental cost research.

Table 1. List of organizations with more than eight articles.

quantity	institution	quantity	institution
25	University of California system	9	University of Manchester
12	The National Center of Scientific Research	8	Carnegie Mellon University
12	Stanford University	8	China Agricultural University
9	University of British Columbia	8	Commonwealth scientific industrial research organization
9	University of Illinois System	8	Duke University

3. Research topic analysis

Through the CiteSpaceV software, we use knowledge maps to deeply explore the current situation of environmental cost research, and grasp the theme research situation and frontier trends. Set the time slice to 1, the threshold is top50, select the shortest path algorithm, generate knowledge maps such as keyword co-occurrence, time zone view, and mutation word list, and sort out the main research contents, research methods and research trend of environmental cost from 2007 to 2019.

3.1 Main research content analysis

The key words are the summary of the core of the article. The analysis of the keywords can clarify the content and focus of the current research[6]. We use CitespaceV software to analyze the keywords of environmental costs. The size of the circle indicates the frequency at which the keyword appears, and the thickness of the line indicates the closeness of the relationship between the words. From Figure 5, Network has N=284, E=514 (density=0.0128), that is, the number of keyword network nodes is 284, the number of connections is 514, and the density is 0.0128. Among them, Life cycle assessment, Impact, Model, Management, System, Performance, Emission, Environmental Cost, Environmental

Impact, Energy, and Policy have a high frequency of occurrence, and have a strong relationship with other keywords in the field, and have received more attention in environmental cost research.
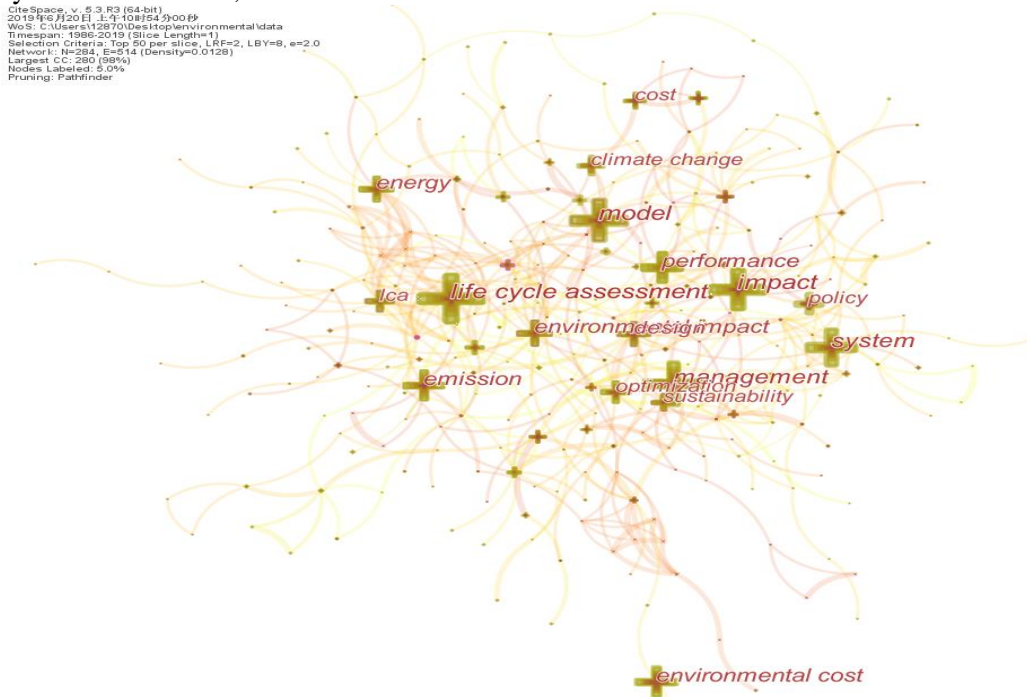

Figure 4. Key words co-occurrence.

Clustering analysis of keywords by CiteSpaceV software shows that the value of ModularityQ is 0.7248, which is much larger than the critical value of 0.3, indicating that the community structure of the common word network is significant, and the clustering effect is better; the MeanSilhouette value is 0.6295, which is greater than the critical value. 0.5, indicating that the clustering results are reasonable. By using the log likelihood ratio LogLikelihoodRatio (LLR) algorithm, a total of 12 main clusters are derived. They reflect the research frontier of environmental cost research, which is the management of environmental costs. On the one hand, we began to find ways to reduce resource consumption. According to the keyword clustering 1 to 7, the current research hotspots mainly focus on the development and utilization of new materials and new energy sources, slowing down the consumption of natural resources, and thus reducing the damage to the environment of the ecosystem. For example, reduce the use of coal-fired power generation, develop and use clean energy and renewable resources such as solar energy to meet the daily needs of human beings, and protect land resources and improve the utilization of land resources. On the other hand, the introduction and implementation of government policies is also one of the important measures to reduce environmental costs. For example, the European Union has proposed the Water Framework Directive (WFD) to protect water resources through the management of rivers.
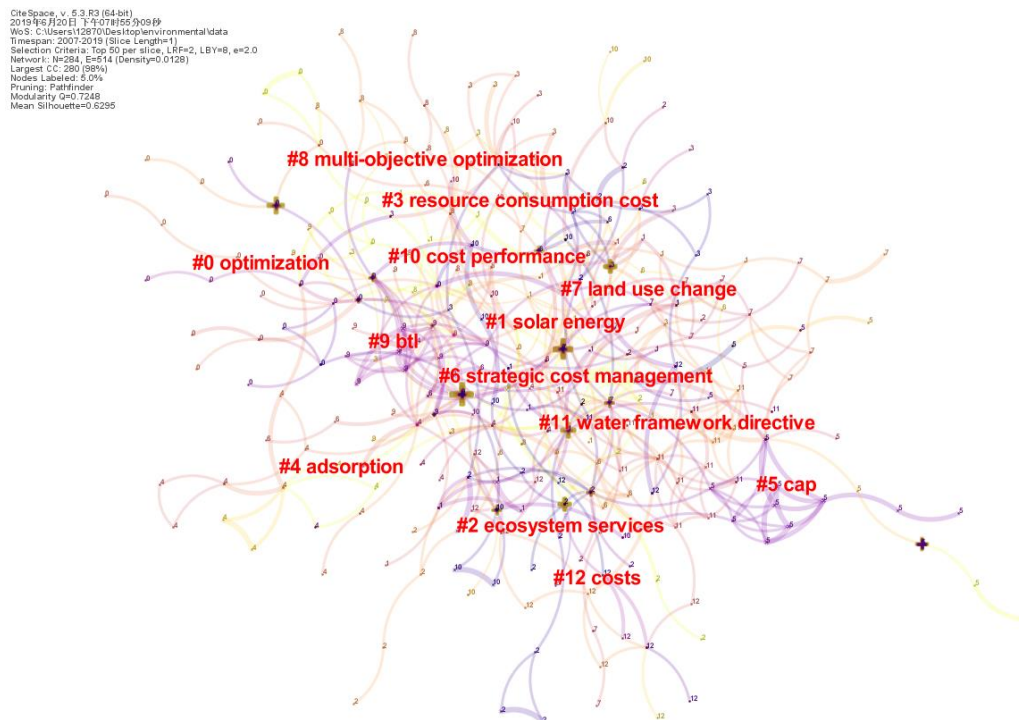
Figure 5. Key words clustering.

Therefore, when studying environmental costs, in addition to considering the rational use of natural resources and achieving sustainable development, it is also necessary for the government to formulate reasonable policies to raise public awareness of environmental protection and increase the penalties for enterprises to damage the environment. After fully considering the above two aspects, it is more comprehensive to consider the effectiveness of environmental cost governance.

3.2 Research path and frontier analysis

The theme time zone view is designed according to the interaction relationship and evolution path of the hot topic. In order to explore the evolution process of the theme of environmental cost, we can use CitespaceV software to draw its theme time zone evolution map. Its theme evolution path shows that we are based on the content and management of environmental costs. With the passage of time, the focus of research on environmental costs has shifted from focusing on the negative effects of environmental costs to the methods of managing environmental costs. This also shows that scholars' research on environmental costs has been targeted with the emergence of social issues. With the emergence of new problems and the emergence of new social needs, how to reduce environmental costs and consumption of natural resources has become the current research topic, which is consistent with the analysis results of our previous research.

The number and change of keywords can effectively highlight the development process and frontier issues of an academic field. In order to explore the research frontier of environmental cost, we can use the expansion word detection technology and algorithm that comes with CitespaceV software to detect the emergent words. The result is more reliable than the frequency of the keyword occurrence. It can be seen from Figure 6 that in the process of environmental cost research, the keyword with high degree of emergence is consumption, indicating that natural resources and energy consumption are the frontiers in the field of environmental cost research. At the same time, the graph can be used to derive the research frontier of environmental costs for each time period from 2007 to 2019. The results and the subject path analysis also confirm each other.

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Top 13 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2007 – 2019
environmental policy	2007	4.5607	**2007**	2010	
air pollution	2007	3.593	**2007**	2008	
pollution control	2007	2.9739	**2008**	2011	
policy	2007	5.0167	**2008**	2011	
uncertainty	2007	3.0745	**2008**	2010	
externality	2007	3.1931	**2010**	2012	
water	2007	3.3023	**2011**	2014	
pollution	2007	2.9316	**2012**	2014	
transaction cost	2007	4.1234	**2013**	2015	
cost analysis	2007	2.6684	**2013**	2014	
electricity	2007	3.2042	**2013**	2014	
algorithm	2007	2.8432	**2014**	2016	
consumption	2007	3.2219	**2017**	2019	

Figure 6. Highlights of the top 13.

4.Conclusion

Taking the environmental cost as the research object, this paper uses CitespaceV visual analysis software to display the time, author and organization distribution of the literature in the field through knowledge map, and analyzes the main research content, subject evolution path and research front in the field for follow-up research. It provides a reference and also provides a new combing method and research ideas for the management of environmental costs in China, which has certain innovation. At the same time, the visualization software of this paper utilizes CitespaceV software, but it is not mature in terms of map type and map complexity. Therefore, when using visual methods to analyze this field, it can be combined with other visualization tools for comprehensive analysis. It can only be used as an auxiliary tool for our research. We also need to combine a lot of research and thinking to analyze the problem, so that the result is more comprehensive and credible[7].

Based on the above research, this paper proposes the following concepts: under the background of the new development concept of "innovation, coordination, green, open and sharing" in China, we should take environmental cost management as a research topic, and at the same time, we should also reveal the key node of enterprise environmental cost management in close combination with China's enterprise operation. Only in this way can we further encourage enterprises to make changes of higher quality, higher efficiency and more conducive to sustainable development.

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