

Strategic Diagram Analysis Based on Knowledge Network

---Taking Journal Articles on Environmental Effect of Trade for Example

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Abstract—This paper, based on existing researches, taking journal articles on environmental effect of trade as research object to explore the field's research status, hot spots and novel direction by applying co-word clustering analysis and strategic diagram. By taking the relevant literature in CNKI database as the data source, this study aims to form a comprehensive understanding of the environmental effect of trade. The study suggests that carbon emission effect of trade and environmental effect of trade are the most novel research fields. In addition, the research on comparative advantage of environment has aroused much attention although neither its research direction nor research content is mature.

Keywords—environmental effect of trade; co-word analysis; cluster analysis; strategic diagram.

I. INTRODUCTION

With the continuous expanding of trade scale, the environmental problems are becoming more and more severe. The increasingly outstanding environmental effect of trade has been arousing extensive attention of experts and scholars from both home and abroad. Divergences concerning the relationship between trade and environment are mainly as follows: some scholars argue that trade is the root and direct cause of environmental problems^{[1][2]}; some scholars think that international trade has a positive impact on improving environment^{[3][4]}; the third kind of perspective is that trade has a complex impact which is determined by comparison among all the factors^{[5][6]}.

In the aspect of empirical analysis of the environmental effect of trade, Wan Neng applied Grossman and Krueger's methods to conduct empirical analysis on scale effect, technique effect and composition effect of environmental effect of foreign trade in China during 1994 to 2003^[7]. Zhu Qirong, by utilizing input-output method, conducted comparative study on environmental effect of export trade in eastern, middle and western China. His study showed that the scale change of export trade is negatively correlated with environmental pollution^[8]. Liu Linqi employed Panel-Data Model to study China's environmental effect of foreign trade from the aspects of scale, structure, technology, market efficiency, environmental policies^[9], etc.

To sum up, currently, the empirical analysis of environmental effect of trade conducted in China adopts

mainly the input-output method, panel data and time series data method. There is no relevant empirical analysis of the overall status of this research field. This paper, on purpose of studying comprehensively the research status, hot spots and development trend of this domain, is going to carry out a bibliometric study on relevant literature which is on the subject of relationships between trade and environment, trade and carbon emission.

II. RESEARCH METHODS AND INDICATOR CONSTRUCTION

A. Research methods

1) *Co-word analysis*: it is one of the commonly used co-occurrence analysis. It is a kind of content analysis technique that is effective in mapping co-occurrence relationship and strength between a pair of items (i.e., words or noun phrases) existing in the same text, illustrating relationships between items, and revealing inner construction and trend of change in a certain research field. Co-word analysis was firstly developed during the 1980s; later, Callon and other scholars put forward the theoretical foundation and application examples in the year 1983^[10] and 1986^[11] respectively; after that, co-word analysis has been improved to a great extent.

Co-word analysis was firstly applied to the field of biotechnology^[12], artificial intelligence^[13], etc. Now researchers in and abroad have applied this method to even more domains, such as library and information science^[14]. All these domains share the same characteristics: they all use words to illustrate main content of the text; they also reveal the hot topics, frontiers and trend of development of the research field by mapping co-occurrence relationships and strength.

2) *Cluster analysis*: it is a main task of explorative data mining for bibliometric analysis and visualization. It analyzes co-occurrence strength among keywords, and then assigns the keywords which have relatively greater strength into various types of clusters. Clustering algorithms can be classified into hierarchical clustering, nonhierarchical clustering, K-means clustering, intelligent clustering, etc. Since traditional clustering algorithm is to cluster words with lowest distance, this method has several drawbacks: having no central concept; the clustered words may not likely to express the same content; it may unable to illustrate relationships among clusters. This paper, on basis of clustering algorithms, borrowing from Callon's method of

constituting sub-sets, i.e., having no more than 10 keywords in a constituted sub-set, takes a pair of technical terms which have the highest cosine index in co-occurrence matrix (the greatest co-occurrence strength) as keywords, to finally reflect the research content and orientation of this cluster.

3) *Strategic diagram*: it was first proposed by Law in 1988. This method is used to analyze structure and changing trend of hot spots of a certain research field^[15]. Strategic diagram is a two-dimensional planar graph. This paper, based on cluster analysis, takes the attention indicator as lateral axis, and the novelty indicator as longitudinal axis to establish strategic diagram of clusters. The strategic diagram could demonstrate position of each cluster in the entire research domain. In light of distribution of each cluster in the four quadrants, it can also describe current status of the subject research domain, as well as its development and change in the future, as shown in Fig. 1.

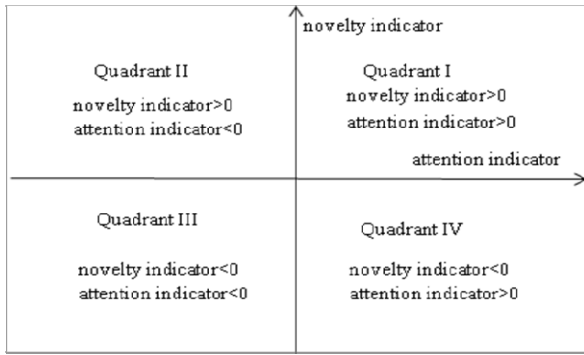


Fig.1 Strategic Diagram

The novelty indicator and attention indicator in Quadrant I both exceed 0. It indicates that the researches represented by these clusters receive comparatively higher attention, meanwhile, they are hot spots in recent years. These researches are at the same time a relatively mature direction and the core of the whole research domain.

In Quadrant II, the novelty indicator is more than 0, while attention indicator is less than 0. This demonstrates that the researches represented by the clusters, though aroused less attention from scholars, are new hot spots in recent years. Consequently, only when attention indicator can be improved, the clusters in Quadrant II could move on to Quadrant I and become mature research hot spots. These researches are only secondary research by now.

In Quadrant III, the novelty indicator and attention indicator are both less than 0. This illustrates that the researches represented by the clusters receive less attention. Furthermore, with fewer studies conducted on the subject, these researches would become marginalized.

In Quadrant IV, the attention indicator is more than 0, while the novelty indicator is less than 0. We can draw the point that the researches represented by these clusters have received much attention, but they are not research hot spots in recent years. Though less R&D has been conducted on these researches, they are still fundamental in the field, especially the ones received extremely higher attention. We call them fundamental researches.

B. Indicator construction

1) *Cosine index*. The node signifies keyword in the co-word network. Linking between nodes shows co-occurring relationships between keywords. The strength of the link represents co-occurring strength. It is measured by cosine index. The equation is as follows:

$$\text{Cosine} = \frac{F(A, B)}{\sqrt{F(A)F(B)}} \quad (1)$$

Where $F(A)$ is the frequency of keyword A appeared in the given set of keywords; $F(B)$ is the frequency of keyword B appeared in the given set; $F(A, B)$ is the frequency of appearance of both keyword A and keyword B . The value range is between 0 and 1, the greater the value, the higher co-occurring strength between the keywords.

2) *Novelty indicator*: it calculates average co-occurring time of each cluster according to the time when keywords reach threshold so as to reflect average year of that cluster. The mean deviation between average year of individual cluster and average co-occurrence year of all co-occurring keywords is the novelty Indicator. It could be either positive or negative. When it is positive, the research is conducted comparatively later; when it is negative, the time is relatively earlier.

Let N be amount of co-occurring keywords; K be amount of clusters formed; M be number of keywords in each cluster; Y be the year. The equation for novelty indicator is as follows:

$$ND_i = \frac{1}{M} \sum_{j=1}^m Y_{ij} - \frac{1}{N} \sum_{g=1}^n Y_g, (i = 1, 2, \dots \dots K) \quad (2)$$

Where ND_i is the novelty indicator of the i th cluster, $1/M \sum_{j=1}^m Y_{ij}$ is average co-occurrence year of M keywords in the i th cluster, and $1/N \sum_{g=1}^n Y_g$ is average co-occurrence year of N co-occurring keywords.

3) *Attention indicator*: it is used to calculate average co-occurrence frequency of each cluster according to co-occurrence frequency of each keyword. The mean deviation between average co-occurrence frequency of individual cluster and average co-occurrence frequency of all co-occurring keywords is called attention indicator which can reflect attention degree of that cluster. The value could be positive or negative. When it is positive, the research represented by the cluster receives comparatively higher attention. When it is negative, the research receives less attention.

Let the amount of co-occurring keywords be N ; amount of clusters be K ; the number of keywords in each cluster be M ; the co-occurrence frequency be F . The equation for attention indicator is as follows:

$$C_i = \frac{1}{M} \sum_{j=1}^m F_{ij} - \frac{1}{N} \sum_{g=1}^n F_g, (i = 1, 2, \dots \dots K) \quad (3)$$

Where C_i is attention indicator of the i th cluster, $\frac{1}{M} \sum_{j=1}^M F_{ij}$ is average co-occurrence frequency of M keywords in the i th cluster, $\frac{1}{N} \sum_{k=1}^N F_{ik}$ is average co-occurrence frequency of N keywords.

III. EMPIRICAL ANALYSIS

A. Selection of database and standardization of data.

In this paper, the data and statistics were generated from CNKI. Retrieval terms were chosen by combining the following phases: trade, international trade, foreign trade, trade liberalization, export trade and import trade with environment and carbon emission. This paper finally gained 4603 valid data from literature published from 1992 to 2011, with update time in October, 2011. Owing to the indexer effect, we need to standardize keywords indexing of the literature data so as to objectively and accurately visualize the research status, hot spots and development trend of the research field.

B. Co-word cluster analysis.

With the help of visual software CiteSpace, we got 127 high-frequency keywords. According to co-occurrence relationship and cosine index of keywords, a 127×127 co-occurrence matrix of keywords was constituted.

The principles of clustering used by this paper were as follows: 1) In the co-occurrence matrix (127×127) which was generated by CiteSpace, the pair of keywords with the highest cosine index were taken as the themes of the first cluster. 2) Sequence the 127 keywords in descending order; then select from top of the ranking 10 keywords (including the themes). If there were less than 10 keywords whose cosine index was more than 0, only select the keywords whose cosine index was more than 0. If there were more than 10 keywords whose cosine index was more than 0, choose the first 10 keywords to join in the cluster, for that cluster had reached saturation value (10 keywords). 3) When the first cluster formed (or saturated, or there were less than 10 keywords whose cosine index was more than 0), deleted the keywords which had joined the cluster from the matrix (deletion should include both the row and the column), so as to ensure that these keywords would not join in the following other clusters. 4) Go over repeatedly step 1 to 3, so that clusters could be formed one by one, until all co-occurring keywords had joined in clusters. If there were still some keywords with no co-occurrence relationship, i.e., the co-occurring strength among all keywords was 0 (cosine index=0), the clustering generation was finished. All the keywords left would not ever join in any cluster.

Among the 127 high-frequency keywords, the ones concerning international economics and trade have the highest frequency (Freq=669); but it is still unable to identify research content and direction only with help of individual high-frequency keyword. Therefore, this paper applied Callon's cluster analysis for reference to identify research content and direction. According to the above clustering algorithms and principles, 127 keywords were distributed

into 14 clusters with each cluster having its name summarized on account of the keywords included. The 14 names are just the research contents and directions in that field (see Table 1).

From Table 1, we can find out that the research contents of environmental effect of trade mainly include scale effect, technical effect, structural effect, environmental effect, etc. There are in all 14 research contents or directions directly connected with environmental effect of trade, such as trade barrier, trade and environment, comparative advantage of environment, sustainable development and carbon emission effect of trade.

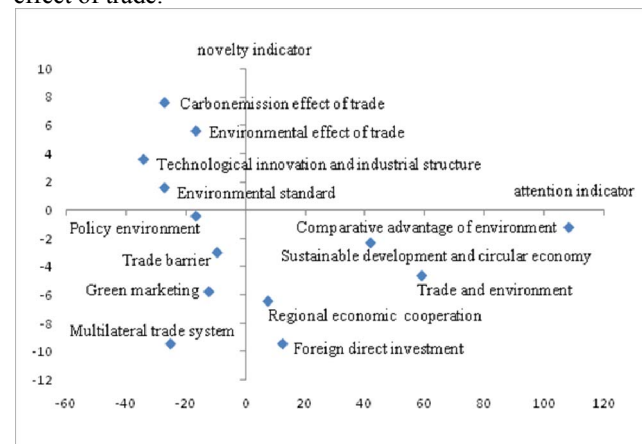


Fig.2 Strategic Diagram for Environmental Effect of Trade

C. Strategic diagram

In strategic diagram (Fig.2), the attention indicator is taken as lateral axis, and the novelty indicator is taken as longitudinal axis. According to meanings of these two indicators and positions of quadrants, we can find out some research areas which, though have received great attention, but are short of novelty. These researches are foreign direct investment, cooperation in trade area, sustainable development, circular economy, etc., among which comparative advantage of environment has attracted the highest degree of attention. Siebert (1974) firstly cited environmental factor in H-O Theory. He points out that environmental factor is a significant factor that influences comparative advantage of a country. If a country is rich in environmental resources, it would export high-pollution products. Relative price difference is decided by both environmental scarcity and value of the richness. Environmental factor takes form of environmental endowment to decide formation of comparative advantage. Thus comparative advantage of environment has become a fundamental theory when analyzing trade and environment. This explains why the research has received much attention but less in novelty. Since the 1990s, scholars in China have started research in the field of trade and environment. They argue that the relationship between trade and environment is mutually promoting and contradictory. The green barrier is the focus of conflict between trade and environment. However, there is so far no new breakthrough and novelty in this research area in recent years.

When comparing on basis of novelty indicator, domains with higher novelty indicators are carbon emission effect of trade and environmental effect of trade. In particular, carbon emission effect of trade has the highest novelty indicator. When analyzing deeply the components of carbon emission effect of trade, we can find the concepts newly brought in recent years as follows: climate change, carbon tariff, CO₂ emission, etc.

Nowadays, with the global warming has gradually become a heated issue, reduction of carbon emission is now a consensus in the whole world. Since 2009, China has become the second largest trading country and the first exporting country in the world. Though international trade has contributed greatly to China's economic development, with expansion of scale of foreign trade, energy consumption has been increasing continuously. Environmental pollution, especially the total amount of CO₂ emission is becoming increasingly severe. According to statistics from International Energy Agency, in 2007, CO₂ discharged by fossil fuel has reached 6,284 billion ton in China, 21.01% of the world's total amount of emission (29,914 billion tons), exceeding America (20.08%). China has now become the first greenhouse gas emission country, facing tremendous stress of emission-reduction from both home and abroad. On the eve of opening of Copenhagen Climate Conference in 2009, Chinese government proposed detailed objectives of reduction of greenhouse gas emission for the first time, i.e., in 2020, the total amount of CO₂ emission would be reduced by 40%~45% of that in 2005. China is now actively formulating policies concerning emission-reduction of CO₂ to achieve her objectives. Based on this background, carbon emission effect of trade has now become an emerging hot spot of research.

Other researches which have a certain value of novelty but lack in degree of attention are technological innovation and industrial structure, policy environment and environmental standard, etc. The trade barrier has a low degree both in novelty and attention. This shows that though this research has been started very early, with diversification of trade barrier, its novelty indicator is decreasing. Since much more effort is spent on studying green barrier, environmental barrier, etc. the research on trade barrier is reducing; for now, it is mostly studied as a condition or factor. Quadrant III shows us the fields with extremely low indicator of both novelty and attention. These are marginalized research contents and directions. Researches like green marketing, multilateral trade system, and trade liberalization are gradually marginalized in their domains; they may even vanish if they no longer have any research value.

We can also learn from the strategic diagram that there is no cluster in Quadrant I. This shows that so far there is no research whose attention indicator and novelty indicator are both very high. This also indicates that the research of environmental effect of trade has just been emerging in China, with neither a mature direction nor content been developed yet. This situation implies that this research will have a mature and vigorous future, and more crossing fields are expecting.

From a dynamic point of view, Quadrant II shows us the newly emerging research areas, including carbon emission effect of trade, environmental effect of trade, etc. As long as scholars commit extensive studies on these researches, their attention indicators would increase continuously. Then they would move from the Quadrant II to the Quadrant I, turning into mature research subjects or directions.

IV. CONCLUSIONS

This paper adopts co-word analysis, cluster analysis and strategic diagram to explore research status, hot spots and development trend of environmental effect of trade in China. The study shows that the researches with the highest attention indicators are comparative advantage of environment and trade and environment. This indicates that scholars have conducted comparatively more research in these two fields. This situation also coincides with the social background in general. The researches with the highest novelty indicators are carbon emission effect of trade and environmental effect of trade. This shows that in the field of trade and environment, the interest in carbon emission is comparatively new and immature.

This paper tries to show the research status, hot spots and trend of a research field by utilizing visual software together with co-word analysis. Though this attempt tried hard to be visual, clear and comprehensive, there may still be some restrictions such as indexer effect, manual handling of standardization processing of statistics and setting of threshold. These factors, though may have a certain impact on analysis results, would not affect the accuracy of this paper. Much more work will be done to improve these weaknesses in the future.

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TABLE I. NAMES OF CLUSTERS AND THEIR COMPONENTS

Name of Cluster	Components
Environmental effect of trade	Scale effect, Technical effect, Structural effect, Environmental effect
Trade barrier	Post-quota era, Textile trade, Trade barrier, New trade barrier, Environmental barrier, Green barrier, Doha round, Technical barriers to trade, Environmental protection consciousness
Cooperation in trade area	China-ASEAN, Free trade area, Regional economic cooperation, Investment environment, Internal and external environment, Economic and trade cooperation, International environment
Trade and environment	Trade liberalization, Trade environment, Environmental protection, WTO, Agricultural products trade, Anti-dumping, Environmental regulation, Trade protectionism, Economic and trade relations, Export trade
Comparative advantage of environment	Competitive advantage, Comparative advantage, Environmental cost, Resources and environment, International economics and trade, Environmental factors
Multilateral trade system	GATT, International trade environment, Enterprise, GATT rejoining, Trade friction, EU, New trade protectionism, Multilateral trade system
Sustainable development and circular economy	Sustainable development, Circular economy, Environmental problems, Ecological environment, Trade and environment, Frontier trade, Foreign economic trade, Scientific development view, Environmental cost internalization
Foreign direct investment	Direct investment, Multinational corporation, International competitiveness, Economic environment, Competitive environment, Economic growth, Foreign direct investment, Environmental pollution, Environmental Kuznets curve
Environmental standard	ISO14000; SA8000; Environmental standard
Technological innovation and industrial structure	Independent innovation, Intellectual property, Resources and environment, Technological innovation, Industrial structure, the 12th Five-Year Plan, Low-carbon economy
Policy environment	Policy environment, Processing trade, Internationalization
Carbon emission effect of trade	Climate change, Carbon tariff, CO2 emission, Carbon emission, Energy-saving and emission-reduction, Carbon emission permits
Trade liberalization	Globalization, Free trade, Opening to the outside world, External environment, Reform and opening, Foreign investment
Green marketing	Agricultural products, Green marketing, Green trade