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Analysis on the Influence Factors of National Trade Transfer and Environmental Pollution of Organic Chemicals

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More frequent trade transactions between countries exacerbate the environmental pollution, especially chemical products which are rather sensitive to environmental impact since they have rich varieties and high complexity of chemical reaction process. It is therefore necessary for us to analyze and study the national trade transfers and environmental pollution of so many chemicals. Based on the complex network theory, this paper throws light on the national trade transfer properties of organic chemicals. Given this, it is analyzed what impact they play on environmental pollution. A network map of environmental pollution impact is thereby built, providing the clues to the production and trading of organic chemicals in China.

1. Introduction

The chemical industry contributes much to the development of the national economy, but the environment issues induced by it cannot be ignored in the process. Concurrently, along with the internationalization of trade, chemical product is not only confined to a particular area where they are produced and make a deal, but also causes impact internationally (Hanigan et al., 2018). There are rich varieties of organic chemicals, which emerge with more complicated structures, and are prone to produce highly complex chemical reactions (Williams and Shumway, 2000). As a consequence, it is more cumbersome to trade them as they present a high sensitivity to the environmental impact. Based on these properties of organic chemicals, it is necessary to analyze their trade transfer in a country and clarify what’s impact they will produce on the environment pollution, providing the clues to improving international trade level and abating environmental pollution.

Complex network algorithm applies to more complex structures or systems. In recent years, more and more scholars have introduced this algorithm into the study of international trade or environmental pollution. Garlaschelli et al. believe that the structure of trade network system has a bearing on the GDP in the countries worldwide (Garlaschelli et al., 2007; Garlaschelli and Loffredo, 2005); Li et al. built a scale-free network for international trade (Li et al., 2003); Grossman et al. explored the relationship between environmental pollution and trade income (Grossman and Krueger, 1995). The relationship between trade and environmental pollution is more complex, so that it is awkward for us to determine the relationship between the above two from multiple perspectives (Managi and Kaneko, 2006; Cole and Elliott, 2010). Some scholars argue that the negative impact the trade has is often greater than positive impact it does on the environment, especially in developing countries (Lee and Oh, 2015; Coxhead and Jayasuriya, 2003).

Based on the complex network algorithm, this paper throws light on the properties of national trade transfer of organic chemicals, in conjunction with its impact on environmental pollution, providing the reference to the production and trade of organic chemicals in China.

2. Analysis of national trade transfer of organic chemicals

2.1 Network construction

The *Comtrde* trade database is used to analyze the overall trade network of organic chemicals. The property of the national TradeNet of organic chemicals is shown in Table 1.

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Table 1: The basic property of TradeNet

Property	Node Number	Edges	Average Node Number	Density	Average Path Length
Organic Chemicals	170	2795	32.95	0.0979	2.14
PVC	178	1680	19.06	0.0542	2.31

2.2 Establishment of TradeNet indicators

This paper focuses more on the scale-free property and correlation of the TradeNet, including the average degree and strength of neighbor nodes. The average degree $< k_{nn} >_i$of node next to node *i* is calculated by formula (1), as that of $k_i$neighbor nodes of it.

$$< k_{nn} >_i = \frac{1}{k_i} \sum_{j=1}^{k_i} k_{i_j} \qquad (1)$$

Where, k_{ij} represents the degree of the neighbor node j of the node *i*.
The average of k node degrees is calculated as follows:

$$< k_{nn} > (k) = \frac{1}{i_k} \sum_{k_i = k} < k_{nn} >_i \qquad (2)$$

Where, $i_k$represents the number of nodes at *k* node degrees.
If it is a weighted network, the average degree can be converted into the average intensity, as shown in formulas (3) and (4).

$$< k_{nn}^{w} >_i = \frac{1}{k_i} \sum_{j=1}^{k_i} w_{i_j} \qquad (3)$$

$$< k_{nn} > (s) = \frac{1}{i_k} \sum_{s_i = s} < k_{nn}^{w} >_i \qquad (4)$$

Where, wj_i represents the strength of the adjacent node *j* of node *i*; $i_k$represents the number of nodes with the strength of the node *s.*

2.3 Network analysis

Data processing and fitting are performed on the out-degree and in-degree of organic chemicals, and the results are shown in Figure 1.

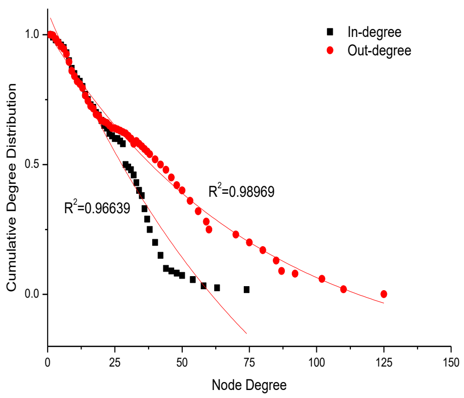

Figure 1: Cumulative Degree Distribution of organic chemicals

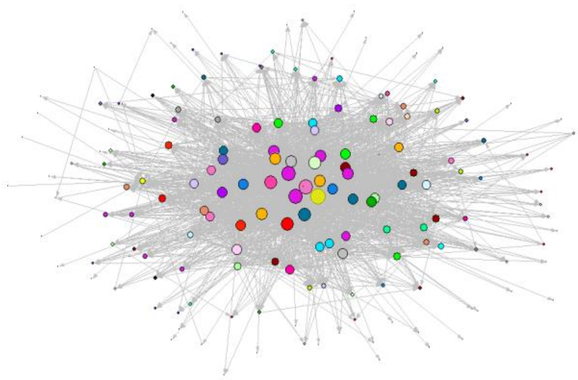

Figure 2: Trade network diagram of organic chemicals

It can be seen from Figure 1, the accessibility of the national trade transfer network of organic chemicals is in line with the exponential distribution. The change of node degree is a regular process that reflects the uniformity of the organic chemical trade network. Refer to Figure 2 for its network results.
As shown in Figure 2, the national trade transfer network diagram of organic chemicals has more dense nodes and ligatures, but distributed ununiformly. There are countries with more nodes, and also countries with less nodes. The cumulative intensity of organic chemical trade is analyzed, as shown in Figure 3. It is clear that the cumulative intensity distribution is not obvious, and does not have the characteristics of exponential or regular distributions, inconformity to the scale-free network.

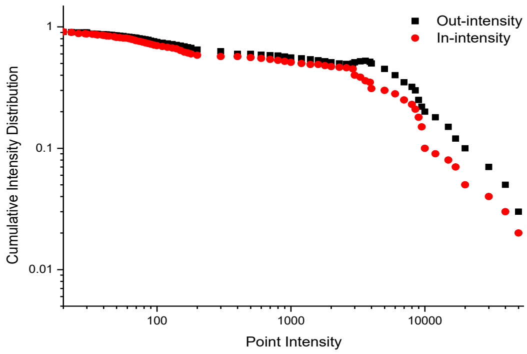

Figure 3: integrated intensity distribution diagram of organic chemicals

As above, the distribution of the national trade transfer network of organic chemicals conforms to the exponential distribution law and has a certain uniformity, but its network diagram is not uniform due to the diversity of chemical products, and different economic level of each country. Trade is required according to domestic consumption level and demand, and the diversity of chemicals just makes up for the gaps of countries for one or more products, making the whole network of organic chemicals uniform.

3. Analysis of environmental pollution impact

As described above, there are many types of organic chemicals, and the relationship between trade and environmental pollution seems so complicated that it is impossible to analyze each product. Therefore, this paper selects the typical chemicals for study. Based on relevant information (Staff, 2001; Bidoki and Wittlinger, 2010), PVCs, a type of high molecular polymer polyvinyl chloride, are traded in bulk in various countries and have produced a large environmental impact. Therefore, PVC is chosen for study.

3.1 Environmental pollution impact potential

Considering the impact of national trade transfer on environmental pollution at two levels, namely at global and regional levels; global impact mainly allows for global warming, and regional impact mainly involves eutrophication, acidification, and human body toxicity. Gabi software is used for calculation and analysis, and environmental pollution relevant data built in and automatically updated by Gabi. The PVC production process varies from country to country, so that there are different impacts on the environment. Thus, the potential values may be calculated according to different production processes, as shown in Table 2.

Table 2: Environmental impact potential of different PVC manufacturing technique

Impact type		Impact Potential			Unit
		Ethylene Method of Gabi	Ethylene Method of China	Calcium Carbide Method	
Global	Global Warming	1.9102	2.9913	9.1046	$kgCO_2eq/kg$
Regional	Eutrophication	0.0006	0.0014	0.0032	$kgPO_4eq/kg$
	Acidification	0.0055	0.0127	0.0381	$kgSO_2eq/kg$
	Photochemical ozone creation	0.0004	0.0015	0.0022	kgC_2H_4eq/kg
	Human toxicity	0.1166	0.1598	0.5403	kgDCBeq/kg

In the table, there are the results calculated by the three processes. The developed countries use the ethylene process, i.e. Gabi built-in data. The developing countries are represented by the Chinese-style ethylene method, that is, it is regarded that the PVC production capacity and its environmental impact in developing countries are comparable to that in China; the calcium carbide method, as the main process for the production of PVC in China, has an impact obviously different from what the ethylene method does on the environment. Therefore, for considering the potential impact of environmental pollution in China, the ethylene and calcium carbide methods should be integrated and calculated proportionally, taking 21% and 79%, respectively. The potential values of the impact on the PVC production environment in China is calculated as shown in Table 3.

Table 3: Environmental impact potential of PVC manufacture for China

Impact type		Impact Potential	Unit
Global	Global Warming	7.8947	$kgCO_2eq/kg$
Regional	Eutrophication	0.0031	$kgPO_4eq/kg$
	Acidification	0.3348	$kgSO_2eq/kg$
	Photochemical ozone creation	0.0020	kgC_2H_4eq/kg
	Human toxicity	0.4679	kgDCBeq/kg

As shown in Table 3, the units of potential values corresponding to different types of environmental pollution are also different. For the sake of comparison, the calculated values are standardized. Given the integrity of available data and the environment quality in the current year, this paper takes the value of 1990 as the basis, and standardizes it by formula (5), in the equivalent of each person per year, expressed as follow.

$$NER(j) = \frac{EP(j)}{NR(j)_{90}} \tag{5}$$

Where, *NER (j)* is the environmental pollution impact potential value after standardization; *ER (j)* is the environmental pollution impact potential value before standardization; $NR(j)_{90}$ is the per capita environmental pollution impact potential value in 1990, and calculated by the formula (6).

$$NR(j)_{90} = \frac{EP(j)_{90}}{POP_{90}} \tag{6}$$

Where, $ER\ (j)_{90}$ is the total environmental pollution impact potential value in 1990; POP_{90} is the total population in 1990.

The environmental pollution impact potential mentioned in this paper includes two types, i.e. the global and regional ones. Globally, it can be analyzed by calculating the impact potential of global warming, but regionally, it concludes different kinds of environmental pollution, for the sake of analysis and comparison, the impact potential values of the pollution types are integrated. This aggregative indicator is expressed as follows:

$$EIL = \sum_j NEP(j) \tag{7}$$

According to the above formula, the environmental pollution impact potential values in developed, developing countries and China are standardized, as shown in Table 3.

Table 4: Normalized environmental impact potential of each region

	Global environmental impact potential/ PE_w	Regional environmental impact potential/ PE_w
Developed Country	0.2251	0.1501
Developing country	0.3532	0.3406
China	0.9247	0.7915

3.2 Establishment of environmental pollution impact network

First, calculate the degree of environmental pollution impact generated when trade occurs between countries by the formula that the trade volume multiplies by the environmental pollution impact degree, as shown in the formula (8), and the environmental pollution impact degree takes the value based on Table 4.

$$W_G = T \times NER(j)$$
$$W_R = T \times EIL \tag{8}$$

Where, W_G, W_R represent the global and regional environment pollution impact degrees; T is the total output of imports or exports.

The environmental pollution impact degrees of the two countries are calculated by formula (8), and the difference between the two is net impact of environmental pollution, as shown in formula (9). If country A is larger than country B, then country A points to country B in the network map, and the resultant environment pollution impact network maps are shown in Figure 4 and Figure 5.

$$\Delta W_{GAB} = W_{GAB} - W_{GBA}$$
$$\Delta W_{RAB} = W_{RAB} - W_{\mathrm{RBA}} \tag{9}$$

Where, W_{GAB} is the degree of the global pollution impact generated when country A exports products to country B; W_{GBA} is the degree of the global pollution impact generated when country B exports products to country A; similarly, W_{RAB}, W_{RBA} are the degrees of regional pollution impact generated when export trade occurs between countries A and B.

If Country A is larger than country B, the country A points to country B in the network map. The resultant environment pollution impact network maps are shown in Figure 4 and Figure 5.

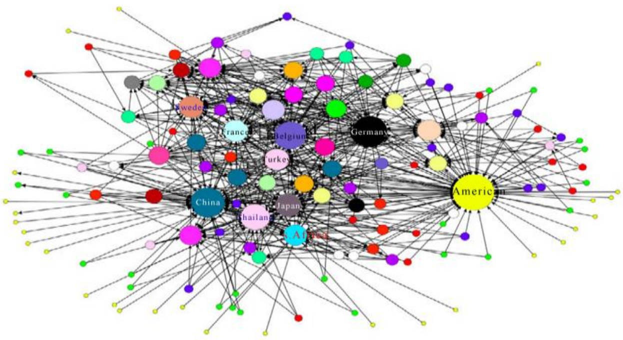

Figure 4: The network diagram of global environmental pollution impact

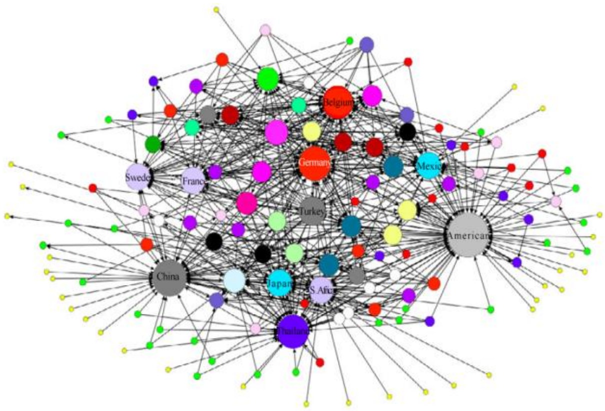

Figure 5: The network diagram of regional environmental pollution impact

The total environmental logistics impact of the countries marked in the map accounts for more than 90% of the global. In the map, there is a relatively dense network, and the major countries that bear the environmental pollution caused by trade are the United States, Germany, China, France, Turkey, Thailand, Belgium, and so on. The national trade transfer of organic chemicals does have a certain impact on environmental pollution. In the process of trade transfer, trade products produce heavy pollution on export places, especially in developing countries. The export of organic chemicals will exacerbate the environmental issues of developing countries, while the trade exports of developed countries can alleviate the environmental pollution pressures of developing countries.

4. Conclusion

Based on the complex network algorithm, this paper analyzes the national trade transfer characteristics of organic chemicals and their impact on environmental pollution. Now we draw the following conclusions:
(1) The degree of access of the national trade transfer network of organic chemicals is subject to the exponential distribution and has a certain homogeneity;
(2) A network map is built for the national trade transfer of organic chemicals, in a dense state, but its distribution is not balanced;
(3) Another network map is also available for the impact of national trade transfer of organic chemicals on environmental pollution. Exports from developing countries will worsen environmental pollution in other areas, while exports from developed countries can reduce the environmental pressures in developing countries to a certain extent.

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