

Evolution of Global Plastic Scrap Trade and Analysis of China's Plastic Scrap Trade Network under the "Dual Carbon" Goal

Yubo Lan

School of Management, Xi'an Polytechnic University, China

Abstract: Plastics and their products are favored by the public for their advantages such as good corrosion resistance, high convenience, good transparency, cheap price, and wide range of uses, which have triggered a further increase in the demand for plastics and their products. However, plastics and their products directly or indirectly affect the global climate due to their inability to be decomposed naturally, easy to burn and produce toxic gases, and difficult to be recycled. Based on the UN Comtrade database, this paper obtains the global scrap plastics trade data from 2012 to 2021, including 233 countries around the world, constructs 20 overall trade networks of import and export of global scrap plastics trade, and synthesizes 10 years of data to explore the characteristics of the global plastics trade pattern as well as the evolution process, and conducts an analysis of China's plastics trade network in terms of the structure of the trade network and the roles and partners. Analyze the trade network from the perspective of trade network structure and roles and partners. The results show that: the participation of developing countries in import gradually increases, while developed countries take the primary position in export; China exits from the top in both import and export rankings in the evolution of the trade pattern of plastics scrap; the global greenhouse effect and the aggravation of environmental pollution make the participation in the import trade of every country in the world decline, but still dominated by developed countries.

Keywords: Trade Patterns, Scrap Plastics, Carbon Neutrality, Carbon Peaking, Social Network Analysis.

1. Introduction and Literature Review

Climate change is an important common issue, and in October 2022, the 26th United Nations Climate Change Conference emphasized the impacts of climate change on food security, refugees, and ecosystems, among other socio-economic issues.²⁰²³ In July 2023, the World Meteorological Organization (WMO) released its "State of the Climate in Asia 2022", which indicated that temperatures in Asia will continue to rise in 2022. The National Development and Reform Commission (NDRC) and the Ministry of Ecology and Environment (MOE) issued and implemented the Opinions on Further Strengthening the Treatment of Plastic Pollution in January 2020, and the NDRC responded to the "14th Five-Year Plan of Action for the Treatment of Plastic Pollution" in September 2021, and the Central Committee of the Communist Party of China (CPC) and the State Council issued the "Opinions on the Complete and Accurate Comprehensive In October 2021, the CPC Central Committee and the State Council "Opinions on Implementing the New Development Concept and Doing a Good Job in Carbon Peak and Carbon Neutrality" pointed out that realizing carbon peak and carbon neutrality is an inevitable choice to focus on solving the outstanding problems of resource and environmental constraints, and emphasized that it is important to incorporate carbon peak and carbon neutrality into the overall situation of economic and social development, to reduce the level of carbon dioxide emissions, and to enhance the ecosystem's ability to be a carbon sink. The State Council issued the notice of National Climate Change Adaptation Strategy 2035 in June 2022, emphasizing that all provinces and regions should effectively prevent the adverse impacts and risks brought by climate change. The current high temperatures and low rainfall in the

middle and lower reaches of China's Yangtze River Basin have caused incalculable impacts on local shipping/crops and drinking water supply, as well as economic losses. global sea level is expected to rise by an average of 4.62 millimeters per year from 2013 to 2022. The twenty-sixth Conference of the Parties to the United Nations Framework Convention on Climate Change emphasized the need to act now in solidarity to protect the environment and save humanity.

This paper is based on the development of social network analysis method. since 1973, when Granvit published his article about weak relationships, social networks began to appear frequently in the journals of Chinese and foreign scholars. in 1969, Milgram proposed small-world studies, and in 2020, Byron & Landis suggested that social network analysis might gain new development. At present, social network analysis has been developed and matured in the most basic network structure characteristics. Therefore, it is feasible and extremely necessary to make an in-depth analysis of the structure as well as the evolution characteristics of the global trade pattern of plastic scrap with the help of social network analysis. Theoretically, it is possible to visualize the degree of participation of each country and the dynamic evolution of the trade pattern through the analysis of the plastic scrap trade network.

Empirically, there is a lot of literature on the use of social networks to study trade, but little literature on plastic trade. In terms of research objects, there are studies on the impact of product trade, the impact of industrial trade, and the change in the status of a certain country or region in the trade network and the relationship between countries. In terms of product trade, Zhan Miaohua (2018) analyzes and studies the agricultural export trade based on the agricultural trade data in the UN Comtrade database and argues that the complementarity of agricultural exports between countries is

greater than the competition^[1]; Zhong Zuchang et al. (2022) find that there is an interactive effect between the import and export trade of high-tech products through the high-tech products' export trade network^[2]; in terms of industrial trade, Xu Xin (2020) argues that there is interconnection of productive service trade between countries, and analyzes the influencing factors through the QAP way, and finds that geographic distance has a greater impact on productive service trade^[3]. In terms of country status and inter-country relations, Dai Ling et al. (2022) focus on analyzing the relationship between China and Europe in terms of value-added trade, and find that the scale of value-added trade is growing, and that there is a closer connection between countries^[4]; Ge Chunbao et al. (2022), based on UNCTAD-Eora value-added trade data combined with the spatial Durbin model, show that the direct facilitation effect of trade facilitation in countries with low network status is more obvious^[5]. The study shows that the direct facilitation effect of trade facilitation is more obvious in countries with low network status. From the perspective of research, there are analyses of trade patterns and structural characteristics of trade networks. In terms of trade pattern analysis, Xu Bin (2015) used social network analysis to find that China did not have a significant impact on international trade^[6]; Jiang Xuemei et al. (2021) used the OECD inter-regional input-output table to identify the key nodes of the trade network based on the PageRank algorithm to find that the status of developed economies declined, while the status of developing economies in global trade has increased^[7]. In terms of the structural characteristics of the trade network, Li Guangqin et al. (2022) obtain ICT trade data, construct an ICT export trade network, and use QAP to explain the structure of the trade network, and find that China occupies the core nodes in the field of manufacturing equipment^[8].

In view of this, this paper takes the global plastic scrap trade network as the research object, selects the data of UN Comtrade database from 2012 to 2021, applies the social network analysis method, explores the characteristics of the evolution of the global plastic scrap trade pattern as well as the trend, and selects China as the center of the self-network, and analyzes the value of the import and export trade as well as the volume of trade in China's plastics trade network. The main marginal contributions of this paper are: to study the trade of waste plastics that have an impact on the environment from the perspective of the dual-carbon goal; to explore the evolution of the trade pattern using the social network analysis method with the global trade network of waste plastics as the research object.

2. Research Design

2.1. Research methodology

2.1.1. Network Structure Measurement Metrics and Descriptions

(1) Network node centrality

Network node centrality is an indicator of network individual characteristics, which is a broad and wide concept. Specifically, it includes: in-degree centrality, out-degree centrality, proximity centrality, intermediate centrality, and eigenvector centrality. network node centrality in this paper refers to Average centrality (AC), which is manifested in each node. The average centrality of node i is the total number of direct connections between i and other $n-1$ nodes, which can be expressed as Eq:

$$AC_i = \sum_{j=1}^n x_{ij} (i \neq j)$$

where AC_i denotes the average centrality of node i , and x_{ij} denotes the relationship between node i and node j . When node i is related to node j , $x_{ij} = 1$, otherwise $x_{ij} = 0$. ($i \neq j$) That is, excluding the connection between i and itself, in simple terms, the formula is to add up the cell values of node i in the corresponding row or column of the network matrix.

(2) Strength of network node links

Network node linkage strength is a network individual characteristic indicator, refers to the trade volume of all nodes directly connected to node i with the node, using network node linkage strength to portray the value of trade transactions occurring directly between a certain country and other countries, which in this paper refers to the value volume of direct plastics trade, which is manifested as the edges connecting each node. The network connection strength of node i is measured by the sum of plastic trade value (Trade Value, TV) between node i and other $n-1$ nodes, which can be expressed by the formula:

$$TV_i = \sum_{j=1}^n tv_{ij} x_{ij} (i \neq j)$$

where TV_i denotes the total trade value between node i and each of the other nodes, and tv_{ij} denotes the value of plastic trade that occurs between country i and country j both. The network node centrality as well as the network node linkage strength can be synthesized and represented by a matrix:

$$X_{ij}^T = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nn} \end{bmatrix} \begin{cases} x_{ij} = 1, \\ x_{ij} = 0, \end{cases} \quad \text{There is plastic trade}$$

between node ij , $x_{ij} = 1$ and vice versa is 0. Eq. X_{ij}^T denotes the plastic trade network with node j in year T with node i as the self-centering point, obviously there is a direction, thus X_{ij}^T is a directed network, to indicate the country's direct trade value of the edge with the value of trade tv_{ij} . To reflect, we can construct the plastic trade network in year t with trade direction and trade value. TV_{ij}^t Its matrix form is as follows:

$$TV_{ij}^t = \begin{bmatrix} tv_{11} & \cdots & tv_{1n} \\ \vdots & \ddots & \vdots \\ tv_{n1} & \cdots & tv_{nn} \end{bmatrix}$$

(3) Network density

Network density (ND) is a kind of network overall characteristic index, used to measure the close degree of connection of the nodes in the network, the value range is $[0,1]$, the smaller the network density, that is, the smaller the degree of connection of the nodes in the network. In addition to this, the overall network characteristics indicators are network diameter, average path length and average clustering coefficient. Network density refers to the actual existence of plastic trade transactions accounted for (ideally) the proportion of the network assuming that the nodes have trade, can be expressed as:

$$ND = \frac{F}{\frac{n(n-1)}{2}}$$

Eq: F refers to the total sum of the number of plastic trade transactions that actually exist, which can be expressed as:

$$F = \sum_{i=1}^n \sum_{j=1}^n x_{ij} (i \neq j)$$

(4) Average clustering coefficient

Clustering refers to the fact that countries with i There may also be links between other countries that are linked to form a cluster. Clustering coefficient refers to the closeness of the links between the countries within the cluster, and takes values in the range of $[0,1]$. Average clustering coefficient (ACC) is the average of the clustering coefficients of all nodes in the network and can be expressed as:

$$ACC = \frac{1}{n} \times \sum_{i=1}^n \frac{P_i}{AC_i(AC_i - 1)}$$

Eq: AC_i denotes the network node centrality, i.e., the number of nodes i the number of trades that exist with other nodes in the network. $AC_i(AC_i - 1)$ denotes the ideal case where countries that are i trade exists with all other countries linked to it (obviously, this assumption is directed) P_i indicates that trade exists with the country i indicates the number of other countries linked to the country with which trade exists.

(5) Degree Distribution and Cumulative Degree Distribution

The nodal degree distribution mainly refers to the distribution pattern of plastic trade with other countries connected to a particular country, and the cumulative degree distribution refers to the percentage of countries connected to a certain overall network with the number of countries not less than x . The distribution function of nodal degree is expressed by the formula:

$$p(x) = \frac{n_x}{n}$$

where: n is the number of nodes, i.e., the total number of countries in the plastics trade network, and n_x is the number of nodes whose node centrality is x of the number of nodes. The cumulative degree distribution is expressed by Eq:

$$p(x \geq x_0) = \sum_{x=x_0}^{x_{max}} p(x)$$

Eq: x_{max} refers to the node with the greatest node centrality corresponding to the AC_i that $p(x)$ which is the degree distribution described above.

2.1.2. Block model analysis for network associations

By profiling the structural characteristics of the network, countries with i connected to other countries consisting of clusters with high clustering coefficients are considered as a block model, which is then analyzed as a model. This method of chunking structurally similar countries facilitates the analysis of the roles and partners of individual countries in the plastics trade network. If the number of countries included in a block model B is N_B , then the total number of trade links in that block of the model in the ideal state is $N_B(N_B - 1)$, and at the same time, the number of countries included in that model B N_B countries have a total number of trade links with all the countries in that network in an ideal state is $N_B(N - 1)$, then the proportion of model B in the whole is $(N_B - 1)/(N - 1)$ Therefore, the global plastic scrap trade network can be categorized according to the range of ratios, as shown in the following table

Table 1. Global Plastic Scrap Trade Network by Block

tectonic plate	Countries with high TV for import and export of waste plastics
Eastern European	Czech Republic (CZE), Poland (POL), Slovakia (SVK)
Western European	Austria (AUT), Belgium (BEL), France (FRA), Germany (DEU), Netherlands (NLD)
southern Europe	Italy (ITA), Spain (ESP)
Scandinavia	Denmark (DNK), Sweden (SWE), United Kingdom of Great Britain (GBR)
any property	China (CHN), Hong Kong, China (HKG)
southern Asia	India (IND)
Southeast Asia	Indonesia (IDN), Malaysia (MYS), Philippines (PHL), Thailand (THA), Viet Nam (VNM)
North America	United States (USA)

2.2. Data sources

Data from the United Nations Conference on Trade and Development database UNCTAD stat involving Global plastics trade, ANNUAL 233 countries from 2012-2021 total plastics trade value as well as trade volume. In addition, using the United Nations Commodity Trade Statistics Database UN Comtrade, the value of export trade in plastics scrap (HS code 3915) and the value of import trade in plastics scrap in 233 countries from 2012-2021 and 2012-2021, we constructed 20 "whole nets" to analyze the trade pattern of plastics in a separate and comprehensive manner. In 2013, China implemented the "Green Fence Initiative", and in 2017, it enacted the "Upgraded Plastic Ban", and 2021 is the opening year of the 14th Five-Year Plan, as well as the first year of the implementation of the Carbon Peak and Carbon Neutral Strategies, which is the first year of the implementation of the Carbon Neutral Strategy, which is the first year of the implementation of the Carbon Peak Strategy. Based on the principle of equidistant sampling of time nodes, the four years of 2013, 2016, 2019 and 2021 are selected as special analysis samples for personalized analysis.

3. Evolution of the Global Trade Pattern of Waste Plastics

3.1. Centrality analysis of core nodes of the global plastics scrap trade network

3.1.1. Core import node centrality

Tables 1 and 2 below show the top 15 countries after sorting the import TV in the global scrap plastics trade in accordance with the selected time points, and extracting the top ranked countries. Countries with more imported plastics trade TV are in a more advanced relative position, i.e., the higher the country's participation in the scrap plastics trade network. From 2012-2017, China, Hong Kong, China, and the U.S. steadily ranked in the top three of the import trade volume of scrap plastics, and the Netherlands, Germany, India, Belgium, Italy, Malaysia, Canada, Ireland, the United Kingdom, Austria, France, these countries also ranked in the top of the plastic import trade volume. 2018-2021, the trade pattern has changed a lot, China fell out of the top fifteen, China's scrap plastics import trade value in 2019 is only

0.0104 billion U.S. dollars, located in the global ranking of 91st. In 2018-2020, the United States replaces China at the top of the list. In 2021, the United States exits the rankings, the Netherlands tops the list in terms of the value of trade in scrap plastics imports, and developing countries gradually emerge, with top-ranked developing countries including Turkey, Poland, Mexico, India, and Pakistan.

China's plastic restriction enacted in 2017 has greatly changed the global trade pattern of waste plastics and reshaped the global cross-border transfer of waste plastics. The developing countries of Hong Kong, China, the

Netherlands, Germany, Belgium, Italy, and Canada are at the forefront of the trade value of scrap plastics imports from 2012-2021, indicating that the above countries continue to have a high degree of participation in the global plastics trade, and realize frequent trade transactions with other countries around the globe in the trade of scrap plastics with a large trading volume, and have a core node centrality. In the 21st century, when the level of climate pollution is getting more and more serious, these countries should be more responsible and should formulate relevant policies to control the import and use of waste plastics and plastic products.

Table 2. Top 15 countries in terms of import TV for trade in plastics scrap, 2012-2017 (in billions of dollars)

2012		2013		2014		2015		2016		2017	
nations	TV	nations	TV	nations	TV	nations	TV	nations	TV	nations	TV
CHN	128.084	CHN	120.979	CHN	120.693	CHN	83.677	CHN	73.894	CHN	65.267
HKG	25.701	HKG	21.153	HKG	25.431	HKG	20.932	HKG	18.374	HKG	13.248
USA	4.473	USA	5.245	USA	5.747	USA	4.695	USA	4.676	USA	4.885
NLD	4.160	NLD	4.976	NLD	5.402	NLD	4.350	NLD	3.895	NLD	4.178
DEU	4.053	DEU	3.837	DEU	4.699	DEU	3.914	DEU	3.751	DEU	3.382
BEL	2.457	IND	3.177	IND	3.255	BEL	2.198	ITA	2.078	MYS	2.286
IND	2.312	BEL	2.603	BEL	2.374	IND	1.885	BEL	1.953	ITA	2.276
ITA	2.092	MYS	1.997	ITA	2.267	ITA	1.857	IND	1.595	BEL	2.035
CAN	1.921	ITA	1.972	CAN	1.937	CAN	1.752	CAN	1.516	TUR	1.465
IRL	1.805	IRL	1.798	IRL	1.802	AUT	1.389	GBR	1.355	IND	1.438
AUT	1.429	IDN	1.630	AUT	1.793	IRL	1.312	MYS	1.322	VNM	1.416
IDN	1.334	CAN	1.537	GBR	1.713	MYS	1.242	IRL	1.197	CAN	1.401
MYS	1.310	GBR	1.461	FRA	1.280	GBR	1.083	AUT	1.113	IRL	1.343
FRA	1.236	AUT	1.375	IDN	1.050	VNM	1.030	POL	0.992	GBR	1.203
GBR	1.164	FRA	1.304	VNM	1.044	FRA	0.970	FRA	0.974	POL	1.194

Table 3. Top 15 countries in terms of import TV for trade in plastics scrap, 2018-2021 (in billions of dollars)

2018		2019		2020		2021	
nations	TV (\$)	nations	TV (\$)	nations	TV (\$)	nations	TV (\$)
USA	5.379	USA	4.981	USA	4.660	NLD	6.083
HKG	4.873	HKG	3.982	NLD	3.502	TUR	3.902
NLD	3.883	NLD	3.775	MYS	3.355	DEU	3.852
DEU	3.131	DEU	3.355	DEU	2.852	ITA	2.199
ITA	2.189	VNM	3.003	VNM	2.831	CAN	2.140
VNM	2.162	TUR	2.262	TUR	2.796	BEL	2.026
BEL	2.149	MYS	2.199	HKG	1.936	ESP	1.807
IDN	2.047	ITA	1.741	BEL	1.537	POL	1.508
POL	1.579	BEL	1.704	CAN	1.396	MEX	1.047
IRL	1.501	IDN	1.664	ITA	1.396	HKG	0.684
CAN	1.471	FRA	1.543	FRA	1.349	IND	0.574
FRA	1.462	GBR	1.496	IDN	1.261	PAK	0.549
THA	1.458	CAN	1.451	POL	1.095	CZE	0.502
IND	1.378	ESP	1.415	AUT	1.094	SWE	0.470
GBR	1.368	POL	1.374	GBR	1.049	LTU	0.432

3.1.2. Core exit node centrality

Similarly we take 2017 as the dividing line, the top ranked countries in 2012-2017 in terms of export TV of plastic scrap trade are the United States, Hong Kong, China, Japan, Germany, the United Kingdom, Mexico, France, the Netherlands, Thailand, Belgium, Spain, Vietnam, Canada, India and so on. Among them, Mexico, Thailand, Vietnam, and India belong to developing countries, and the rest are developed countries. The 2018-2021 Scrap Plastics trade

pattern is very different from 2012-2017, and the top developing countries in 2018 are Mexico, Thailand, Vietnam, and Poland. The developing country Philippines' Scrap Plastics trade export volume is gradually rising in 2019, with a trade transaction value of 189.3 million USD and ranked 10th. China reappears in 2019-2020 at the top of the trade export list, and the Czech Republic, Sweden, Slovakia, and Denmark make their first appearance in 2021 in trade exports of plastics scrap.

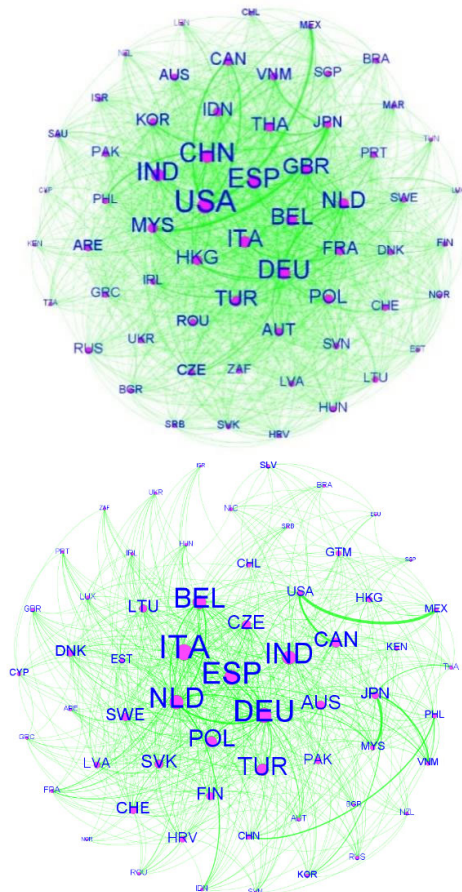


Figure 3,4. Plastic scrap export trade network in 2019,2021

Prior to 2017, the network density of the global plastic scrap export trade network was clearly high. Through the scrap plastics export trade network in 2013 (Figure 1), it can be clearly seen that the lines between individual countries are intertwined and kneaded into one. That is, the trade and export links between countries are extremely close. Among them, China, the United States, Hong Kong, China, India, the United Kingdom, Germany, Italy, Belgium, Spain, the Netherlands, the participation in the trade network is relatively high, occupying a more important position. It is not difficult to find, in addition to China, India, other countries or regions (Hong Kong, China) are developed countries or developed economies (Hong Kong, China). In addition, Germany, the United Kingdom, Belgium, the Netherlands belongs to the Western European countries; Italy, Spain belongs to the Southern European countries; the United States belongs to the North American countries; China, Hong Kong, China belongs to the Asian countries and regions; India belongs to the South Asian countries. That is, these countries with high network density are centrally distributed in Europe, North America and Asia. 2016 scrap plastics export trade network is also the same, the trade links between countries are relatively close, the network density of countries with high network density did not change much compared with 2013, France in Western Europe, Canada in North America gradually emerged.

After 2017, the network density of the global trade network for plastics scrap exports decreases, trade exports between countries decrease, and trade relations become sparse. The trade network for plastics scrap in 2019 becomes significantly sparse compared to the network in 2013 as well as in 2016,

with a significant decrease in the number of edges. The trade network in 2021 becomes even more sparse, with a decrease in the export of plastics scrap between countries. Among these countries are Germany, Italy, Spain, the Netherlands, Belgium, Poland, Turkey, India, Canada, and Australia, which are at the core of the trade network, i.e., they are more involved in the export of plastics from scrap. Australia belongs to Oceania, Turkey belongs to Asia, these countries are concentrated in Europe, Asia, North America and Oceania. With the exception of Poland, India, and Turkey, the rest of the countries are developed countries.

3.2.2. Network Density of Global Scrap Plastics Import Trade Networks

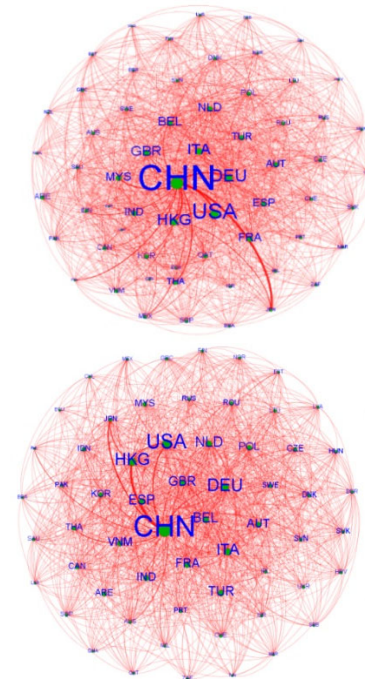


Figure 5,6. Plastic scrap import trade network in 2013,2016

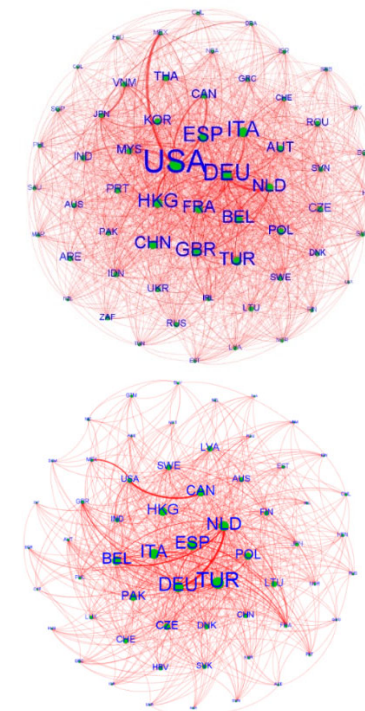


Figure 7,8. Plastic scrap import trade network in 2019,2021

By observing the degree of intertwining of lines in the network in 2013 and 2016, it can be known that the network density of the global import trade network of plastics scrap is high, and the import of plastics scrap trade between countries is extremely close, and China is at the core of the network until 2017, and China has the highest participation in the network, i.e., China imports plastics scrap from many countries or China is the primary export of plastics scrap from many countries object of choice. In the network, China mainly imports waste plastics from developed countries such as the United States, France, Japan and Germany. In 2013, in addition to China, there are the United States, Germany, Hong Kong, China, Italy, the United Kingdom, Belgium, the Netherlands, Malaysia, India, France, Spain, Turkey, Austria in the import of waste plastics in the higher participation. Among them, except for Malaysia, India and Turkey, the rest of the countries are developed countries. In 2016, China, the United States, Hong Kong, China, Germany, Italy, Turkey, the Netherlands, Belgium, the United Kingdom, and Spain occupy important positions in the trade network. Compared to 2013, the relative positions have not changed much.

After 2017, the global trade pattern of waste plastics was clearly affected by China's enactment of the plastic ban, with the United States replacing China at the center of the network. Combined with the comparison in Figure 3, the United States occupies an important position in both import and export trade of waste plastics, with the highest degree of participation. In the trade network in 2019 (Figure 7), the United States, Germany, Spain, Italy, the Netherlands, Hong Kong, China, Turkey, Belgium, the United Kingdom, China, France, Poland, and Malaysia, which are all developing countries, have a high degree of participation. Among them, Poland, Malaysia, Turkey and China are all developing countries. In addition to this, it can also be seen that China has been the primary choice of the United States and other developed countries to export waste plastics until 2017, while in 2019, the United States and other developed countries mainly exported waste plastics to Malaysia, India, Vietnam, Thailand, Indonesia and these developing countries. Among them, except for India, all other countries are Southeast Asian countries. 2021 The trade network (Figure 8), which is more sparse than that of 2019, has a significantly lower network density. Unlike in the past the participation of the United States in the scrap plastics import network has significantly decreased, probably due to the growing epidemic of New Crown Pneumonia in the U.S. Many developing countries have abandoned the U.S. in favor of importing scrap plastics

from other developed countries or even from developing countries. Developing country Turkey is at the core of the network, besides Germany, Netherlands, Spain, Italy, Belgium, Canada, Hong Kong (China) and Poland have a high participation in the network of plastic scrap trade. It is also clear that China's ban on plastics is not a "total" ban, and the presence of China in the import trade network in 2019 and 2021 may be related to the global C.N.C.P. epidemic, where on the one hand people tend to choose disposable products in order to minimize the risk of infection, and on the other hand the C.N.C.P. epidemic is related to medical devices, nucleic acid tests, and other products that have been used for the past few years. On the one hand, people tend to choose disposable products in order to minimize infections; on the other hand, medical devices related to the CIP epidemic, such as nucleic acid testing "swabs" and syringes, are all related to plastics, and in this context, China's demand for plastics and their products has risen sharply, which has led to imports of some waste plastics.

Overall, affected by China's plastic ban in 2017, the export object of the United States and other developed countries has been expanded from the original East Asian country China to a number of developing countries in Southeast Asia, and China's initiative has had a profound impact on the global trade pattern of waste plastics, which has led to the evolution of the global trade pattern of waste plastics.

3.2.3. Clustering coefficients and community discovery

The clustering coefficient is the degree to which a country i The clustering coefficient is the degree to which there is some connection between other countries linked to a certain country. Given that the import and export trade of waste plastics is concentrated in Europe, Asia, and North America, this paper selects each state import and export TV_{max} countries and use them as the core countries in the calculation of the clustering coefficient i . Again, 2017 is used as the dividing line to observe the evolution of the global import and export trade pattern of scrap plastics. Core countries of scrap plastics trade in each segment i Based on the import and export TV_{max} principle, specifically: Poland for Eastern Europe, Germany for Western Europe, Italy for Southern Europe, the UK for Northern Europe, China for East Asia, India for South Asia, Indonesia for Southeast Asia, and the United States for North America. After considering the latitude and longitude, the network diagram of global import and export of plastic scrap trade in 2013 and 2021 is as follows:

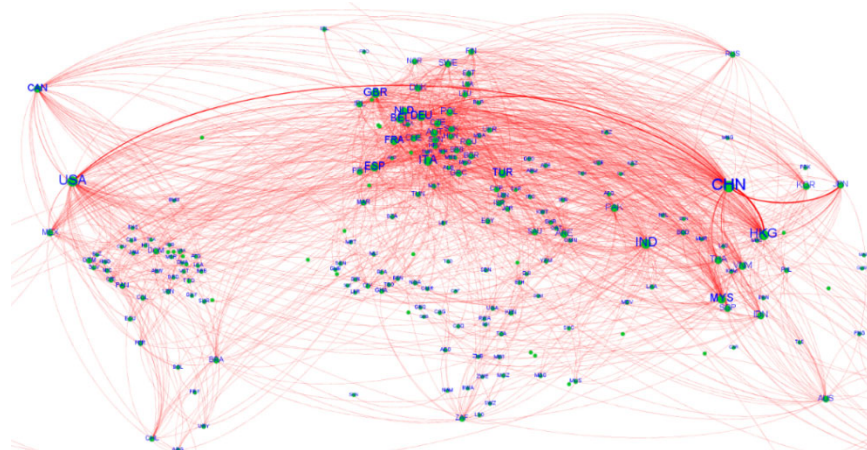


Figure 9. Export network for trade in plastics scrap in 2013 (latitude and longitude)

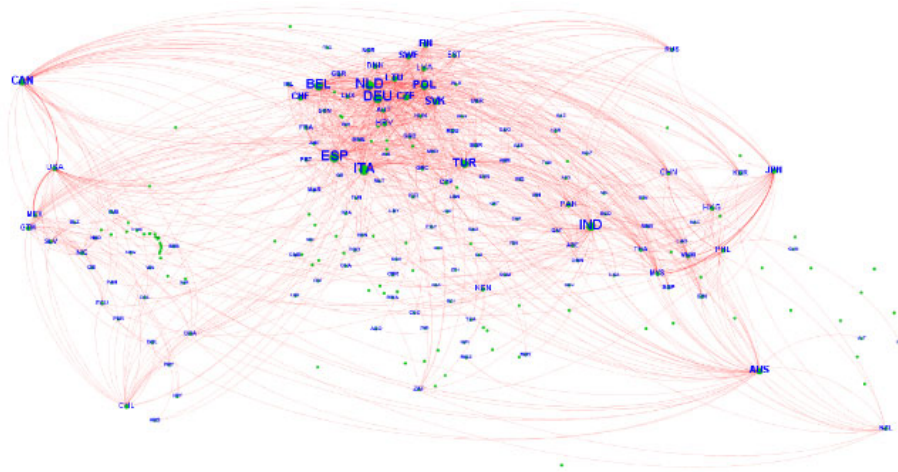


Figure 10. Export network for trade in plastics scrap in 2021 (latitude and longitude)

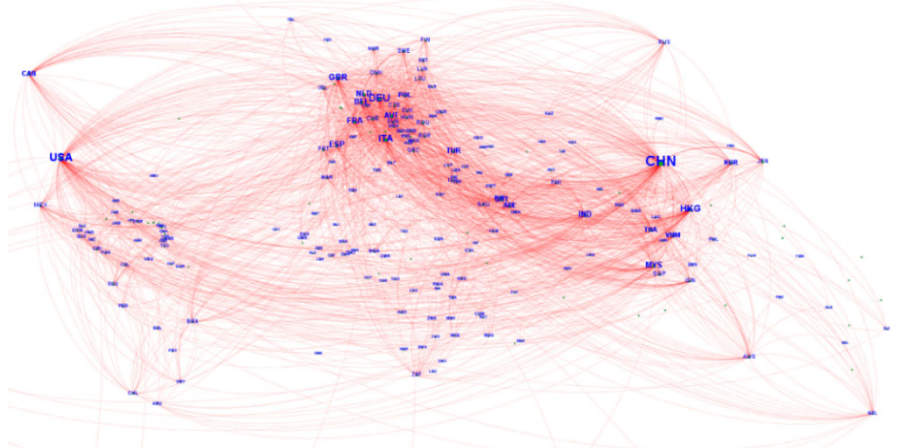


Figure 11. Import network for trade in plastics scrap in 2013 (latitude and longitude)

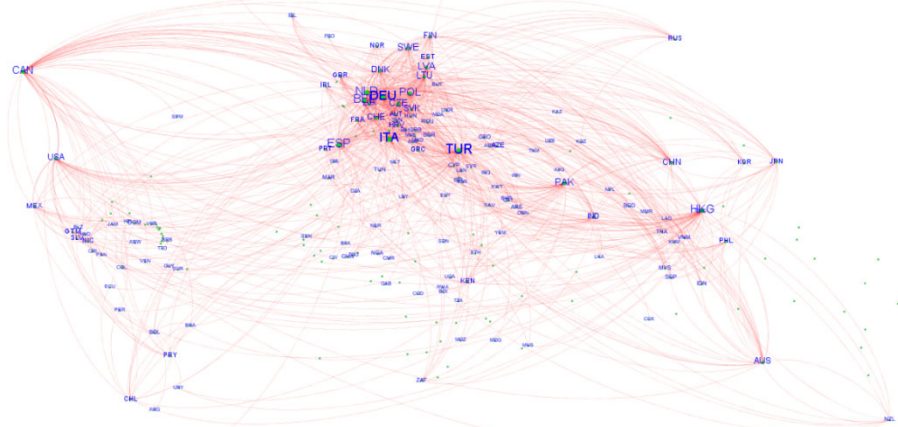


Figure 12. Import network for trade in plastics scrap in 2021 (latitude and longitude)

From the network diagram of global scrap plastics trade import and export in 2013 and 2021, it can be seen that the pattern of import and export trade has changed drastically. In 2013, the clustering coefficient is higher in Eastern Europe, Southeast Asia, North America and other major segments. In 2021, the clustering coefficient is higher in Western Europe, North America, Eastern Europe, Southern Europe, South Asia and other major segments.

4. Analysis of China's Plastics Trade Network

4.1. Analysis of the structure of China's plastics trade network

(1) Through the import centrality statistics of the global

scrap plastics trade network, it is found that China's scrap plastics import trade volume steadily ranked first among 233 countries in the world from 2012 to 2017. Due to the enactment of China's plastic restriction in 2017 greatly changed the global waste plastic trade pattern. 2018-2020 the United States of America's waste plastic trade imports jumped to the top, while the Netherlands replaced the United Kingdom in 2021, and China's waste plastic trade imports dropped sharply since 2018.

(2) On the contrary, through the collation of global statistics, it was found that China's excessive demand for plastic products due to its large population base from 2012-2017 has kept China in a passive import of waste plastics trade with little or no export behavior of waste plastics trade. The enactment of the plastic restriction order in 2017 has resulted

in China being in an active exporter of waste plastic trade in the period of 2018-2021. In Carbon Neutral, Carbon Peak and fulfill its commitments.

4.2. China's role and partners in the global plastics trade network

Due to space constraints, this paper selects the special years of 2013, 2016, 2019, and 2021 as personalized analysis samples to analyze China's role and partnership in the global plastics trade network.

In 2013, China's participation in the global scrap plastics trade and export network is high in the core node position, as a major scrap plastics trade exporter main trading partners are the United States, Hong Kong, China, the United Kingdom, Germany, etc. In 2016, China and the United States as the two major scrap plastics trade exporters, China's main trading partners compared with 2013 increased Belgium, Italy, Turkey, Japan and so on. several countries, and the export trade gradually expanded. However, from 2019, China's participation in the export trade of plastics scrap declined, and the main trading partners gradually changed from developed countries to developing countries, and showed a decreasing trend. In 2021, China gradually faded out of the export trade network of plastics scrap, and its trading partners are mainly Poland.

From the global import network of scrap plastics trade, it can be seen that in 2013 China, as a major importing trading country, was disconnected from other trading countries, mainly importing scrap plastics from the United States, Hong Kong, China, Germany, Italy, Belgium, the United Kingdom, and other countries. The situation eased in 2016, the participation of the United States, Germany, and Italy gradually increased, and although China, as a major exporter of scrap plastics trade, the degree of involvement has decreased, and the main trading partners have not changed much compared to 2013. In 2019, China's participation has decreased sharply, and the main trading partners have changed from developed countries to some developing countries, such as Pakistan and Ukraine. In 2021, China has almost no more import activities in the scrap plastics trade network, and not only China, but also the global greenhouse effect and the increase of environmental pollution, which makes the The global greenhouse effect and increasing environmental pollution have led to a decline in import trade participation in every country in the world. Among them, China has only a very small amount of plastic scrap imports with a very small number of developing countries.

5. Conclusions and Revelations

5.1. Conclusion

(1) Through the global 233 countries or regions scrap plastics import and export trade volume statistics found that in 2012 the scrap plastics imports more countries (or regions) are China, Hong Kong, China, the United States, the Netherlands, Germany, Belgium, imports ranked in the top fifteen countries or regions only four developing countries, developed countries or regions accounted for about 73%; the largest exports of countries (or regions) for the Hong Kong, China, the United States, Japan, Germany, the United Kingdom, Mexico, exports ranked in the top fifteen countries or regions only five belonging to developing countries, developed countries or regions accounted for 2/3. 2021 the largest volume of imports of waste plastics is the Netherlands,

imports ranked in the top fifteen of Turkey, Poland, Mexico, India, Pakistan, these developing countries participation is gradually revealed, China's imports Sharp decline, there is no longer China in the top fifteen. The largest export volume of countries for Germany, the Czech Republic, Sweden, Slovakia, Denmark in the waste plastic trade exports for the first time, only Mexico, the Philippines for developing countries, developed countries accounted for about 87%. From 2012-2021, it is clearly visualized that the participation of developing countries in exports is gradually increasing, while developed countries occupy the primary position in exports.

(2) In 2013, when China implemented "Operation Green Fence", China temporarily ranked first in the global trade pattern of waste plastics in terms of imports, and after China enacted the "upgraded version of the ban on plastics" in 2017, and as the opening year of the 14th Five-Year Plan in 2021, both import and export rankings of trade in waste plastics have dropped out of the top rankings. In 2017, after China enacted the "upgraded plastic ban", in 2021, the opening year of the 14th Five-Year Plan, the ranking of import and export of waste plastics will be withdrawn from the top.

(3) In 2013, China's plastic scrap export trade partners are mainly the United States, Hong Kong, China, the United Kingdom, Germany, etc.; import trade partners are the United States, Hong Kong, China, Germany, Italy, Belgium, the United Kingdom, etc. In 2021, China is gradually fading out of the plastic scrap export trade network, and the trade partners are mainly Poland; China is almost no longer imported in the plastic scrap trade network, and it's not only China, but also the whole world. Greenhouse effect as well as the intensification of environmental pollution, so that all countries around the world import trade participation has declined.

5.2. Revelations

(1) The countries or regions with the highest trade volume of plastic scrap imports in 2021 are the Netherlands, Turkey, Germany, Italy, Canada, Belgium, Spain, Poland, Mexico, Hong Kong (China), India, Pakistan, the Czech Republic, Switzerland and Lithuania. The import of waste plastics can lead to higher management costs for developing countries, while at the same time causing incalculable environmental impacts due to the difficulty of degradation. In this regard, developing countries need to raise awareness of the potential environmental risks associated with the disposal of foreign waste plastics and develop timely and restrictive policies to improve global environmental sustainability.

(2) The countries or regions with the largest export trade volume of waste plastics in 2021 include Germany, Japan, the Netherlands, Mexico, Belgium, Italy, Canada, the Philippines, Poland, Spain, Austria, the Czech Republic, Switzerland, Slovakia, Denmark and so on. The countries with higher export volume are still mainly developed countries, which can strengthen the territorialized management of waste plastics and enhance the recycling rate through policy incentives and financial support.

(3) China has developed many policies in favor of environmental protection in the import and export trade of waste plastics. In order to further reach the goal of carbon neutrality and carbon peaking, China should further reduce greenhouse gas emissions by lowering the threshold as well as the cost of sustainable consumption, quantifying the carbon reduction contribution of consumers, and then increasing

public participation and enforcement. It should also improve the whole chain management system of plastic pollution, further refine the reduction of plastic use at the source, and reduce the amount of plastic waste going to landfills and environmental leakage.

References

- [1] Zhan Miaohua. *Competitiveness and Complementarity of Agricultural Product Trade in Countries Along the "Belt and Road" Route - Based on Social Network Analysis Method*[J]. *Problems of Agricultural Economy*. 2018(02): 103-114.
- [2] Zuchang Zhong, Peixuan Yu, Xiao Xiao, et al. A study on the impact of high-tech product export trade network construction on a country or region's position in the global value chain division of labor: a perspective based on social network analysis[J]. *Management Review*. 2022, No.34(03): 127-140.
- [3] Xu Xin, Xu Xiaoyu, Han Zhulin. Research on the Characteristics of Global Productive Services Trade Network and Its Influencing Factors-Based on Social Network Analysis[J]. *Price Theory and Practice*. 2020(03): 18-21.
- [4] Dai Ling, Pan An. The Evolutionary Characteristics of Sino-European Trade Relations from the Perspective of Global Value Chain and Its Implications[J]. *Comparison of economic and social systems*. 2022(01): 178-189.
- [5] Ge Chunbao, Yuan Xiaojin, Yu Jinping, et al. Trade Facilitation, Spatial Spillovers and Value-Added Trade Network Position: A Social Network and Spatial Econometric Analysis Based on the Countries Along the Belt and Road[J]. *Exploration of Economic Issues*. 2022(07): 150-172.
- [6] Xu Bin. Social network analysis of international iron ore trade pattern[J]. *Economic Geography*. 2015, No.35(10): 123-129.
- [7] Jiang Xuemei, Zhang Shaoxue. Analysis of the evolution of global trade network pattern of intermediate goods based on PageRank algorithm[J]. *International Business Research*. 2021, No.42(01): 38-49.
- [8] Li Guangqin, Jin Yuping, He Renwei. Characteristics of ICT export trade network structure and influencing factors based on social network analysis[J]. *Geoscience*. 2022, No.42(03): 446-455.