China’s waste plastic ban has sparked a discussion about how the global plastic waste trade (GPWT) will develop in the future. GPWT has certain stability and sustainability; although plastic waste trade has narrowed under the ban, it still has the potential trend of reconnecting the same type of links. Specifically, from a regional perspective, the future trade of new plastic waste trade will be dominated by cross-regional trade. Plastic waste may continue to flow to countries in the Asian-Pacific, Middle East, and African regions, while European countries will strengthen the internal recycling and processing of plastic waste. From the perspective of the national income level, the establishment of the new relationship will show an evolutionary trend in which high-income countries are dominated and the scale of trade between non-high-income countries expands. In addition, the differences in the level of economic development, liner transport connectivity, and the proportion of mismanagement of plastic waste among countries has a positive effect on the establishment of a new relationship in the GPWT, while tariff rates have an inhibitory effect.

1. Introduction

From 1992 to 2016, 45% of the world’s plastic waste was exported to China, with such a large volume of plastic waste imports resulting in the “displacement” of huge amounts of plastic waste after China’s ban, which is estimated to reach 111 million metric tons in 2030 [1]. This triggered the transfer of the global plastic recycling system, and global plastic recycling fell into a panic [2]. While many countries have recognized the recycling and utilization of domestic plastic waste streams, they do not yet have sufficient industrial infrastructure and capacity [1]. After the ban, a large number of plastic waste exports were transferred to other Asian countries such as Indonesia, Vietnam, Malaysia and Philippines [3], and Turkey has also become a new plastic waste recycling market in some European countries [4]. This prompted such countries to adopt import control measures to reduce the import of plastic waste. Although some scholars have pointed out that the import ban in developing countries would force developed countries to establish new plastic treatment facilities [3], but until now the plastic waste trade is still profitable for traders [4]. On the one hand, local enterprises in some countries are more inclined to import low-cost plastic waste than to invest in domestic waste recycling systems [7]. On the other hand, compared with domestic processing, developed countries have found that exporting plastics is a more cost-effective approach [5]. In particular, some scholars have recently pointed out that after China’s ban, the rapid inflow of plastic waste has overwhelmed Turkey’s waste management, and waste pollution in Turkey and its Mediterranean coast has continued to increase [8]. Malaysia [7], Thailand [10] and other countries are also in the same predicament. Under the goal of public governance policy, the pursuit of profit by capital has prompted the continuation of the plastic waste trade. These “displaced” plastic wastes pose a challenge to global plastic waste governance, because most countries in the world lack the ability to sustainably manage excessive imports of plastic waste [11], and the risk of plastic waste being illegally dumped into the ocean and freshwater is increasing [2].
Affected by the ban, the “displaced” plastic waste has triggered discussions on the global issue of how the GPWT will develop in the future. What are the potential links to the plastic waste trade? What is the distribution law of these potential links? What are the influencing factors behind the generation of potential links? The exploration of such issues has both an important theoretical and practical significance. Link prediction is a method to predict possible new links in the future based on the current network snapshot [12]. Due to its ability to dig out the potential information and evolution trends of complex networks [13][14], it has been widely used in many fields [15][16][17]. Therefore, this attempts to use the link prediction method to forecast the potential links of the GPWT, and deconstruct the distribution law of potential links from multiple angles and the generation influencing factors, to conduct in-depth exploration and discussion on the trend of establishing new plastic waste trade relations. This will not only answer the important question of how the GPWT will develop in the future, but also help to understand the nature of the relationship building in the GPWTN and the underlying laws of its operation, and provide new ideas for potential solutions to the GPWT, promote the smooth progress of the global plastic waste management task.

2. Global Plastic Waste Trade

The current research on GPWT is mainly concentrated on the structure and evolution of the GPWTN [15][18][19][20], the impact of the plastic waste trade on the environment [8][21][22], and the driving factors of the plastic waste trade [23][28]. Especially after China promulgated the ban on plastics, related research on the plastic waste trade has increased rapidly.

In terms of research on the structure and evolution trend of the plastic waste trade network, Wang et al. (2020) analyzed the temporal and spatial evolution of the GPWTN. The results show that Asia has now become the world’s largest import region, while North America and Europe are the main sources of plastic waste [5]. Pacini et al. (2021) conducted a network survey on GPWT and found that the European Union and North American countries play a key role in the GPWTN and have close ties with some Asian countries [18]. Li et al. (2021) used a cascading failure model to quantify the process of plastic waste trade collapse due to the Chinese ban and found that the GPWT would collapse after the ban starting from China’s trading partners, and lead to a global overload of plastic waste [23]. In terms of research on the impact of plastic waste trade on the environment, Liu et al. (2021) explored whether the reuse and recycling of the GPWT has a positive impact on environmental benefits. The results show that the GPWT may help reduce potential greenhouse gas emissions and other environmental benefits, but at this stage, the GPWT distribution is flawed and its structure should be adjusted [21]. Wen et al. (2021) used the Life Cycle Assessment method to quantify the environmental impact of changes in plastic waste flow patterns and treatment methods after the implementation of the Chinese ban. The results show that the ban has significantly improved environmental indicators in the short term, but at the same time, it has caused global warming [22]. Ren et al. (2020) evaluated the environmental impact of China’s ban through scenario simulation and life cycle methods, and the results showed that the ban may impose adverse environmental impacts on plastic waste, which would be contrary to the original intention of the ban to protect the ecological environment and human health [26]. In terms of research on the drivers of the plastic waste trade, Barnes (2019) applied an explanatory type of theory in terms of the plastic waste trade, and believed that “out of sight, out of mind” is the main reason why developed countries export huge amounts of plastic waste to developing countries, and the supervision or control of plastic waste in developed economies should be strengthened [23]. Kellenberg (2015) reviewed the waste trade and identified differences in national environmental policies, taxes, disposal fees, and transportation costs as important determinants of the development of the trade [24].

The evolution of the GPWTN is complicated, and most of the existing studies on the plastic waste
trade network have analyzed the past evolutionary trends of the network by calculating several indicators, but the nature of the construction of trade relations between countries and the trend of possible new trade relations to be established in the future need to be further explored. Especially after China and other Asian countries passed bans to restrict imports, the market has begun to fall into chaos and is in an extremely unstable state. The surge in imports of plastic waste faced by some countries has brought huge challenges to the waste management of these countries. The question of the trend of establishing new plastic waste trade relations needs to be answered urgently.

3. Link Prediction

Link prediction is a research method based on data mining; the research ideas and methods have mainly evolved from the Markov chain and machine learning. Since social networks usually present a complex and dynamic evolution state, as time goes by, the nodes in the network will change their association mode under the influence of certain driving forces, which promotes the birth of link prediction. In 2007, when Liben-Nowell and Kleinberg studied the problem of establishing new relationships between members over time in social networks, they first generalized it as a link prediction problem, and link prediction has gradually become one of the main research methods in social networks. Among them, the application of link prediction in the network mainly includes the prediction of unknown links and future links. The prediction of future links is specifically shown in Figure 1, that is, through a snapshot of the network structure at time t, it can predict which new links will be added to the network at time t’ in the future compared with the network at time t.

As an emerging research method, the previous link prediction research mainly focused on the improvement of current algorithms and the innovation of new algorithms, that is, which algorithm can better predict the potential links of real relationships. With the development of link prediction research, some scholars gradually apply link prediction to real networks, such as social networks, scientist coauthor networks, protein networks, transportation networks, and criminal networks. The structure, scale, and characteristics of the above networks are different, but through continuous attempts, scholars have found that applying the link prediction method to the above networks not only obtains relatively ideal prediction results, but also helps to dig out the potential information of the network. For example, researchers proposed a link
prediction algorithm suitable for the yeast protein–protein interaction (PPI) network, and found that the biological relevance of links in the yeast PPI network reconstructed by this algorithm is significantly higher than that of the original network [31]. Through the successful application of the algorithm, it was discovered that yeast proteins with high-order topological similarity are more likely to interact, which is an important potential information.

With the expansion of link prediction practice, the current relatively novel research tends to apply this method to the global trade network, mainly based on the relationship between countries in the trade network, to predict the potential trade relations that may develop into actual trade relations in the future. This groundbreaking research began when Guan et al. (2016) predicted the potential global crude oil trade relationship based on the common neighbor (CN) algorithm. In addition to predicting potential links, it was also discovered that the number of mutual trading partners is one of the motivations for the establishment of new global crude oil trade relations [32]. Later, some scholars gradually applied link prediction to bauxite trade [33], cobalt ore trade [34], lithium carbonate trade [35]. Among them, Liu and Dong (2019) found 17 pairs of potential bauxite trade links using the link prediction method from the perspective of the topological relationship of the trade network of countries and provided suggestions for ensuring national bauxite safety [33]. Liu et al. (2020) cited this method in the cobalt ore trade and predicted 13 possible future cobalt ore trade relationships, which have helped relevant countries find more new trading partners [34]. Zhang et al. (2021) applied the link prediction method to the prediction of potential trade links of lithium carbonate trade and found three trade rules for lithium carbonate trade, which are of great importance to strengthen the supply security of lithium carbonate resources in international trade significance [35].

The above scholars have used different trade networks to verify the accuracy and effectiveness of link prediction methods applied to the prediction and mining of potential trade relations. Relying on its powerful ability to analyze the evolution of the network, the link prediction method has attracted much attention from academia [36]. Although some scholars have applied the link prediction model to the prediction of potential trade relations, the discussion on the prediction results is relatively simple, and no further research has been conducted on the distribution law of predicted potential trade relations and the influencing factors.

References


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