Research Article

Analysis Model Design on the Influencing Factors and Countermeasures of China’s International Trade Facing the Belt and Road

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Since the “Belt and Road” Initiative was put forward in 2013, it has attracted more and more attention. Many countries along the Belt and Road have participated in it, which has further deepened regional economic integration. Complex network analysis is an interdisciplinary method, which has a perfect overall perspective and data indicators that can quantify the relationship. More and more scholars have begun to pay attention to it and use it to carry out research. Based on the perspective of complex networks, this paper constructs the “Belt and Road” directed weighted network, respectively, according to the import and export trade data of countries and international organizations that have signed cooperation documents, and then studies the characteristics of the “Belt and Road” trade network by using a variety of network topology attribute analysis methods and node centric indicators.

1. Introduction

At the end of the 20th century, the establishment of WTO, G20, APEC, and other international trade organizations promoted the flow of production factors in various countries, adjusted the distribution of means of production in various countries, promoted the optimization of global industrial structure, and had a far-reaching impact on the development of the world economy [1, 2]. Since the beginning of the 21st century, similar regional cooperation cases have sprung up.

The “Belt and Road” Initiative takes peace and cooperation, openness and inclusiveness, mutual learning, and mutual benefit as the core spirit, adheres to the principles of joint consultation, joint construction, and sharing, and sends invitations to all countries and international organizations around the world to jointly address global economic issues, seek new development opportunities, and achieve mutual complementarity of strengths among countries, mutual benefit, and win-win results [3–8]. Since the Belt and Road Initiative was put forward, it has attracted wide attention, and more and more countries have participated in it. By the end of January 2020, 138 countries and regions have signed cooperation documents with China to jointly build the Belt and Road. At present, domestic economic development has entered the new normal, and the downward pressure on the economy is great. Expanding foreign cooperation has become an important way to promote the rapid transformation and development of the domestic economy. China has problems such as irrational industrial structure and large regional economic development gap [9–12]. The proposal of the “Belt and Road” Initiative will help to transfer the excess capacity in the eastern coastal areas to the central and Western regions and overseas so as to optimize the industrial structure and narrow the gap between the rich and the poor.

At present, domestic and foreign scholars’ research on the trade of “the Belt and Road” is mostly from the perspective of the two countries participating in the cooperation and carries out empirical analysis on the economic and trade reciprocity brought about by the “Belt and Road” Initiative. However, this kind of analysis lacks a discussion on the overall pattern of trade among the Belt and Road cooperative countries, and there are few studies on quantitative analysis.
of the interaction of trade among the Belt and Road countries through complex network analysis (CNA). Considering the interaction among multilateral countries, this paper constructs a trade network based on the bilateral import and export trade data of the "Belt and Road," explores the attribute characteristics of the "Belt and Road" trade from the perspective of a complex network, as well as the changes in the topology of the trade network since the "Belt and Road" Initiative, and puts forward and analyzed the deep-seated reasons affecting the changes in the pattern of the "Belt and Road" trade network, which has strong theoretical significance. The Belt and Road Initiative takes into account the needs of countries along the Belt and Road in economic development and trade cooperation and is conducive to promoting economic and trade exchanges between regions and countries.

Based on the import and export trade data of countries along the Belt and Road from 2009 to 2017, this paper uses the complex network analysis method to build the "Belt and Road" trade network, discuss the overall topology of the network and important trading countries, explore the changing trend of the trade network and the division of communities, discuss the main factors affecting the trade cooperation of countries along the Belt and Road, and then put forward some suggestions on the development of China’s "the Belt and Road" cooperation, which has strong practical significance.

2. Construction of Trade Network

Nodes and edges between nodes are two essential elements for building complex networks [13]. In "the Belt and Road," trade, countries, and economies act as nodes, and trade relations act as links, forming a network structure. However, such a simple undirected, weightless network is challenging to describe the direction and scale of trade flow, and the network’s topology is abstracted too simply, which will cause much information to be ignored and be quite different from the real trade network. Generally speaking, trade activities are bidirectional, including import and export. Scholars often combine import and export data into a network to conduct research. Import and export trade have significantly different meanings for a country: import reflects the inflow of goods and the country’s demand for consumer goods, while export shows more of the country’s resource output capability and manufacturing level. This paper constructs "the Belt and Road" import and export trade network and compares and analyzes the differences between national nodes in the two networks.

As of the end of January 2020, our country has signed 200 cooperation documents on the joint construction of the "Belt and Road" with 138 governments and 30 international organizations. The trade data of various countries in this paper are selected from the United Nations Trade Database (UNComtrade Database), and the bilateral trade data of the countries cooperating with the “Belt and Road” Initiative from 2009 to 2017 are extracted [14–16]. Specifically, this paper only studies commodity trade but does not include service industries. The customs HS code (Harmonized System) of trade data selects the latest version according to the data year, and trade data consists of all commodity codes (Commodity Codes), namely, AG1–AG6. The scale of the "Belt and Road" trade data is vast, the trade volume between countries is very different, and some countries have the phenomenon of missing trade data. Taking into account these factors may have an impact on the analysis of the network topology, setting a threshold of $1 billion for trade volume. Mainly analyze the trade network composed of significant import and export member countries. These countries’ import and export trade volume accounts for 84.9% and 83.5% of the total import and export trade volume of the "Belt and Road," which is sufficiently illustrative and representative. After data preprocessing, the “Belt and Road” import trade network in 2017 included 93 nodes and 507 edges, and the export trade network had 101 nodes and 484 edges, excluding self-loops. Table 1 shows the number of nodes in the network.

We build "the Belt and Road" trade network through the adjacency matrix. In the import trade network, the trade volume of country $i$ imported from country $j$ is $m$, and we write as

$$w_{ji}^{in} = m.$$  \hspace{1cm} (1)

The export volume of country $i$ to country $j$ is $n$, denoted as

$$w_{ij}^{out} = n.$$  \hspace{1cm} (2)

Through the visualization processing of Gephi software, the "Belt and Road" import and export trade network in 2017 can be obtained.

3. Topological Structure Analysis of the Trade Network

3.1. Basic Characteristic Indicators of the Network. In complex network analysis, the degree is the most direct and important concept to describe the characteristics of nodes [17]. In an undirected network, the degree $k_i$ of node $i$ equals the number of edges directly connected to this node. For directed networks such as the "Belt and Road" trade network, we can introduce the concepts of in-degree and out-degree to expand: in-degree refers to the number of edges pointing from other nodes to this node, and out-degree refers to the number of edges from this node to other nodes. The average degree of all nodes in the network is the average degree of the network (AverageDegree) [18–20]. On average, each country in the "Belt and Road" trade network has import trade with 5 other countries and export trade with 5 other countries. In contrast, import trade is more extensive than export trade. Table 2 shows the average degree of import and export network.

From a statistical point of view, the number of all nodes with a degree of a certain value can be compared to the total number of nodes in the network as the probability of the degree value appearing. Thereby, the degree distribution of network nodes is obtained. The most common data distribution in daily life and study research is the normal
distribution (Gaussian distribution). In economics research, many data distributions are often very different from normal distributions. Such distributions do not have a single characteristic scale and are also called "scale-free" distributions.

In 2017, the "Belt and Road" import and export trade network all obeyed such high-degree nodes, which accounted for a minority. And nodes with small-degrees account for the vast majority of "long-tailed distributions" (a type of "scale-free" distribution). In the import and export networks, 57% and 60% of the nodes have degrees less than or equal to 5, respectively. This shows that, in the "Belt and Road" trade cooperation, the trade connections of most countries are still relatively limited, and the network structure is not balanced.

Another dimension to studying the total nature of the BRI trade network is the degree of correlation. The correlation of degree considers the correlation of degree attributes between each node in the network. If the correlation is positive, it means that a node with a large degree is more inclined to connect to other nodes with a large degree. Such a network is called a "homologous network"; otherwise, it is called a "heterogeneous network." The "assortativity coefficient" is an important indicator to quantify the network’s assortativity. It is defined as follows:

$$ r = \frac{1}{\sigma_q^2} \sum_{j,k} jk (e_{jk} - q_j q_k), $$

where $\sigma_q^2$ is the variance of the redundancy distribution $q_k$.

Table 1: Number of nodes in the network.

<table>
<thead>
<tr>
<th></th>
<th>Import trade network</th>
<th>Export trade network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of nodes before processing</td>
<td>145</td>
<td>145</td>
</tr>
<tr>
<td>Number of connected edges before processing</td>
<td>12133</td>
<td>10542</td>
</tr>
<tr>
<td>Number of nodes after processing</td>
<td>92</td>
<td>103</td>
</tr>
<tr>
<td>Number of corresponding edges after processing</td>
<td>509</td>
<td>488</td>
</tr>
</tbody>
</table>

Table 2: Average degree of import and export network.

<table>
<thead>
<tr>
<th></th>
<th>Import trade network</th>
<th>Export trade network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average in-degree</td>
<td>5.48</td>
<td>4.81</td>
</tr>
<tr>
<td>Average out-degree</td>
<td>5.48</td>
<td>4.81</td>
</tr>
</tbody>
</table>

Table 3: Import and export network assortativity coefficient.

<table>
<thead>
<tr>
<th></th>
<th>Import trade network</th>
<th>Export trade network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assortativity coefficient</td>
<td>−0.39</td>
<td>−0.40</td>
</tr>
</tbody>
</table>

3.2. Centrality of Network Nodes. In complex networks, the location of a node determines its importance. Various centrality indicators can analyze the location of nodes in the network from different sides and then measure the importance of nodes placed in the network. The nodal centrality indicators studied in this paper mainly include degree centrality, betweenness centrality, closeness centrality, and eigenvector centrality.

3.2.1. Degree Centrality. Degree centrality is to use the degree of a node as a criterion for measuring the importance of its location. The larger the degree, the more important the node in the network:

$$ DC_i = \frac{k_i}{N - 1} $$

Among them, $N$ is the number of nodes in the network, and $k_i$ is the degree of node $i$. Considering the influence of trade scale, the trade volume between the two countries is used as the weight of the connected edges, and for the directed weighted network, there are

$$ DC_{i}^{in} = \sum_{j=1}^{N} w_{ji}, $$

$$ DC_{i}^{out} = \sum_{j=1}^{N} w_{ij}. $$

Table 4 shows the weighted in/out-degree of import and export network. By comparing the top ten countries with weighted in-degree and weighted out-degree in 2017, it is found that our country has the most extensive connections and the most significant trade volume in the import and export trade network. South Korea and Russia ranked second and third, respectively, and other countries with large trade volumes were mainly concentrated in Southeast Asia and the Middle East.

3.2.2. Betweenness Centrality. Bridges are often the only way to connect two places. In the trade network, if the connection between node A and node B must pass through node C, then C is such a node that acts as a bridge intermediary.
Another metric based on the
3.2.3. Closeness Centrality.
trade by connecting with these countries.
respectively. Each intraregional node realizes
cross-regional
Eastern Europe, East Asia, the Middle East, and Africa,
Russia, South Korea, the United Arab Emirates, and Turkey are the core trade countries in Western Europe,
Russia, South Korea, the United Arab Emirates, South Africa, and
Turkey also play a key "trade bridge" role. In fact, Italy,
South Korea, the United Arab Emirates, South Africa, and
second. In addition to China, countries such as Italy, Russia,
abovetable that our country has played a very important role
the "Belt and Road" trade in 2017. It can be seen from the
import and export trade
impact on the trade network.
excluding these countries will also have a more significant
have a more vital ability to influence trade activities, and
cooperation, countries with higher betweenness centrality
shortest path between nodes is closeness centrality. If be-

each node in the network. It shows that these countries are
not only trade bridges but also trade centers of various
regions. The comparison of import and export networks
shows that the imported network is closer, the connectivity
between nodes is more robust, and its closeness centrality is
generally higher than that of the export trade network.

3.2.4. Eigenvector Centrality. The importance of a node in
the network is not only determined by the number of other
nodes it is connected to but also closely related to the signif-
ficance of these connected neighbor nodes. Imagine that
node A is connected to several "network edge" nodes, and	node B is connected to a small number of nodes with large
betweenness. Although the degree of node B may be equal to
or even smaller than that of A, the position of B in the
network is much more important than that of A because it is
also very likely to be an important "bridge" in the network.
Based on this idea, the eigenvector centrality is defined as

\[ x_i = c \sum_{j=1}^{N} a_{ij} x_j, \]

where \( C \) is a proportional constant, \( x_i \) is the important
measure of node \( i \), and \( a_{ij} \) is the network's adjacency matrix.

It can be obtained by iterative calculation:

\[ x = \lambda_1^{-1} Ax, \]

where \( \lambda_1 \) is the characteristic single root with the largest
modulus of matrix \( A \) and \( x \) is the main eigenvector corre-
sponding to \( \lambda_1 \).

Table 7 shows that the countries with high eigenvector
centrality are mainly concentrated in East Asia and
Southeast Asia. These countries are often the origin of raw
materials for industrial production and are located on the
"Belt and Road" shipping routes with convenient trans-
portation. Most of the countries that trade with them are
countries with a high degree of weight or betweenness.

Combining the above four different network centrality
indicators, it can be found that our country has a pivotal
position in the "Belt and Road" trade network. Specifically,
our country's weighted in-degree and weighted out-degree
are ranked first, and it is the largest import and export trade

<table>
<thead>
<tr>
<th>ID</th>
<th>Import trade network countries</th>
<th>Import trade network weighted in-degree</th>
<th>Export trade network countries</th>
<th>Export trade network weighted out-degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>China</td>
<td>8.74E+11</td>
<td>China</td>
<td>8.26E+11</td>
</tr>
<tr>
<td>2</td>
<td>South Korea</td>
<td>3.32E+11</td>
<td>South Korea</td>
<td>2.99E+11</td>
</tr>
<tr>
<td>3</td>
<td>Russia</td>
<td>1.97E+11</td>
<td>Russia</td>
<td>2.09E+11</td>
</tr>
<tr>
<td>4</td>
<td>Italy</td>
<td>1.66E+11</td>
<td>Singapore</td>
<td>1.98E+11</td>
</tr>
<tr>
<td>5</td>
<td>Malaysia</td>
<td>1.34E+11</td>
<td>Italy</td>
<td>1.62E+11</td>
</tr>
<tr>
<td>6</td>
<td>Thailand</td>
<td>1.13E+11</td>
<td>Malaysia</td>
<td>1.07E+11</td>
</tr>
<tr>
<td>7</td>
<td>Vietnam</td>
<td>1.09E+11</td>
<td>Vietnam</td>
<td>8.62E+10</td>
</tr>
<tr>
<td>8</td>
<td>Singapore</td>
<td>1.08E+11</td>
<td>United Arab Emirates</td>
<td>8.58E+10</td>
</tr>
<tr>
<td>9</td>
<td>Saudi Arabia</td>
<td>1.08E+11</td>
<td>Indonesia</td>
<td>8.18E+10</td>
</tr>
<tr>
<td>10</td>
<td>United Arab Emirates</td>
<td>8.81E+10</td>
<td>Poland</td>
<td>7.01E+10</td>
</tr>
</tbody>
</table>

The topological index that measures this characteristic of
a node is called betweenness centrality, which is specifically
defined as

\[ BC_m = \sum_{s \neq m \neq t} \frac{n^m_{st}}{n_{st}} \]

where \( g_m \) is the number of shortest paths from node \( s \) to
node \( t \) and \( n^m_{st} \) is the number of shortest paths from node \( s \) to
node \( t \) through node \( m \).

From the perspective of the ability to control trade
cooperation, countries with higher betweenness centrality
have a more vital ability to influence trade activities, and
excluding these countries will also have a more significant
impact on the trade network.

Table 5 shows the betweenness centrality of countries in
the "Belt and Road" trade in 2017. It can be seen from the
above table that our country has played a very important role
in connecting the "Belt and Road" import and export trade
network. Betweenness centrality is nearly twice as high as the
second. In addition to China, countries such as Italy, Russia,
South Korea, the United Arab Emirates, South Africa, and
Turkey also play a key "trade bridge" role. In fact, Italy,
Russia, South Korea, the United Arab Emirates, and South
Africa are the core trade countries in Western Europe,
Eastern Europe, East Asia, the Middle East, and Africa,
respectively. Each intraregional node realizes cross-regional
trade by connecting with these countries.

3.2.3. Closeness Centrality. Another metric based on the
shortest path between nodes is closeness centrality. If be-
tweenness measures a country's ability to control a trade
network, closeness quantifies the centrality of the country's
topological position in the network. Closeness centrality is
the average length of the shortest path from each node to
other nodes. For a node, the closer it is to other nodes in the
network, the higher the closeness centrality is:

\[ CC_i = \frac{1}{d_i} = \frac{1}{\sum_{j=1}^{N} d_{ij}} \]

Table 6 shows the closeness centrality of countries in the
"Belt and Road" trade in 2017. Similar to betweenness
centrality, the closeness centrality of China, Italy, Russia,
country. Our country’s closeness centrality is the highest, which means that our country is at the center of the trade network. At the same time, our country also plays a powerful bridge intermediary role, strengthening economic and trade exchanges between regions.

3.3. Small-World Network Features. “Small-world network” is a representative class of complex networks. In such a network, many nodes are not directly connected but can be reached from any other node in the network via a small number of countable paths. The topological metrics that best describe this property are “average path length” and “clustering coefficient.” The path in the network that connects the fewest edges between two nodes is the shortest between two points. The average path length is defined as the average of the geodesic distance between any two points in the network:

\[ L = \frac{\sum_{s \neq t \in V} d(s, t)}{n(n-1)} \]  

where \( V \) is the set of nodes in the network, \( d(s, t) \) is the shortest distance from \( s \) to \( t \), and \( n \) is the number of nodes in the network.

The average path length reflects the closeness between nodes in the network, while the clustering coefficient reflects the “structure” of the network. It depicts the probability that nodes B and C connected to node A are also connected. \( E_i \) is the number of edges between all adjacent nodes of node \( i \).

\[ C_i = \frac{E_i}{(k_i(k_i - 1))/2} = \frac{2E_i}{k_i(k_i - 1)} \]  

(11)

The small-world network is a “transition type” between the fully regular nearest neighbor network and the random ER random network. The nodes in the former network have high clustering and long average distance, while the latter is the opposite. Small-world networks can be generated by adding randomness to the regular network. The small-world characteristics of the network can be measured using the Sigma parameter and the Omega parameter, which are defined as follows:

\[ \text{Sigma} = \frac{C}{C_r} = \frac{L}{L_r} \]  

(12)

where \( C \) and \( L \) are the average clustering coefficient and average shortest path length of the network, respectively. \( C_r \) and \( L_r \) are the average clustering coefficient and shortest path length of the equivalent random graph. If Sigma > 1, the network is generally considered to have small-world properties.

The small-world coefficient (Omega) is between −1 and 1. The value close to 0 represents that the network has small-world features. The value close to −1 represents that the network is a lattice shape, and the value close to 1 represents that the network is a random graph by calculating the Sigma, Omega coefficients, and related indicators of the “Belt and Road” trade network in 2017 as shown in Table 8.

The Sigma coefficients of the “Belt and Road” import and export trade network are all greater than 1, and the Omega
coefficient is close to 0. It shows that these two trade networks align with the characteristics of the small-world network. The Omega coefficients of the import and export trade network are all less than zero, and they tend to be random networks. The average path length of the export trade network is shorter. It shows that the export trade between countries along the “Belt and Road” is closer.

According to the phenomenon of “small-world” and trade networks, a trade network with the characteristics of “small-world” has unique advantages in terms of transaction efficiency. Because of its robust network connectivity, it can realize the overall situation Pareto Improvement of Networks.

4. Evolution of Node Importance

The previous section discussed the importance of nodes in the “Belt and Road” trade network in 2017 from different dimensions by analyzing various node centrality indicators. To study the changes in node attributes in the import and export trade network in the past nine years, the author first uses the PageRank algorithm to extract the top ten important nodes in the trade network in 2017 and then discusses the degree centrality, betweenness centrality, and closeness centrality of these core countries.

4.1. Network Core Node Selection. The PageRank algorithm [21–23] is a well-known key technology for web page ranking. It gave birth to the emergence and development of the Google search engine. The algorithm’s starting point is that a node’s importance depends on the number and quality of nodes pointing to it.

From this point of view, the PageRank algorithm can be regarded as a generalization of eigenvector centrality on directed graphs. The PageRank algorithm is divided into three steps. The initial step will equally divide the total PR value among all nodes, and then

$$\sum_{i=1}^{N} PR_i(0) = 1.$$  (14)

In the second step, the PR value of each node in step \(K - 1\) is equally divided by the nodes it points to, and the new PR value of each node is the sum of the PR values it has obtained. The third step is to reduce the scale factor \(s\) to keep the total PR value of the network at 1, and then

$$PR_i(k) = s \sum_{j=1}^{N} a_{ij} PR_j(k - 1) + (1 - s) \frac{1}{N}.$$  (15)

Through calculation, the top ten core node countries with the average PageRank score of the “Belt and Road” import and export trade network in the past nine years are extracted, as shown in Tables 9 and 10.

The top ten countries in the PageRank score of the “Belt and Road” import trade network include China, South Korea, Russia, Italy, Saudi Arabia, Malaysia, the United Arab Emirates, Singapore, Thailand, and Indonesia. Among them, our country has always maintained first place in PR worth and is much higher than second South Korea. In the past 9 years, the fluctuation of our country’s PR value has been slight, and the overall trend has maintained an upward trend, indicating that our country’s position in the “Belt and Road” import trade network is improving. Except for Saudi Arabia and the United Arab Emirates, two Middle Eastern countries, two European countries, Italy and Russia, and other core countries are mainly located in Southeast Asia, which shows that the import trade of the “Maritime Silk Road” is more active.
The top ten countries in the PageRank score of the "Belt and Road" export trade network include China, Italy, Russia, South Korea, Singapore, the United Arab Emirates, Turkey, Malaysia, Poland, and Saudi Arabia. Comparing the two networks, our country's advantages in export trade are not as obvious as those in import networks. It shows that our country still has development potential in export trade, and the other node members in the two networks have not changed much.

Through screening the core nodes of PageRank, the countries in the "Belt and Road" trade network can be divided into import, export, and two-way trade, as shown in Table 11. Among them, import-oriented countries are represented by Thailand and Indonesia, and Poland and Turkey represent export-oriented countries. China, Italy, Russia, South Korea, Singapore, and the United Arab Emirates are all at the core of the import and export network and are two-way trade countries.

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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>0.2001</td>
<td>0.2079</td>
<td>0.1981</td>
<td>0.2019</td>
<td>0.2101</td>
<td>0.2199</td>
<td>0.2471</td>
<td>0.2329</td>
<td>0.2371</td>
</tr>
<tr>
<td>South Korea</td>
<td>0.0738</td>
<td>0.0763</td>
<td>0.0708</td>
<td>0.0653</td>
<td>0.0738</td>
<td>0.0733</td>
<td>0.0788</td>
<td>0.0873</td>
<td>0.0728</td>
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<td>0.0542</td>
<td>0.0563</td>
<td>0.0562</td>
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<td>0.0469</td>
<td>0.0471</td>
<td>0.0499</td>
<td>0.0511</td>
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<td>0.0408</td>
<td>0.0403</td>
<td>0.0408</td>
<td>0.0383</td>
<td>0.0318</td>
<td>0.0293</td>
<td>0.0268</td>
</tr>
<tr>
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<td>0.0392</td>
<td>0.0343</td>
<td>0.0312</td>
<td>0.0303</td>
<td>0.0282</td>
<td>0.0333</td>
<td>0.0352</td>
<td>0.0283</td>
</tr>
<tr>
<td>United Arab Emirates</td>
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<td>0.0399</td>
<td>0.0391</td>
<td>0.0329</td>
<td>0.0411</td>
<td>0.0369</td>
<td>0.0261</td>
<td>0.0279</td>
<td>0.0281</td>
</tr>
<tr>
<td>Singapore</td>
<td>0.0368</td>
<td>0.0373</td>
<td>0.0318</td>
<td>0.0353</td>
<td>0.0298</td>
<td>0.0303</td>
<td>0.0318</td>
<td>0.0303</td>
<td>0.0258</td>
</tr>
<tr>
<td>Thailand</td>
<td>0.0293</td>
<td>0.0332</td>
<td>0.0303</td>
<td>0.0272</td>
<td>0.0273</td>
<td>0.0262</td>
<td>0.0323</td>
<td>0.0362</td>
<td>0.0273</td>
</tr>
<tr>
<td>Indonesia</td>
<td>0.0241</td>
<td>0.0249</td>
<td>0.0251</td>
<td>0.0219</td>
<td>0.0211</td>
<td>0.0189</td>
<td>0.0221</td>
<td>0.0229</td>
<td>0.0211</td>
</tr>
</tbody>
</table>

The top ten countries in the PageRank score of the "Belt and Road" export trade network include China, Italy, Russia, South Korea, Singapore, the United Arab Emirates, Turkey, Malaysia, Poland, and Saudi Arabia. Comparing the two networks, our country's advantages in export trade are not as obvious as those in import networks. It shows that our country still has development potential in export trade, and the other node members in the two networks have not changed much.

Through screening the core nodes of PageRank, the countries in the "Belt and Road" trade network can be divided into import, export, and two-way trade, as shown in Table 11. Among them, import-oriented countries are represented by Thailand and Indonesia, and Poland and Turkey represent export-oriented countries. China, Italy, Russia, South Korea, Singapore, and the United Arab Emirates are all at the core of the import and export network and are two-way trade countries.

4.2. Changes in the Degree Centrality of Core Nodes. For the above representative important nodes, combined with the analysis methods of nodal degree centrality, betweenness centrality, and closeness centrality in the previous chapter, we further study the changes in the topological structure of the import and export trade network in 9 years.

According to the degree centrality, both networks can be divided into three echelons. Our country is in the first echelon, Italy, Russia, and South Korea are in the second echelon, and other core node countries form the third echelon. Overall, the degree centrality of the two network core nodes fluctuated relatively minor, and there was no obvious improvement around 2014. Except for China, the in-degree value of the imported network and the out-degree value of the export network are concentrated between 0.1 and 0.4. Our country's inbound and outbound centrality is ahead of other countries and maintains a steady growth trend. Compared with import trade, more countries have trade connections with our country in the export network, reaching 80. It accounts for 79% of the total number of exporting countries in the "Belt and Road."

In the import trade network, Italy, Russia, and South Korea are ranked after our country. Italy and South Korea have very similar in-degree curves, with fewer import partners in 2011 and 2012. In addition, affected by the sharp drop in international crude oil futures prices and Western economic sanctions, the financial crisis in Russia in 2014 and 2015 caused its import and export trade to enter an "ice period." The remaining core nodes are Southeast Asian countries, and their trade connections are mainly distributed along the "Maritime Silk Road." The Italian economy was affected by the European debt crisis in the export trade network. Before 2013, the export trade volume was less than 1 billion US dollars. It then increased in 2014 and remained around 0.4. South Korea, which ranks second in the centrality of out-degree, has been very active in export trade in recent years, and the average out-degree has increased by 25% compared with the average in-degree. In 2017, 33 countries became their export trading partners. In contrast, Russia's import and export trade is more balanced, including 25 partner countries.

4.3. Changes in Betweenness Centrality of Core Nodes. Compared with degree centrality, the betweenness variation of the two networks fluctuates greatly, and there is no
obvious echelon division. Same as the degree centrality, in the two networks, our country’s betweenness also ranks first, and the import betweenness is generally higher than the export betweenness, indicating that our country’s role as a bridge in import trade is more prominent. In 2012 and 2015, due to the strengthening of import trade with Belarus, Sudan, Romania, Nigeria, and other countries, our country’s betweenness showed a stepwise increase. Affected by the financial crisis, our country’s export betweenness dropped from 0.31 in 2009 to 0.17 in 2011 and then remained relatively stable at around 0.2.

In the import trade network, in addition to China, the betweenness of Russia, the United Arab Emirates, and Indonesia also increased significantly in 2012. Among them, Russia and Indonesia have strengthened their import cooperation with the United Arab Emirates, Ecuador, and other Middle East and South American countries. But the increase in the betweenness of the UAE is due to the significant reduction in the import trade between Turkey, which has a strong trade connection, and the large betweenness countries such as Singapore and South Africa. On the other hand, it is due to the increase in the import trade volume between the UAE and regional representative node countries such as South Africa and Indonesia. In the export trade network, the value of Italian exports to Ukraine and South Africa nearly tripled. So, from 2014 to 2016, its export betweenness increased rapidly. However, Austria, Latvia, Slovenia, and other European countries reduced their export trade to South Korea, Russia, and the United Arab Emirates; the three countries’ exports declined between 2013 and 2015.

4.4. Discussions. Through the above two centrality analyses on the core nodes of the “Belt and Road” import and export network, it was found that the proposal of the “Belt and Road” Initiative has a more significant impact on the export network than the imported network. The specific performance is that, after 2013, the export trade links between regions along the “Belt and Road” have become very close, and the overall export network has shown a trend of “decentralized” coordinated development. Affected by the external macroeconomic environment, the betweenness centrality of countries in the past nine years has been relatively sensitive and fluctuated wildly. As the only country in the EU that has signed a memorandum of understanding, Italy’s influence on the trade network is gradually increasing. The UAE does not have the most significant number of trade connections in the import and export network. Still, its betweenness centrality is prominent, which shows that the UAE has a powerful ability to control trade in the Middle East. On the one hand, the top-level strategy of “the Belt and Road” has extensively promoted our country’s foreign export trade. On the other hand, as a bridge of the trade network center, our country has strengthened the trade links between regions and countries along the “Belt and Road.”

5. Conclusions

The “Belt and Road” trade network is a typical complex network. There are few pieces of authoritative literature at home and abroad that apply the complex network analysis method to the “Belt and Road” trade. This study has some innovations in terms of angle and method. This paper studies the trade networks of countries along the “Belt and Road” from the perspective of complex networks. This perspective is different from the model of taking a single country as the research object in most “the Belt and Road” trade studies but comprehensively analyzes the multilateral trade relations of countries along the “Belt and Road” and desalinates the impact of countries’ own attribute differences on trade characteristics.

This research has certain characteristics of theoretical research and practical guidance. The theoretical characteristics are as follows. Although the practice of applying complex network technology to the research of international trade networks has been adopted by some scholars, most of the current research and analysis dimensions related to trade networks are one-sided. For example, only the topological structure of the network is analyzed and elaborated, and the influence factors of time and trade networks are not considered. In addition, through the application of analysis software, the network can be visually presented, which is more intuitive and convenient for further understanding and analysis. On the other hand, the research ideas and methods of this paper can also be extended to the trade network research of other regional or economic organizations, such as APEC, WTO, and G20, which provides a certain theoretical and methodological reference for subsequent related research. The characteristics of practice guidance are as follows: the research scope of this paper is the “Belt and Road” trade network. The node is composed of 138 cooperative countries. Compared with other global trade networks, it is more specific and focuses on the regional economy. The research results provide a theoretical basis and policy suggestions for guiding China to cope with the changes in the “Belt and Road” trade network.

Data Availability

The dataset can be accessed upon request.

Conflicts of Interest

The author declares no conflicts of interest.
References


