Spatial Network Structure of Global Logistics Service Trade

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Keywords: Spatial Network Structure, Social Network Analysis, QAP, Distance.

Abstract: Research purpose: Logistics service trade is an important part of international service trade, but the spatial network structure of logistics service trade and its influencing factors is not clear. Research methods: This paper uses the WIOD world input-output table, constructs a world logistics service trade matrix, establishes relational data, and uses social network analysis to characterize. On this basis, it uses QAP regression methods to study the factors affecting trade in logistics services. Study found: The logistics service trade network has a small-world network effect. The overall cyberspace structure of global logistics service trade is getting closer and closer. Developed countries are at the core. China's status in developing countries is gradually rising. The network density of the global logistics service trade network shows an upward trend, but the change of the network is a gradual process. The control of each country in the global logistics service trade network is declining. Economic distance, geographical distance, proximity and trade distance have significant effects on global logistics service trade.

1 INTRODUCTION

This paper attempts to analyse the spatial network structure of global in logistics services trade and its influencing factors. The development of the logistics industry has significantly reduced the cost of international trade, increased the efficiency of global trade, reduced the impact of geographical distance on global trade, and connected the various links of the global value chain. It can effectively facilitate the full integration of goods, technology, knowledge and services across borders. Developed countries not only occupy the middle and high end of global R&D and design value chains, but also dominate in logistics services. The World Bank report "Connecting to Compete: Trade Logistics in the Global Economy 2018" shows that developed economies continue to lead in global trade logistics and that most countries in the world are actively developing innovative logistics services. Logistics services are not only an important component of global trade, but also an important part of international trade and a highly profitable link in the global value chain. Therefore, logistics services trade plays an important role in international trade in services and is a further focus of international trade in services.

Compared to other productive services, logistics services trade is more widespread, extensive and intimate. The links are no longer mere geo-adjacencies, but rather a multi-threaded and complex network structure. The spatial network structure of logistics services trade provides a better measure of the position and evolution of logistics services in global trade across countries. Spatial network structure characteristics can reflect the comparative advantage of countries in logistics services trade. Most studies have focused on producer services trade. Few studies have been conducted on the sub-sectors of logistics services trade. There are no systematic answers to the characteristics of the vertically linked network structure of logistics services trade and the factors influencing it. Logistics services trade is very different from other productive service industries. Using typical studies of other productive service trades is not conducive to an accurate understanding of the changing characteristics of logistics services trade and its influencing factors. The article uses the world input-output tables provided by the WIOD database to construct a logistics service trade matrix and uses social network analysis to describe the characteristics of the spatial network structure of logistics service trade. To solve the problem that traditional statistical methods cannot quantitatively

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study "relational" data, the QAP regression analysis method is used to study the influencing factors of the vertical network structure of logistics service trade.

2 LITERATURE REVIEW

Logistics services exist in the production, marketing, consumption and recycling of global value chains (Bai, 2010). Logistics services are an important component of the global value chain, connecting all aspects of the value chain. Logistics service providers are required in the global value chain to provide services beyond "basic" production (Bair, 2005). Microscopically, leading companies in the global value chain can outsource non-core services such as logistics services to focus on their core competencies, optimize their internal value chains and industry chains, and thereby enhance their competitiveness (Memedovic, Ojala, Rodrigue, et al, 2008). Macroscopically, fierce competition has reduced corporate profit margins. Logistics services are the result of an effective division of labor in the value chain, which contributes to the rationalization of industrial division of labor and industrial structure, and improves the production efficiency of complex production networks in global value chains, which in turn can enhance the overall economy. Innovation and competitiveness (Rodrigue, 2010). Research in the apparel industry shows that the development of logistics and supply chain management helps to the development of the apparel industry in the global value chain (Cammett, 2013). The above research has shown that logistics services are the result of the international division of labor and an important subsystem of the global value chain, connecting all aspects of the global value chain. Logistics services can improve the core competitiveness of enterprises in the global value chain on a micro level. They can enhance the innovation and competitiveness of the economy on a macro level, promote the progress of global value chains, and form a complex global value chain production network.

How to measure the logistics service network with the appropriate method is an issue we must solve. Previous studies have concentrated on micro-enterprise logistics operations networks or product distribution networks (MD, Haijema, Bloemhof, et al, 2015). Less discussion of logistics service trade networks from a global perspective. Moreover, existing research mainly adopts geography methods, ESDA spatial analysis techniques or regression analysis methods. These methods form the basis for quantitative research on this issue. However, traditional statistical methods mainly deal with "attribute" data, and cannot process data with obvious "relationship" characteristics. Therefore, existing research lacks quantitative research on the spatial network structure and evolution of logistics service trade, especially the lack of quantification of the space network from the network "relationships".

Social network analysis is just an effective method to study "relationship" data. It has been implemented in logistics network research and provides new methods and ideas for researching logistics networks. The first use of social network analysis methods to study logistics networks, and believe that the various nodes of logistics trade and transportation can be continuously optimized in the network (Phillips, Phillips, 1998). Social network analysis has changed the way of relying on surveys in the field of logistics and supply chain management. In particular, it can study the model of binary relationship in logistics and supply chain, and catch up with the lack of attention to traditional research methods relationship" (Carter, Ellram, Tate, 2010).

Therefore, based on the relationship data and network perspective, using the logistics service export data of 43 major economies (including China Taiwan) provided by WIOD in 2000-2014, the logistics service trade matrix is constructed, and its spatial network structure is analyzed by means of social network analysis. And the influencing factors were studied. This study reflects the overall characteristics and evolution of the spatial network of logistics service trade by measuring network density and the overall network structure. Through central analysis, the status and role of each economy in the spatial network of logistics service trade are examined. Finally, QAP regression analysis is utilized to study study the impact of economic distance, geographical distance, proximity and trade distance on the spatial network of logistics service trade.

3 RESEARCH METHODS AND DATA

3.1 Model Building

The logistics input service network model is constructed by using the world input-output table provided by the WIOD database. According to the gravity model, the two basic factors affecting international trade are economic size and geographical distance. The efficient scale is positively related to international trade and has a negative correlation with geographical distance. Therefore, the factors affecting logistics service trade choose GDP, geographical distance, and proximity as variables. Considering the demand for logistics services, influenced by the scale of global trade, the value added of trade is added as a variable to the model. The model is built as following:

$$Logtra=f(GDP, Dist, Contig, VAX) \quad (1)$$

In equation (1), Logtra represents the logistics service trade matrix. GDP represents economic distance. Dist represents geographical distance. Contig represents proximity. VAX represents trade distance.

3.2 Variable Selection and Meaning

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Logtra means logistics service trade. The WIOD database provides a world input-output table built by the world's major economies, using public data from the logistics industry code H49-H53 to merge, and 43 countries (or regions) as nodes (remove ROW data). Logistics service trade matrix. Because the determinants of the international competitiveness of the production services sector is mainly intermediate needs and technical levels (Carter, Ellram, Tate, 2010). The logistics service trade matrix constructed is a power matrix. According to the social network analysis, the UCINET6.212 software is used to convert the appropriate matrix into a weightless binary matrix.

GDP means Economic distance. Economic distance is characterized by GDP differences. Select the GDP data of each country provided by the IMF to construct a GDP difference matrix. With each country as a node, the GDP difference matrix is constructed by subtracting the GDP of other countries of the GDP of one country. That is, the GDP of country i is subtracted from the GDP of country j, which is 0 on the diagonal. The calculation method is presented in Equation 2.

$$GDP_{ij}=GDP_i-GDP_j \quad (2)$$

GDP means Geographic distance. A geographic distance matrix is constructed by selecting geographic distance data between capitals of various countries in the CEPII database. The geographical distance is the farther, the higher the cost and risk of providing logistics services between the two countries, and the less likely it is to trade logistics services.

Contig means Proximity relationship. Considering the neighbor relationship on land between countries, the neighbor relationship matrix is constructed. "0" indicates that there is no adjacent relationship between the two countries on the land, and"1” indicates that the two countries have adjacent relations on land. If the two countries have adjacent relations on land, it is more convenient to trade logistics services, especially between landlocked countries and neighboring coastal countries (Evangelista, 2000).

VAX means Trade distance. The value-added export matrix produced in the final stage of the WIOD database builds a trade distance matrix. The value-added exports produced in the final stage reflect the mutual production and value added of trade between the two countries, which better reflects the trade gap between the two countries, especially the trade level between the two countries. With each country as a node, the VAX of one country is subtracted from the VAX of other countries to construct a trade distance matrix. That is, the VAX of the country i is subtracted from the VAX of the country j, and the diagonal is 0. The calculation method is shown in Equation 3.

$$VAX_{ij}=VAX_i-VAX_j \quad (3)$$

According to the international trade gravity model, the relationship between logistics service trade and explanatory variables is expected as follows:

Expectation1: The economic distance is in line with the symbol of the international logistics service trade matrix.

Expectation2: The geographical distance and the symbol of the international logistics service trade matrix are negative.

Expectation3: The symbol of the proximity relationship and the international logistics service trade matrix is positive.

Expectation4: The trade distance and the symbol of the international logistics service trade matrix are positive.

3.3 Data Sources

Logistics service trade data comes from the WIOD database. National GDP data comes from the World Monetary Fund (where Taiwan data comes from Taiwan's monthly statistical report). Geographic distance and proximity data are derived from the CEPII database. The added value export data for the final stage production is derived from the WIOD database. The data sources and descriptions are shown in Table I.

Table 1: Data source description.

Variable symbol	Variable meaning	Data source
Logtra	International Logistics Services Trade	http://www.wiod.org
Dist	Geographical distance	http://www.cepii.fr
Contig	Proximity	http://www.cepii.fr
GDP	Economic distance	http://data.un.org/IMF
VAX	Trading Distance	http://www.wiod.org

4 INTERNATIONAL LOGISTICS SERVICE TRADE NETWORK ANALYSIS

4.1 Small World Characteristic

Logistics service trade efficiency has increased. Cooperation has become closer and closer, and geographical distance has been narrowed. The length of the feature path reflects the efficiency of information transfer for each node in the network. The larger the value, the lower the efficiency; otherwise, the higher the efficiency. Table 2 shows that the length of the characteristic pathway decreased from 1.317 in 2000 to 1.122 in 2014. The characteristic path length is much smaller than the network size of 43 and is also significantly lower than the 6 steps mentioned in six-degree separation inference (Milgram's,1967). Explain that the logistics service trade network has obvious characteristics of small world networks. Moreover, the length of the feature route is declining from 2000 to 2014, indicating that the logistics service trade has a phenomenon of bridging and bridging. The characteristics of the group show that the cooperation between countries in the world is getting closer and closer, and mutual trust is getting higher and higher. Bridging shows that the geographical distances of countries around the world are getting closer, and countries are more likely to get logistics services from other countries.

Table 2: Average Shortest Path and Aggregation Coefficient Table.

Variable	2000	2005	2010	2014
Average Shortest Path	1.317	1.171	1.127	1.122
Aggregation Coefficient	0.825	0.877	0.900	0.903

Logistics service trade is highly aggregated. The clustering coefficient indicates the case where the points of the network are connected to each other. The value of the set class coefficient is [0, 1]. When the set class coefficient is 1, it means that there is a connection between any two points in the network. When the set class coefficient is 0, it means that the network does not. There are cases where three points are completely connected to each other. Table 2 shows that the clustering coefficient of logistics service trade increased from 0.825 to 0.903 in 2014 from 2000 to 2014, and the clustering coefficient is getting closer to 1. It shows that the logistics service trade network is highly concentrated, and the number of sides is also very large. This means that in the world, goods can be reached in a short path from one country to another. It proves that logistics service trade has obvious Small World Characteristic characteristics.

4.2 Overall Spatial Network Structure

Netdraw, a visualization tool of UCINET6.212 software, is used to map the logistics service trade network. Due to space limitations, only the logistics service trade network structure maps for 2000 and 2014 are given. According to the network structure chart, the following conclusions can be brought: (1)

The logistics service trade space network has obvious structure and strict space, and all countries can carry out logistics service trade with other countries. There is a link between countries, indicating the existence of logistics services trade between the two countries. The size of the network node is precisely proportional to the centrality of a country's trade network. The larger the node, the higher the centrality of the country's logistics service trade network. (2) The relationship between countries is closer. Observing the graph, it can be seen that 2014 was more dense than the 2000 network. Explain that the relationship between countries in the network is closer with time. (3) Developed countries are still at the core of the network. Developed countries such as the United States, the Netherlands, France, Germany, Denmark, the United Kingdom, and Spain are mostly at the core of the network. (4) China gradually approaches the center from the edge in the network. In 2014, China's position in the network was closer to the network center than countries such as Japan, South Korea and Canada, indicating that China's position in the network is gradually rising.

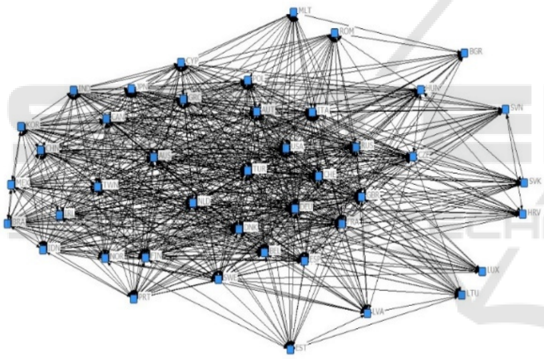

Figure 1: Structure of the international logistics service trade network in 2000.

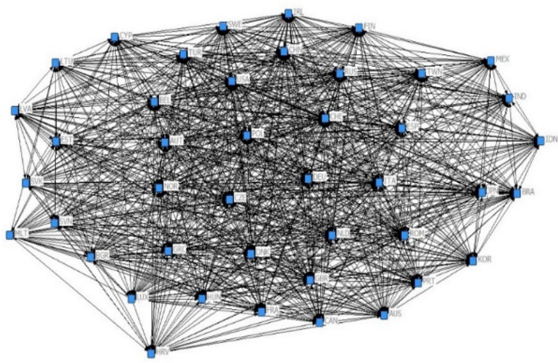

Figure 2: Structure of the international logistics service trade network in 2014.

4.3 Overall Spatial Network Structure

The logistics links between countries are getting closer and closer and showing a steady growth trend. Social network analysis uses density to measure the ratio of the total number of relationships actually present in a network to the total number of possible theoretical relationships. Network density can be used to assess the tightness of connections between nodes in a network. According to Table III, it can be observed that the density of logistics service trade network increased from 0.6827 in 2000 to 0.8776 in 2014, and there was no obvious sudden drop or upward trend. It shows that the network density of logistics service trade network shows an overall upward trend, reflecting the increasingly precise logistics trade between countries. It also demonstrates that the logistics service trade between countries has shown a steady growth state, and the relationship is getting closer and closer.

Table 3: Global Logistics Service Trade Network Density Table 2000-2014.

Year	2000	2005	2010	2014
Density	0.6827	0.8295	0.8726	0.8776

5 QAP REGRESSION RESULTS AND ANALYSIS

Using the constructed model, QAP regression analysis was carried out on the spatial network matrix of logistics service trade and the matrix of various influencing factors from 2000 to 2014, and the number of random replacements was selected 10,000 time. The observation value 1806 means that the composition between 43 countries or regions is a matrix of 43 × 43, and the observation value is 1,806 except for the diagonal. Table IV reports the regression results. The adjusted R2 in 15 years is between 0.488 and 0.556, and the significance probability value is 0.000, indicating that the difference in economic distance, geographical distance, proximity and trade distance can account for this logistics service trade. Spatial network changes from 48.8% to 55.6%.

First of all, the economic distance has a significant effect on the logistics service trade network, and the symbol is positive. The logistics services trade network has passed at least a 10% significant test in all years except 2003. It is shown that the size of the economy can significantly affect the relevance of logistics service trade. The smaller the economic distance, the higher the possibility of logistics services trade, the higher the correlation between logistics service trade between the two countries. That is to say. The logistics service trade between countries is more likely to occur between countries with similar economic development levels. This conclusion is in line with the gravity model. The closer the economic distance is, the more frequent the logistics service trade between countries and the stronger the network relationship.

Secondly, geographical distance has a significant effect on the logistics service trade network, and the symbol is negative. The logistics service trade network did not pass the significance test before 2006, but passed the significance test of at least 10% in the years after 2006. The significance of recent years has increased substantially, and all symbols are negative. It shows that geographical distance has a significant impact on logistics services trade between countries, i.e. the greater the geographical distance between countries, the less likely it is that logistics services trade will take place. This phenomenon is consistent with the relationship between the median distance of gravity model and trade. This is explained by the fact that the farther away the two countries are, the higher the cost of logistics service trade will be, and the probability of risk increases. It is more inclined to choose countries with closer distances as trading partners of logistics services. The less the geographical distance, less international logistics services trade, and the weaker the network relationship.

Thirdly, the proximity relationship has a significant impact on the logistics service trade, and the symbol is positive. Except for 2000, the proximity relationship between the two countries has passed at least 10% significance test, and the symbols are positive. Explain that proximity can promote the trade of logistics services between countries. The main reason is that logistics service trade between neighboring countries can make up for the lack of logistics capacity between countries to meet the needs of import and export. It is more reasonable to choose logistics services from neighboring countries, which can effectively reduce the cost and risk of logistics service trade between countries. More international logistics services trade between countries with neighboring relationships, the stronger the network relationship.

Finally, trade distance significantly affects the logistics service trade network, and the symbol is positive. The trade distance between countries has a 1% significant test on the impact of logistics services trade, and the symbols are all conclusive. It shows that the greater the trade distance between countries, the more likely the countries are to trade logistics services. This conclusion is consistent with international trade theory. Because logistics services are the cause of demand, when goods trade between the two countries generates demand for logistics services, the more frequent the trade of goods between countries, the larger the scale, the greater the demand for logistics services. Moreover, it is more likely to be consistent with the flow of goods to trade, that is to say, when a country exports goods, it may also bring export of logistics services. The trade distance is farther, the less logistics services trade between countries and the weaker the network relationship.

Table 4: Global Logistics Service Trade Weighted Network Qap Regression Results.

Year	2000	2014
GDP	0.051**	0.083**
Dist	-0.002	-0.046*
Contig	0.006	0.066 ***
VAX	0.742 ***	0.675 ***
R^2	0.556	0.488
Adj R^2	0.555	0.488
Probability	0.000	0.000
Number of observation	1806	1806
Number of permutations	10000	10000

6 CONCLUSIONS

As a downstream link of the global value chain, logistics services are increasingly valued by various countries. Developed countries not only occupy the upstream links of global value chains, but also occupy the dominant position of logistics services in global trade. Utilizing the world input-output table provided by WIOD database, constructing logistics service trade matrix, using UCINET to study the spatial network structure and evolution of logistics service trade, and using QAP analysis to study the influencing factors of logistics service trade, the following conclusions are obtained:

First, the logistics service trade network has a small world network effect. The length of the characteristic route of logistics service trade has been decreasing year by year, and the logistics service trade between countries is increasing. The clustering coefficient is getting bigger and bigger, and the logistics service relationship between countries is getting closer and closer.

Second, the overall cyberspace structure of logistics service trade is getting closer and closer, the developed countries are right on the core, and the status of China in developing countries is gradually rising. In 2014, the logistics service trade network was more dense than the 2000 network, indicating that the relationship between countries in the logistics service trade network is closer. Developed countries remain at the core of logistics service trade. China is moved from the edge to the center in the logistics service trade network, and its position in the logistics service trade network has gradually increased.

Third, the network density of the logistics service trade network is on the rise, but the change of the network is a gradual process. Since 2000, the network density of the logistics service trade network has generally shown an upward trend, and the trade links between countries in the network have become more and more close.

Fourth, economic distance, geographical distance, proximity and trade distance have a significant effect on logistics service trade. The economic distance has a significant effect on the logistics service trade network. The closer the economic distance is, the more noticeable the interaction of the logistics service trade and the stronger the network relationship. Geographical distance has a negative effect on the logistics service trade network. The farther the geographical distance is, the weaker the worldwide logistics service trade network relationship. Neighboring relations have a significant influence on logistics service trade. The more frequent worldwide logistics service trade between countries with neighboring relationships, the stronger the network relationship. The trade distance substantially affects the logistics service trade network. The closer the trade distance is, the more frequent the logistics service trade and the stronger the network relationship. In developing the economy and increasing exports, developing countries have gradually narrowed the gap with developed countries.

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REFERENCES

Bai X J. Research for logistics outsourcing based on value chain promotion. IEEE, 2010.

Bair, Jennifer. Global Capitalism and Commodity Chains: Looking Back, Going Forward[J]. Competition & Change,2005,9(2):153-180.

Cammett M. Development and the Changing Dynamics of Global Production: Global Value Chains and Local Clusters in Apparel Manufacturing[J]. Competition & Change,2013,10(1):23-48.

Carter C R, Ellram L M, Tate W.THE USE OF SOCIAL NETWORK ANALYSIS IN LOGISTICS RESEARCH[J]. Journal of Business Logistics, 2007, 28(1).

Evangelista, Rinaldo. Sectoral Patterns of Technological Change in Services[J]. Economics of Innovation & New Technology, 2000, 9(3): 183-222.

MD Keizer, Haijema R, Bloemhof J M, et al. Hybrid optimization and simulation to design a logistics network for distributing perishable products[J]. Computers & Industrial Engineering, 2015, 88(OCT.): 26-38.

Memedovic O, Ojala L, Rodrigue J P, et al. Fuelling the global value chains: what role for logistics capabilities?[J]. International Journal of Technological Learning Innovation &Development,2008,1(3):353-374.

Milgram S. The Small World Problem[J]. Psychology today, 1967, 2(1).

Phillips D M, Phillips J K. A social network analysis of business logistics and transportation[J]. International Journal of Physical Distribution & Logistics Management, 1998,28(5):328-348.

Rodrigue J P. Transportation and the Geographical and Functional Integration of Global Production Networks[J]. Growth & Change, 2010,37(4):510-525.