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Analysis of Topological Properties of Container Liner Network Based on Complex Network

Qiyu Mu

College of Transport and Communications, Shanghai Maritime University, Shanghai 201306, China.

201830610027@stu.shmtu.edu.cn

Abstract

This paper applies the relevant theory of weighted complex networks to shipping complex networks, Selected container shipping report for Drewry in 2018, Construct a complex network with the ship's frequency on the route as the edge weight, and the topological properties of the weighted node degree, weighted average shortest path, centrality and weighted agglomeration coefficient in the network are analyzed to verify the small world characteristics of the shipping network.

Keywords

Shipping complex networks, topological property, the small world characteristics.

1. Introduction and literature review

1.1 Introduction

In the 1990s, with the small world effect of complex networks [1] and the non-scaled[2]proposed, a wave of research on complex networks was set off. The main idea is to transform the various elements of the real system and the relationships between the elements into nodes and edges of the network, describe the relationship between the parts of the real system in the form of a network, emphasize the topological nature of the system structure, and reveal the essence of the real system. Features, complex networks provide a theoretical approach to the study of complexity science. Complex networks have attracted the interest of researchers in graph theory, computer networks, statistical physics, ecology, sociology, economics, etc., applying complex networks to network virus transmission, virtual communities, temperature changes, disaster spread, biological systems. The research work in other areas has achieved a lot of results. Although these large-scale network functional structures in the natural and social fields are not the same, they show some common features, such as small world effects, scale-free characteristics, hierarchical characteristics, etc. [3].

1.2 Literature review

Complex network theory has also attracted a large number of traffic scholars. As a complex giant system, the transportation system provides an important research tool for complex networks. It also lays a theoretical foundation for in-depth study of the dynamic process of the transportation network and various characteristics, network topology and its interaction. A large number of scholars have carried out relevant research by applying complex network statistical physics. The research on urban transportation network mainly focuses on urban road network and public transportation network.In 《Financial Contagion》, Allen and Gale use the mutual loan behavior between banks as a research object to construct a common loan network and analyze the complexity of the network by using the Social Network Analysis (SNA) in complex networks. Topological features such as relevance and systematicity [4]. Toune et al., in the article 《Comparative Study of Modern Heuristic Algorithms to

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Service Restoration in Distribution Systems》, in order to better study the topological properties of the intelligent distribution network security boundary, the simulation method is used to calculate the safety boundary calculation method of the distribution network. The topological properties and geometric shapes of the inductive safety boundary are simulated by a large number of examples, and the reasons for its formation and application significance are expounded [5].In 《Rainfall spectrum change in North China and its possible mechanism*》, Dai et al. constructed a directed weighted temperature fluctuation network, calculated the topological properties of the network's degree and degree distribution, agglomeration coefficient, and shortest path length, and found temperature fluctuations. The dynamic topological properties of the network are significantly different from the random network, similar to the chaotic network, reflecting the complexity of temperature changes[6]. 《Cointegration between oil spot and future prices of the same and different grades in the presence of structural change》 by Maslyuk et al., by constructing a complex network of futures and spot price weighted linkages, the degree distribution and average shortest of the linkage complex network The analysis of topological properties such as path, small group, weighted agglomeration coefficient and intermediate concentration found some rules of the crude oil price market [7]. In《Industrial symbiosis: Literature and taxonomy》, Chertow et al. used the theory of complex networks to demonstrate the small worlds and scaleless property of the network from the network topology, and made a robustness analysis of the network [8].In the《Scale-free topology of e-mail networks》, Ebel discovered the topology of the e-mail network and found that the network shows the distribution of scale-free links and small-world behavior observed in other social networks. The random structure is more conducive to the spread of e-mail viruses [9]. In the paper《Limiting the spread of misinformation in social networks》, Budak and Agrawal proposed a comprehensive evaluation method for the importance of complex network nodes based on multi-attribute decision-making. By calculating the proximity of each scheme to the ideal scheme, the final result is obtained. The importance of the node is comprehensively evaluated, and the method is easy to extend[10].In《Small worlds: The dynamics of networks between order and randomness》, Watts and Wu discuss the feasibility of using complex network theory to model power systems, and demonstrate the pure topology model in complex network theory from three aspects. It is difficult to accurately describe the actual characteristics of the power grid. It is pointed out that integrating the characteristics of electrical components into complex network system models and establishing real-time online vulnerability identification models is the main research direction in this field[11].In《Does the Knowledge Spillover Theory of Entrepreneur hold for regions?》, Audretsch et al. used complex network theory to analyze the essential problems of innovation clusters and their inherent regularity, construct a complex network analysis framework for innovative clusters, and clarify that innovation clusters are an advanced Innovative organization[12]. In the article《Structure of Growing Networks with Preferential Linking》, Dorogovtsev and Mendes have systematically reviewed the importance ranking methods of nodes in existing complex networks from the perspective of network structure and propagation dynamics, and summarized the importance of nodes. The latest research progress of the sorting method, and the advantages and disadvantages of different node importance ranking indicators and the applicable environment were analyzed[13].

2. Research methods and data processing

2.1 Degree of node

The degree k_i of the node v_i is defined as the number of sides to which the node is connected. Intuitively, the greater the degree of a node, the more "important" this node is in a sense. The average value of the degree k_i of all nodes v_i in the network is called the average degree of the network, and is recorded as <k>,

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$$< \mathrm{k} >= \frac{1}{N}\sum_{i=1}^{N} k_i$$

2.2 Average shortest path length

The distance d_{ij} between two nodes v_i to v_j in the network is defined as the number of sides on the shortest path connecting the two nodes. The average shortest path length L in the network is defined as the average of the distance between any two nodes

$$\mathrm{L} = \frac{2}{N(N-1)}\sum_{1\le i<j\le N} d_{ij}$$

Where: N is the number of network nodes

2.3 Centrality

Centrality reflects the relative importance of each node in the network. In network analysis, there are many methods for characterizing the centrality of a node in the graph, namely degree centrality, betweenness centrality, closeness centrality and eigenvector centrality.

2.3.1 Degree Centrality

The degree centrality of the point $C_D(v_i)$ is the degree k_i divided by the maximum possible degree N-1,

$$C_D(v_i) = k_i / (N-1) 。$$

This central definition can also be extended to the entire network.

In all networks with N nodes, it is assumed that the network $G_{optimal}$ makes the following formula reach the maximum value,

$$H = \sum_{i=1}^{N}\left[C_D(u_{\max}) - C_D(u_i)\right],$$

Where: u_i is the node of the network $G_{optimal}$; u_{max} is the node with the greatest degree centrality in the network $G_{optimal}$.

For a network G with N nodes, let v_{max} denote the node with the greatest degree of centrality, then the degree centrality C_D of the network G. defined as

$$C_D = \frac{1}{H}\sum_{i=1}^{N}\left[C_D(v_{\max}) - C_D(v_i)\right] 。$$

In fact, when a node of the graph $G_{optimal}$ is connected to all other nodes and there is no connection between other nodes, that is, when $G_{optimal}$ is a star network, the H value reaches the maximum, that is,

$$H=(N-1)[1-1/(N-1)]=N-2$$

At this point, the degree C_D of the network G can be simplified to

$$C_D = \frac{1}{N-2}\sum_{i=1}^{N}[C_D(v_{\max}) - C_D(v_i)]$$

2.3.2 Betweenness centrality

The Betweenness centrality of node vi is the normalized mediator of node vi. For an undirected network, this value is equal to the maximum possible number of nodes (N-1)(N-2)/2 in addition to node vi.

Let the mediation of node vi be Bi, then its median centrality CB(vi) can be defined as

$$C_B(v_i) = 2B_i / [(N-1)(N-2)]$$

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The above central definition can also be extended to the entire network.

Let v_{max} denote the node in network G that has the centrality of the highest node medium.

$$H = \frac{1}{N-1}\sum_{i=1}^{N}[C_B(v_{\max}) - C_B(v_i)]$$

2.3.3 Closeness centrality

Closeness is one of the basic concepts in topological space.

For an undirected connected graph, the most natural definition of the node's Closeness Centrality $Cc(v_i)$ can be expressed as

$$C_c(v_i) = \frac{(N-1)}{\sum_{\substack{j=1 \\ j\neq i}}^{N} d_{ij}}$$

That is, the proximity indicates the reciprocal of the sum of the shortest distances from node v_i to all other nodes multiplied by the number of other nodes. The closer the node is to the point where the node is located at the center of the network, the more important it is in the network.

Let v_{max} denote the node with the greatest proximity degree centrality in the network G, and launch the H=(N-1)(N-2)/(2N-3) of the star network, Therefore, the proximity centrality C_C of the connected network G can be obtained as

$$C_c = \frac{2N-3}{(N-1)(N-2)}\sum_{i=1}^{N}[C_C(v_{\max}) - C_C(v_i)]$$

2.3.4 Eigenvector centrality

Eigenvector centrality is also one of the measures of node importance. It assigns a relative score to each node in the network. Of the contributions to a node score, the effect of connecting to a high-score node is greater than the connection to a low-score node.

For node v_i, let its centrality score x_i be proportional to the sum of the central scores of all the nodes connected to it, then

$$x_i = \frac{1}{\lambda}\sum_{j=1}^{N} a_{ij}x_j,$$

Where: N is the total number of nodes; λ is a constant.

2.4 Clustering coefficient

In general, suppose a nodev_i in the network has k_i strips to connect it to other nodes. These k_i nodes are called neighbors of node v_i. Obviously, there may be up to $\mathrm{C}_{k_i}^2$ edges between these k_i nodes. The ratio of the number of sides E_i and the total number of possible sides $k_i(k_i-1)/2$ between the k_i neighbor nodes of the node v_i is defined as the clustering coefficient C_i of the node v_i,

$$C_i = \frac{2E_i}{k_i(k_i-1)}$$

The clustering coefficient C of the entire network is the average value of the clustering coefficient C_i of all nodes v_i,

$$\mathrm{C} = \frac{1}{N}\sum_{i=1}^{N} C_i$$

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2.5 Construction of global container liner route network

Carrier / service	Service Type	Port rotation	Days		No. of Ships			Capacity (teu)		Estimated Wayport deduction		Estimated wayport adjusted (if any)		Estimated (wayport + High cube + Dwt) adjusted	
			Frequency	Round Voyage	Active	Missed	Total	Average Capacity	Annual Operaional Capacity	Eastbound	Westbound	Eastbound	Westbound	Eastbound	Westbound
2M - AE7/Condor	ETE	CNNGB, CNSHA, MYTPP, NLRTM, DEHAM, DEBRV, DEWVN, GBFXT, BEANR, FRLEH, **MAPTM, OMSLL, AEJEA,** CNNGB	7	77	11	0	11	17,816	928,926	45%	0	510,909	928,926	393,400	849,967
2M/ - AE10/Silk	ETE	KRPUS, KRKWA, CNNGB, CNSHA, CNXMN, CNYTN, MYTPP, NLRTM, DEBRV, PLGDN, DEBRV, GBFXT, MYTPP, CNSHA, CNDLC, KRPUS	7	84	12	0	12	18,559	967,666			967,666	967,666	745,103	885,414
2M - AE5/Albatross	ETE	CNXGG, CNTAO, KRPUS, CNNGB, CNSHA, CNYTN, MYTPP, **MAPTM,** DEBRV, DEHAM, SEGOT, DKAAR, DEWVN, DEBRV, NLRTM, SGSIN, CNSHA, CNXGG	7	84	12	0	12	19,346	1,008,700	0	15%	1,008,700	857,395	776,699	784,516
2M - AE2/Swan	ETE	CNXGG, CNTAO, KRPUS, CNNGB, CNYTN, MYTPP, **ESALG,** GBFXT, BEANR, NLRTM, **ESALG,** SGSIN, HKHKG, CNYTN, CNXGG	7	77	11	0	11	18,976	989,409	15%	15%	840,998	840,998	647,568	769,513
2M - AE1/Shogun	ETE	CNSHA, CNNGB, HKHKG, CNYTN, MYTPP, **LKCMB,** GBFXT, NLRTM, GBSOU, DEBRV, NLRTM, **MAPTM, OMSLL, LKCMB,** SGSIN, CNNGB, CNSHA	7	77	11	0	11	19,025	991,964	45%	15%	545,580	843,169	420,097	771,500
2M - AE6/TP6/Lion/Pearl	PDM	JPYOK, CNNGB, CNSHA, CNYTN, MYTPP, PTSIE, BEANR, FRLEH, GBFXT, **MAPTM,** SGSIN, CNNSA, HKHKG, CNYTN, CNXMN, **USLAX,** JPYOK	7	112	16	0	16	13,544	706,184	20%	0	564,947	706,184	435,009	646,158
Ocean Alliance - FAL2/NE3/AEU3/LL2	ETE	CNXGG, CNDLC, CNTAO, CNSHA, CNNGB, SGSIN, **GRPIR,** NLRTM, DEHAM, BEANR, CNSHA, CNXGG	7	77	10	1	11	13,740	716,404	0	15%	716,404	608,943	551,631	557,183
Ocean Alliance - FAL5/NE1/AEU1/LL1	ETE	CNSHA, CNNGB, CNXMN, CNYTN, SGSIN, GBFXT, NLRTM, PLGDN, DEWVN, GBFXT, SGSIN, CNYTN, CNSHA	7	77	11	0	11	20,362	1,061,675			1,061,675	1,061,675	817,490	971,433
Ocean Alliance/ - FAL7/NE7/AEU7LL3	ETE	CNNGB, CNSHA, HKHKG, CNNSA, CNSHK, MYTPP, MYPKG, **GRPIR,** BEANR, DEHAM, NLRTM, GBFXT, GBSOU, **GRPIR,** MYTPP, SGSIN, HKHKG, CNNGB	7	77	11	0	11	14,009	730,429	15%	15%	620,865	620,865	478,066	568,091
Ocean Alliance - FAL6/CEM/AEU5/LL6	ETE	TWKHH, CNNGB, CNSHA, TWTPE, CNYTN, **LKCMB,** NLRTM, GBFXT, DEHAM, NLRTM, **LKCMB,** TWKHH	7	70	10	0	10	13,834	721,305	15%	15%	613,109	613,109	472,094	560,995
Ocean Alliance - FAL3/AEU6/LL5	ETE	CNTAO, CNNGB, CNSHA, CNYTN, VNVUT, SGSIN, FRLEH, NLRTM, DEHAM, BEANR, FRLEH, **MTMAR, SAJED,** CNNSA, CNTAO	7	77	11	0	11	13,753	717,081	30%	0	501,957	717,081	386,507	656,129
Ocean Alliance/APL - FAL1/AEU2/LL4	ETE	CNXGG, KRPUS, CNNGB, CNSHA, CNYTN, SGSIN, **ESALG,** GBSOU, FRDKK, DEHAM, NLRTM, BEZEE, FRLEH, **AEKLF,** MYPKG, CNXMN, CNXGG	7	84	12	0	12	16,931	882,782	15%	15%	750,365	750,365	577,781	686,584
CMA CGM - SEANE	ETE	CNYTN, IDTPP, SGSIN, MYPKG, GBSOU, NLRTM, FRLEH, **ESALG, LBBEY,** SGSIN, CNYTN	7	63	9	0	9	5,294	276,029	30%	0	193,220	276,029	148,779	252,567
CMA CGM/Hapag-Lloyd - NEWMO/EAX	PDM	GBGTW, DEHAM, NLRTM, FRLEH, **FRFOS, ITGOA, EGDAM, REPDG, AUFRE, AUMEL, AUSYD, AUADL,** SGSIN, **INMAA, LKCMB, INKOC, EGDAM, GRPIR, MTMAR,** GBGTW	7	98	14	0	14	6,690	348,817	100%	85%	0	52,323	0	47,876

Figure 2.5 Drewry Particular container liner routes on the European route in the second quarter of 2018

This paper is based on the 2018 Drewry global container liner route report of the Network Resources Department of the Library of Shanghai Maritime University (Figure 2.5, due to the very large number of routes, all of which are not intercepted, only intercepting the report of some container liner routes on the European route in the second quarter of 2018) Establish a corresponding network model.

1) The ports are regarded as network nodes, and the routes between the ports are regarded as side-by-side. It should be noted that this paper uses the P-space method, that is, all ports on the same route are considered to be connected by two.

Port code	newcode	Port name	Region name
AEAUH	1	Abu Dhabi (Port Khalifa)	Middle East
AEFJR	2	Fujairah	Middle East
AEJEA	3	Jebel Ali (Dubai)	Middle East
AEKLF	4	Khor Fakkan	Middle East
AEMSA	5	Ras Al Khaimah (Mina Saqr)	Middle East
AESHJ	6	Port Khalid (Sharjah)	Middle East
AIGTT	7	Georgetown	West Africa
ALDRZ	8	Durres	West Med
ANARU	9	Oranjestad (Aruba)	Central America/Caribbean
ANPHI	10	Philipsburg	North West Europe
ANWIL	11	Willemstad (Curacao)	Central America/Caribbean
AOLAD	12	Luanda	West Africa
AOLOB	13	Lobito	West Africa

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AOMSZ	14	Namibe	West Africa	
ARBHI	15	Bahia Blanca	East Coast South America	
ARBUE	16	Buenos Aires	East Coast South America	
ARPMY	17	Puerto Madryn	East Coast South America	
ARPUD	18	Deseado	East Coast South America	
ARROS	19	Rosario (Argentina)	East Coast South America	
ARUSH	20	Ushuaia	East Coast South America	
ARVCN	21	Villa Constitucion	East Coast South America	
ARZAE	22	Zarate	East Coast South America	

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WWSLU	822	Port Castries (St Lucia)	Central America/Caribbean
WWVIF	823	Vieux Fort (St Lucia)	Central America/Caribbean
YEADE	824	Aden	Middle East
YEHOD	825	Hodeidah	Middle East
YEMKX	826	Mukalla	Middle East
YTLON	827	Longoni	East Africa
ZACPT	828	Cape Town	Southern Africa
ZADUR	829	Durban	Southern Africa
ZAELS	830	East London	Southern Africa
ZANGQ	831	Coega (Ngqura)	Southern Africa
ZAPLZ	832	Port Elizabeth	Southern Africa
ZARCB	833	Richards Bay	Southern Africa
ZRMAT	834	Matadi	West Africa

2) Because the service of the liner service varies, the frequency of ship dispatch varies from channel to route, so the network will be weighted. (For example, the weekly shift has a weight of 1/7, and the weekly shift has a weight of 2/7),This article only considers the frequency of ship departures(Repeat means that a lot of routes contain this port pair). In addition, the port node is counted from 2014 to 2018. There are a lot of ports emerging, declining or integrated. Therefore, the number of ports is very large, reaching 834, but by 2018, there are only 324 main statistics. port.

Initial point	Destination	Frequency reciprocal
1	3	0.142857
1	3	0.055556
1	3	0.055556
1	3	0.142857

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1	3	0.142857
1	3	0.142857
1	3	0.142857
1	3	0.142857
1	3	0.142857
1	3	0.055556
1	3	0.142857
1	3	0.142857
1	3	0.055556
1	3	0.142857
1	3	0.055556
1	3	0.055556
1	44	0.055556
1	44	0.055556
1	44	0.055556
1	44	0.055556
1	44	0.055556
1	44	0.055556

……

833	828	0.071429
833	828	0.071429
833	828	0.04
833	828	0.04
833	829	0.071429
833	829	0.071429
833	829	0.071429
833	829	0.071429
833	829	0.04
833	829	0.04
833	832	0.071429
833	832	0.071429

3) Treat the two ports on the same route as direct access, regardless of port distance or route distance;

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4) Since most of the routes are pendulum routes, the network is an undirected network to simplify calculations.

The global container liner route has 324 major ports in 2018 (December 31, 2018), which can be regarded as 324 nodes in the global liner route network model model, with 82542 port pairs, which can be regarded as global container liners. There are 82,542 consecutive edges in the route network model. By establishing a connected list of global container liner route network models,using Gephi and Matlab software, the adjacency matrix, node degree, compact centrality, feature vector centrality, and median centrality of the global container liner route network model can be obtained.

3. Analysis of network topology properties of global container liner routes

The following diagram can be drawn through the Gephi software to the side-by-side list of the global container liner route network model.

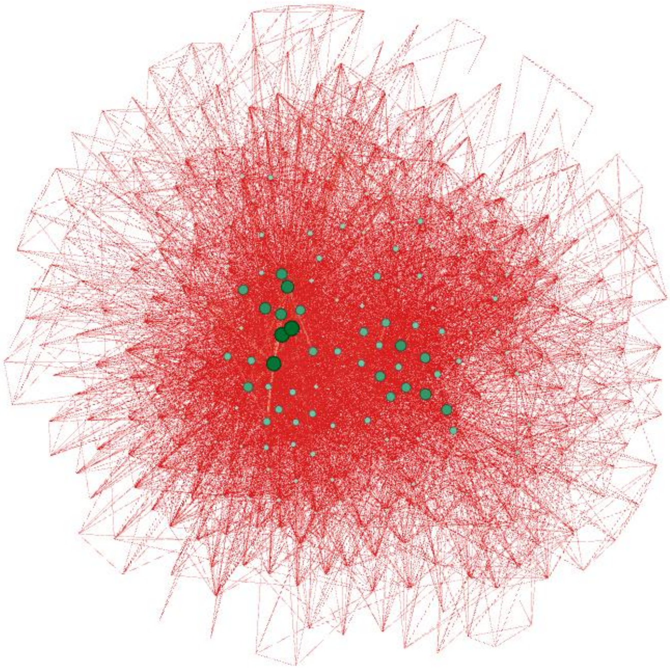

Figure 3 Global container liner route network (Gephi) in 2018

Through the Matlab software, the global model of the container liner route network model can be used to calculate the different types of centrality of each node and obtain the ranking. In addition, Gephi software can also produce relevant calculation results, and specific analysis will be given below.

3.1 Node degree centrality

Port code	Port name	Region name	newcode	Node degree centrality
CNSZX	Shenzhen	Greater China	137	1986052.599
CNSHA	Shanghai	Greater China	133	1878758.059
SGSIN	Singapore	South East Asia	688	1774472.879
CNNGB	Ningbo	Greater China	127	1726534.171
KRPUS	Busan	North Asia	480	1241992.03
CNTAO	Qingdao	Greater China	139	961901.0347
HKHKG	Hong Kong	Greater China	329	961186.482
NLRTM	Rotterdam	North West Europe	556	822038.8879

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LKCMB	Colombo	South Asia	488	624947.8476
MYTPP	Tanjung Pelepas	South East Asia	538	556580.6524

Figure 3.1.1 The top ten ports in the degree centrality of the port in 2018

It can be seen that with the eastward shift of the world economic center, the Far East region has had a significant impact on world economic trade, because the degree of centrality reflects the importance of these ports in the container liner route network. Among them, especially China, there are five ports from China. After entering the 21st century, the rapid growth of China's economy has shocked the world. The contribution of emerging economies such as China to the world's shipping volume and trade volume cannot be neglected. Shenzhen, Ningbo and Shanghai rank among the top three in China and the top four in the world. This also means that there are many trade links between China's coastal areas and the world, and it is the backbone of China's rise. The importance of Singapore is self-evident. As the world's largest transit hub and fuel supply market, most European and Southeast Asian routes have to consider their status.

3.2 Eigenvector centrality

The importance of a port depends both on the number of its neighboring ports (ie the degree of the port) and on the importance of its neighboring ports.

Port code	Port name	Region name	newcode	eigenvector centrality
CNSZX	Shenzhen	Greater China	137	0.41273977
CNSHA	Shanghai	Greater China	133	0.389698276
CNNGB	Ningbo	Greater China	127	0.366742696
SGSIN	Singapore	South East Asia	688	0.347439774
KRPUS	Busan	North Asia	480	0.26170191
CNTAO	Qingdao	Greater China	139	0.221397093
HKHKG	Hong Kong	Greater China	329	0.21222286
NLRTM	Rotterdam	North West Europe	556	0.151223836
MYTPP	Tanjung Pelepas	South East Asia	538	0.131782399
LKCMB	Colombo	South Asia	488	0.131099613

Figure 3.2.1 The top ten ports of the 2018 port eigenvector centrality

The importance of Chinese ports has been mentioned in the previous section, so it is clear that most of the ports from China are neighbors, and their importance rankings are very high, so the feature vector center is ranked very high.

3.3 Average degree

This section differs from the previous one in that the P space method is not used for the time being, and the L space method is used, that is, the two ports are considered to be directly connected only when the two ports are on the same route and adjacent to each other.

Combined with the formula, the weighted part is removed, and the average of the shipping networks of the current three major alliances (2M, Ocean and The Alliance) is calculated, and the average degree of the actual construction of the liner shipping is 3.47, that is, a very small number of nodes have higher The degree of connectivity, while most nodes have only a small degree of connectivity, the hub-spoke feature.

In addition, Singapore is an important port connecting Europe and Asia. In 2018, this phenomenon remained the same, but the difference was that more transit ports began to emerge, replacing the status

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of some ports. The hub ports that serve as bridges in the Mediterranean, such as Marsaxlokk, Gioia Tauro, Algeciras and Valencia, play a vital role in the freight transport connecting the east-west flows in 2018. Because at this time they have become the intermediary axis. In Asia, the rise of Chinese ports (such as Ningbo, Shanghai) and Busan are more reasonable to explain this phenomenon.

3.4 Weighted agglomeration coefficient

According to calculations, the weighted aggregation coefficient of the global container liner route network is 0.71, which indicates that the ports of the global container liner route network are closely connected, and the shorter average shortest path (2.09) reflects the small global container liner route network. The characteristics of the world network.

Figure 3.4.1 Port aggregation coefficient

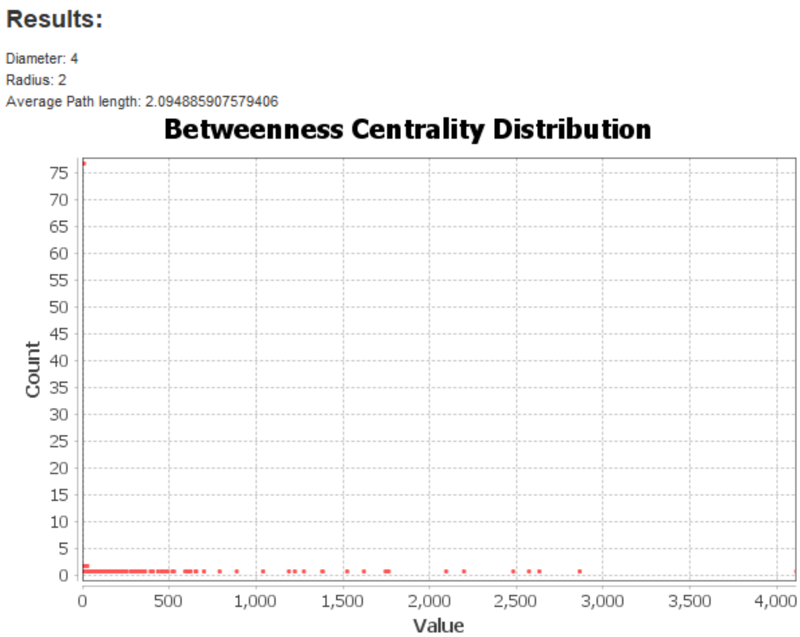

Figure 3.4.1 Network Weighted Average Path Length

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4. Conclusion

This paper takes the global container liner route network as the research object, and through the analysis of its topological properties, the following conclusions are drawn:

(1) This paper collects the data of Drewry, the global authoritative report. After data integration, it compares the non-quantitative statistical characteristics and weighted statistical characteristics of the shipping network, and finds that the ports of the global container liner route network are closely connected, which proves that it has a small world. Network characteristic

(2) For the analysis of the global container liner route network in 2018, calculating the centrality of the node degree and the centrality of the feature vector, it can be found that the world trade center is gradually shifting eastward, and the influence of the Far East on world trade is increasing. In particular, China's economy is strongly reflected in the very high degree of centrality and characteristic vector centrality of Chinese ports. In the 2018 port, the top ten ports in the centrality of the port are from China. The five ports are not only closely related to each other, but also have close ties with other ports in the world. This means that there are many trade links between China's coastal areas and the world, and China has become an indispensable part of world trade;

(3) Using the L-space method to calculate the average of the shipping networks of the current three major alliances (2M, Ocean and The Alliance), it is found that very few ports have a high degree of connectivity, of which Singapore is still connected to Europe and Asia. Important ports, but it should not be overlooked that more transit ports are emerging and play an increasingly important role in the transportation of goods.

The realistic container liner system, as a complex system of static and dynamic interactions, has become an evolutionary product influenced by many factors such as economy, geography, culture and policy in the process of long-term historical evolution. Therefore, for the complex system of shipping system, the complex evolution mechanism and topology of the global liner complex network should continue to be studied in the future, and a new perspective and exploration method should be provided.

References

[1]Watts D J, Strogatz S H. Collective dynamics of |[lsquo]|small-world|[rsquo]| networks[J]. Nature, 1998, 393:440-442.

[2]Barabasi A L, Albert R. Emergence of scaling in random networks[J]. Science, 1999, 286(5439):509.

[3] Albert R , Barabasi A L . Statistical mechanics of complex networks[J]. Reviews of Modern Physics, 2001, 26(1):xii.

[4] Allen F , Gale D M . Financial Contagion[J]. Journal of Political Economy, 2000, 108(1):1-33. [5] Toune S , Fudo H , Genji T , et al. Comparative Study of Modern Heuristic Algorithms to Service Restoration in Distribution Systems[J]. IEEE Power Engineering Review, 2001, 21(11):64-64.

[6] Dai X , Wang P , Zhang P , et al. Rainfall spectrum change in North China and its possible mechanism*[J]. Progress in Natural Science, 2004, 14(7):598-604.

[7] Maslyuk S , Smyth R . Cointegration between oil spot and future prices of the same and different grades in the presence of structural change[J]. Energy Policy, 2009, 37(5):1687-1693.

[8] Chertow M R . Industrial symbiosis: Literature and taxonomy[J]. Annual Review of Energy and the Environment, 2000, 25(1):313-337.

[9]Ebel H, Mielsch L I, Bornholdt S. Scale-free topology of e-mail networks[J]. Physical Review E Statistical Nonlinear & Soft Matter Physics, 2002, 66(3 Pt 2A):035103..

[10] Budak C , Agrawal D , Abbadi A E . Limiting the spread of misinformation in social networks[C]// Proceedings of the 20th International Conference on World Wide Web, WWW 2011, Hyderabad, India, March 28 - April 1, 2011. 2011.

[11] Wu J , Watts D J . Small worlds: The dynamics of networks between order and randomness[J]. ACM SIGMOD Record, 2002, 31(3):74-75.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202001_6(1).0030

[12]. Audretsch D B , Lehmann E E . Does the Knowledge Spillover Theory of Entrepreneurship hold for regions?[J]. Research Policy, 2005, 34(8):0-1202.

[13] Dorogovtsev S N , Mendes J F F , Samukhin A N . Structure of Growing Networks with Preferential Linking[J]. Physical Review Letters, 2000, 85(21):4633-4636.