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Research Trends Analysis on Port Hinterland Using SNA Method

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SNA 분석을 활용한 항만배후지 연구동향 분석에 관한 연구

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Abstract In this paper, the research trends of port hinterland from 1990 to 2018 were analyzed periodically using the Social Network Analysis (SNA) method. The data were collected from major academic journals and totally 116 papers were identified for analysis. The results of the analysis showed that in the first period (1990-1999), keywords can be listed as "containerization", "transport infrastructure" and developed countries related keywords like "Italy", "Canada" and "Germany". The results of the second period (2000-2009) were originated from keywords such as "regionalization", "competitiveness", "Asian consolidation" and "technology". In the third period (2010-2018), the results were derived from keywords such as "intermodal transport", "dry port", "container" and container related keywords and "shipping" and shipping related keywords. We could see the studies of port hinterland are becoming more systematic and integrated. This study provides some important implications for both academic, and industrial viewpoints, and it is helpful to understand the research concentration.

Key Words : Port, Hinterland, SNA, Research trends analysis, Research keywords

요 약 본 연구는 1990년부터 2018년까지 기간 동안의 항만배후지에 대한 연구동향을 사회네트워크 방법론을 이용하여 분석하는 것을 목적으로 하였다. 연구에 사용된 자료는 전 세계 116개 관련 학술논문 자료에서 추출하였다. 10년 단위로 분석된 연구결과를 살펴보면, 먼저 1990-1999년 사이에는 컨테이너화, 수송 기반시설 및 선진물류 국가에 관련된 이탈리아, 독일, 캐나다 등이 분석지표상 상위에 위치하였다. 2000-2009년 사이에는 지역화, 경쟁력, 아시아국가 화물유치 및 물류기술 등이 중심적인 위치를 점하였다. 마지막으로 2010-2018년 사이에는 복합운송, 내륙거점, 컨테이너 및 관련 키워드, 해운 및 연관 키워드가 중요하게 연구되었다. 항만배후지 연구동향은 시대가 변화함에 따라 체계화되고 통합적으로 진행되었음을 확인할 수 있으며. 본 연구결과는 항만배후지와 관련된 학계와 산업계의 산업발전에 대한 이해도 및 연구 집중도에 대한 시사점을 제공한다.

주제어 : 항만, 배후지, 사회네트워크분석, 연구 동향분석, 연구 키워드

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1. Introduction

With the increasing uncertainty of global trade and the tensions between major players of global economy, there are rising competence and lifting pressure on modern port especially in the era of a global supply chain. And the role of port has changed from merely cargo loading, to an important node connecting to logistics services and later becoming global resource allocation centers[1], At the same time, the hinterland of port is also changing its role from the traditional land-based hinterland to a dynamic hinterland including systematic road and rail networks and economic regions[2]. Benefitted from containerization, from sea shipping to inland transport, it is possible to transit goods in a unified way which is more convenient and efficient. Furthermore, the transport system between sea port and dry port is becoming more and more systematic.

Port hinterland, together with regional integration, has been developed to adapt to the increasing traffic volume and shipping capacity in maritime industry. The concept of port hinterland has been flexibly evolved since it was initially used to illustrate the area with contour bounding inland port economic area. Nevertheless, the way to determine the hinterland is also regarded to the factors of cargo and transport mode[3], technology advance, economic cycles or transport policy so this concept is holistically unfollowed a constancy[4].

Literally, the port hinterland is understood as a geographically spatial attribute to identify its fundamental role by how effective the inland connectivity processes. It is defined as the captive hinterland that integration with the inland market of a port is measured in a certain way[5]. Later, this type of hinterland is considered out of date then the emergence of a new concept, contestable hinterland, recognizes the competition among ports, no more a single port with apparent cost advantage[6]. In fact, the hinterland accessibility is contributed by multiple involvers who define its smoothness and the contestable hinterland enables shippers or shipping lines to have more port choices in a certain area[7]. Together with the increasing of ship size and the emergence of maritime hubs which intensively have influence to the hinterland connectivity, the issues surrounding port hinterland are arguable and it is essential to release strategies, recently observed to respond with the challenges regarded to the quantity of traffic, public budget and competition among vehicles or adjacent terminals[8]. Some can be listed as the policies of dry-ports[9], system improvement for port gate efficiency[10] or port modal split[11].

In these days, an efficient supply chain is considered the key factor of a business to create leading business results and higher competitive advantage. Thus, the integration of ports into the supply chain has been concerned as a traditional and sustainable channel of transportation which keeps being favored. The hinterland penetration owns a considerable impact to the port performance with port as a node in the supply chain to establish major values, especially to the international intermodal chains[12]. The development of global supply chain highly stressed into the port operation, including the inland freight distribution with the involvement of a huge traffic follow and in terms of spending for total logistics, it enables customers to save a plenty of cost[13].

Although there has been significant development and a wide variety of studies in port and hinterland area, yet there is scant of research trend analysis about port hinterland. In order to fill this gap, this paper studies the research trends of port hinterland via the Social Network Analysis (SNA). To better analyze the research trends, we divided the overall time span into three periods (1990-1999, 2000-2009, 2010-2018). Additionally, in each period, we build a network using keywords which are collected from academic papers about port hinterland.

This paper contains five parts. Following the introduction, the second part provides the literature

review of port hinterland development. The third section detailed introduced the proposed methodology SNA. Data visualizing and the description of the data analyzing results are in the fourth section and in the fifth part, we provides conclusions, implications and future research chances.

2. Study background

2.1 Literature review

The focus on port hinterland changes from time to time. Van Klink & Van den Berg (1998)[14] studied the intermodal transportation under the increasing massive transshipment background. Their study showed that the growing container transport could stimulate intermodal transportation and open new markets beyond the traditional hinterlands which also considered to use inland terminals to enlarge the hinterland of the sea port. Robinson (2002)[15] argued that the port and its hinterlands' role have changed from a monopoly to an important connecting zone in the logistics chain with the rapid and pervasive restructuring of supply chains. Iannone (2012)[16] analyzed the efficiency of port hinterland container distribution. The study also found out that a full integration of container operations between the regional seaports and inland ports can relieve seaport congestion and promote the rail transport which would cut down the cost of the total intermodal cost.

Many researchers studied the transport network of port hinterland. Halim et al. (2016)[17] used a strategic model to analyze the port hinterland freight distribution networks. They found that the development of new infrastructures such as inland terminal, shared distribution centers and improvement of currently available infrastructures that connect the ports and hinterland regions can obviously improve the connectivity and efficiency of port hinterland freight transport. Halim et al. (2016)[18] also found that port-hinterland connectivity plays a very important role in the port choice of the shippers and hence the routing and volumes of transported goods. Tan (2007)[19] studied the port cities and hinterland using Singapore and Calcutta as comparison. The study showed that political and cultural hinterland played a fundamental role in determining the trajectory of ports cities. Woodburn (2013)[20] analyzed the effects of rail network enhancement on port hinterland container activity and found that the impacts on rail freight efficiency of the gauge enhancement have been substantial, with efficiency improvements evident even at a time of economic stagnation. The study also showed that the transport infrastructure investment plays an important role in determining both efficiency and sustainability of freight transport activity.

Moreover, there is an increasing research field based on the conceptualization of "dry port". Roso, Woxenius & Lumsden (2009)[21] analyzed this concept from the connecting role between container seaports and hinterland. The findings showed that the dry port can help identify ways of shifting freight volumes from road to more efficient traffic modes. Wilmsmeier, Monios & Lambert (2011)[22] examined the spatial development of freight infrastructure and intermodal corridor in relation to inland terminals. Rodrigue & Notteboom (2012)[23] studied the dry ports in European and American. The study analyzed the similarities and the differences of dry ports in Europe and America.

2.2 Literature distinction

This study would concentrate on the research trend of port hinterland in a period of nearly 30 years to generally visualize the evolution of this conceptualization over time. It is essential to approach into this topic due to the lack of available analyses with solely a research of Lam & Gu (2013)[24], however, from the perspective of port hinterland intermodal development. In opposed, this study fulfills the macro perspective which covers a wide range of topics by utilizing SNA as an appreciative tool and become preliminary to the future research project about port hinterland.

3. Methodology

3.1 Research flow

The schematic diagram of research flow is shown in Fig. 1. The first step is to search for the current situation of port hinterland. After that, studies about port hinterland would be the target. These academic papers were mainly collected from three major journals: Science Direct, Taylor &Francis and Springer. Once the keywords were collected, keywords coding would be conducted. The next step is to analyze the coded data using the SNA software, UCINET. This paper selected degree centrality, betweenness centrality and closeness centrality for analyzing the research trend of port hinterland. Based on the analyzing, we then conducted the findings and implications of the analyzing results.

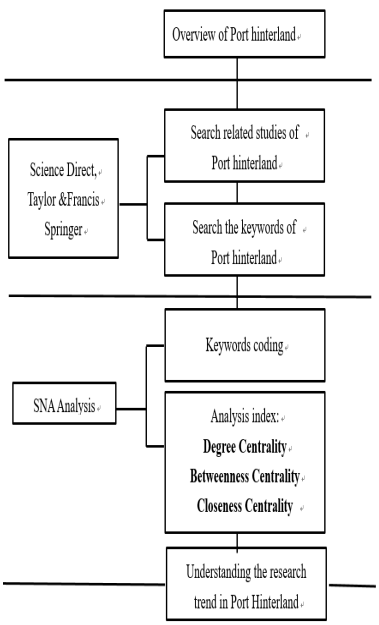

Fig. 1. Research Flow

3.2 Social Network Analysis

This study used the SNA method invented by Barnes[25-27] to analyze the research trend of port hinterland. And the data was analyzed by UCINET, the network analysis software. This paper used degree centrality, betweenness centrality and closeness centrality index for analyzing the research trend of port hinterland.

3.3 Degree centrality

(n_i) shows relation of network. 1 if a node connected other node by link otherwise 0. and in order to generalize for compare with other nodes, it is devided by $g-1$. g is the number of all nodes in network. In this research, the keyword is presented in the visualized keywords network and has been more frequently analyzed by researchers and scholars. A high degree centrality shows that the keyword appeared in more academic papers which can represent more value in the research trend. The degree centrality, $C_D(n_i)$, for node $j(n_j)$ is defined as follows[28,29]:

$$C_D(n_i) = \frac{d(n_i)}{g-1} \quad (1)$$

3.4 Betweenness centrality

Betweenness centrality shows the broker role of a node in the network. It means that the node has more intermediary role in the network which can be the bridge to other nodes. In this paper, it means that the keyword appeared in more papers if a keyword has more betweenness centrality value. Betweenness centrality is expressed as follows[30]:

$$C_B(n_i) = \sum_{j<k} g_{jk}(n_j)/g_{jk} \quad (2)$$

3.5 Closeness centrality

Closeness centrality is the concept of the distance between nodes on the network. In this method, the shortest distance from all the nodes is (d_{ij}) which connects both nodes (i) and (j). The shortest path distance, g is the number of nodes in the network, and $g-1$ for generalization.

$$C_C(g-1) = \left[\sum_{j=1}^{n} d_{ij}\right]^{-1} \quad (3)$$

4. Case study

4.1 Data Collection

In this paper, 116 academic papers from 1990 to 2018 were identified to collect keywords data which all of them were related to port hinterland. These academic papers were found from academic journals including Science Direct, Taylor & Francis and Springer.

Then the research keywords of each paper were summarized and coded as original analyzing data. For better analyzing, we divided every ten years into a period. The time span from 1990 to 2018 was divided into three periods for further analyzing which the first period is from 1990 to 1999, the second period is from 2000 to 2009 and the third period is from 2010 to 2018.

4.2 First period (1990-1999)

Fig. 2 is a visual representation of the keyword network of these identified research papers from the period 1990-1999. Table1 shows the normalized degree centrality, betweenness centrality and closeness centrality values of the keywords specifically.

As showed in the visualization figure, "port" and "hinterland" are located in the center of the first period's keywords network. A port is defined as a transit area through which goods and people move from and to the sea[31] while the definition of a port hinterland can be the area of which the greater part of the trade passes through the port[32,33]. The following keyword shows high degree centrality, closeness centrality and betweenness centrality is "containerization". Containerization has brought important changes to the shipping and inland transportation system since 1960s.

In this period, many researchers focused on the influence of containerization .The wide spread use of containers actually have changed the whole industry from linear shipping to intermodal transport. An efficient way of transportation was provided to shippers[34]. And the keywords related to developed countries and cities also shared high degree centrality and closeness centrality. These keywords including "Italy", "Benelux", "Halifax", "Canada", "Germany", "UK", "Hong Kong" and "Rotterdam". These developed countries related keywords indicate that ports and port hinterland development has a strong relationship with economic development. In other words, port operation can have a direct impact on regional economy[35]. Also the keywords "transport infrastructure", "intermodal links" and "traffic structure" simultaneously showed that port and hinterland can improve the transportation infrastructure and the transport convenience of related regions. The keywords "competition", "seaport" and "Italy" also have high betweenness centrality, which makes these keywords own more intermodal role between "port" and "hinterland" and all other keywords in this network[36].

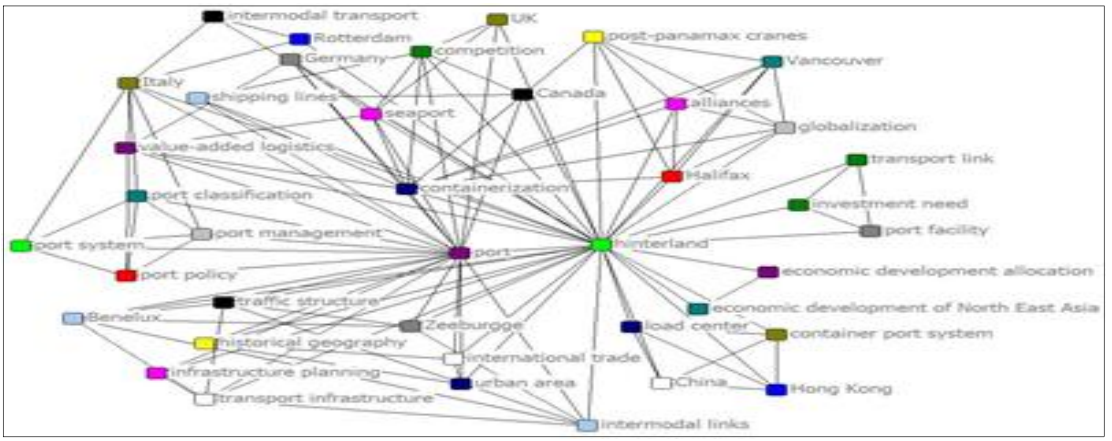

Fig. 2. Result of visualizing keywords in 1990-1999

Table 1. Normalized data of 3 centrality (1990-1999)

	Keywords	Deg.	Close.	Bet.
1	hinterland	0.897	0.907	0.656
2	port	0.59	0.709	0.217
3	containerization	0.333	0.6	0.036
4	Italy	0.205	0.557	0.048
5	competition	0.179	0.549	0.002
6	seaport	0.179	0.549	0.002
7	transport infrastructure	0.154	0.542	0.001
8	Benelux	0.154	0.542	0
9	intermodal links	0.154	0.542	0
10	traffic structure	0.154	0.542	0
11	alliances	0.154	0.513	0
12	globalization	0.154	0.513	0
13	Halifax	0.154	0.513	0
14	post-panamax cranes	0.154	0.513	0
15	Canada	0.128	0.534	0
16	shipping lines	0.128	0.534	0
17	Germany	0.128	0.534	0
18	value-added logistics	0.128	0.534	0
19	port classification	0.128	0.448	0
20	port management	0.128	0.448	0
21	port policy	0.128	0.448	0
22	port system	0.128	0.448	0
23	Zeeburgge	0.128	0.534	0
24	historical geography	0.103	0.527	0
25	international trade	0.103	0.527	0
26	urban area	0.103	0.527	0
27	UK	0.103	0.527	0
28	container port system	0.103	0.5	0
29	load center	0.103	0.5	0
30	Hong Kong	0.103	0.5	0
31	China	0.103	0.5	0
32	investment need	0.077	0.494	0
33	port facility	0.077	0.494	0
34	transport link	0.077	0.494	0
35	infrastructure planning	0.077	0.52	0
36	intermodal transport	0.077	0.52	0
37	Rotterdam	0.077	0.52	0

4.3 Second period (2000-2009)

Fig. 3 is a visual representation of the keyword network of published research papers from the period 2000-2009. Table 2 shows the degree centrality, betweenness centrality and closeness centrality values of the keywords in detail.

In the second period from 2000 to 2009, keywords "port" and "hinterland" are located in the center of the visualized network. Beside, keyword "forelands" have a high degree centrality, closeness centrality and betweenness centrality. In this period, many researchers[19,37] focused on the transformation and difference between hinterland-based regionalization and foreland-based regionalization. This is also the reason why keywords "regions" and "regionalization" share a relatively high degree centrality value. Keywords "competitiveness", "crisis" and "inter-port competition" indicate that researchers focused on the competitiveness of the port hinterland areas. Also there are several keywords related to Asia, such as "East Asian", "Asian consolidation", "Singapore", "China", "Tianjin" and "Calcutta", this shows the power of Asia in port operation and hinterland development rises in this period. The growth rate of container ports in Asian area is dramatic in this period due to globalization and China's growth in global trade[38]. It is also noticed that keywords "technology" and "information and

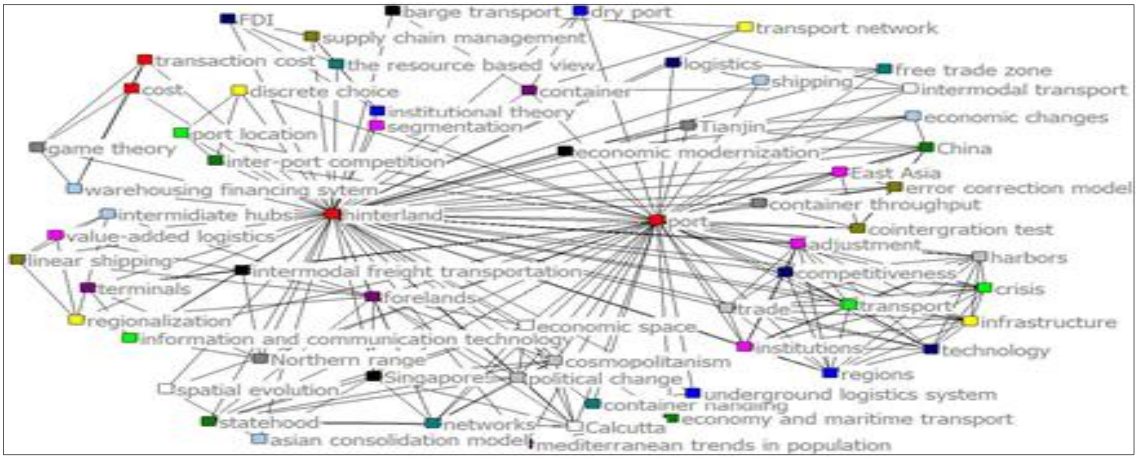

Fig. 3. Result of visualizing keywords in 2000-2009

Table 2. Normalized data of 3 centrality 2000-2009

No.	Keywords	Deg.	Close.	Bet.
1	hinterland	1	1	0.638
2	port	0.77	0.813	0.252
3	forelands	0.213	0.56	0.009
4	harbors	0.18	0.55	0
5	regions	0.18	0.55	0
6	competitiveness	0.18	0.55	0
7	trade	0.18	0.55	0
8	institutions	0.18	0.55	0
9	crisis	0.18	0.55	0
10	adjustment	0.18	0.55	0
11	infrastructure	0.18	0.55	0
12	technology	0.18	0.55	0
13	transport	0.18	0.55	0
14	China	0.148	0.54	0.002
15	Singapore	0.148	0.54	0
16	Calcutta	0.148	0.54	0
17	networks	0.148	0.54	0
18	economic space	0.148	0.54	0
19	political change	0.148	0.54	0
20	container throughput	0.098	0.526	0
21	error correction model	0.098	0.526	0
22	East Asia	0.098	0.526	0
23	container	0.098	0.526	0.002
24	economic modernization	0.082	0.521	0
25	economic changes	0.082	0.521	0
26	Tianjin	0.082	0.521	0
27	information and communication technology	0.082	0.521	0
28	intermodal transport	0.082	0.521	0
29	Northern range	0.082	0.521	0
30	terminals	0.082	0.521	0
31	linear shipping	0.082	0.521	0
32	regionalization	0.082	0.521	0
33	value-added logistics	0.082	0.521	0
34	dry port	0.066	0.517	0
35	free trade zone	0.066	0.517	0
36	shipping	0.066	0.517	0
37	logistics	0.066	0.517	0
38	supply chain management	0.066	0.517	0
39	the resource based view	0.066	0.517	0
40	inter-port competition	0.066	0.517	0
41	port location	0.066	0.517	0
42	game theory	0.066	0.517	0
43	transaction cost	0.066	0.517	0
44	economy and maritime transport	0.049	0.513	0
45	container handling	0.049	0.513	0
46	underground logistics system	0.049	0.513	0
47	barge transport	0.049	0.513	0
48	transport network	0.049	0.513	0
49	Asian consolidation model	0.049	0.513	0

communication technology" frequently appeared in this period. This shows the basic fact that technology always plays an important role in shipping and logistics industries. There are also keywords like "economic space", "economic modernization" and "economic changes". The economy related keywords indicate that the relationship between port and port hinterland and economy is close[39]. Keywords "forelands", "China" and "container" have intermediate roles in port hinterland analysis during this period.

4.4 Third period (2010-2018)

Fig. 4 is a visual representation of the keyword network of published research papers from the period 2010-2018. Table 3 shows the degree centrality, betweenness centrality and closeness centrality values of the keywords in detail.

There are several changes in the third period from 2010 to 2018 comparing to the second period from 2000 to 2009. Firstly, keywords related to "container" increased significantly. In the second period, there were a few keywords related to "container" including "container throughput" and "container handling", but in the third period, more keywords like "containerization", "container transport", "container distribution", "container terminal", empty container repositioning" and "hinterland container operator". Secondly, keywords related to shipping increased. More keywords like "short sea shipping", "container shipping", "shipping lines", "deep sea shipping" and "inland shipping" appeared in the third period. Thirdly, comparing to the first and the second period, more keywords related to China are discussed in this period, for example, "ports of China", "Guangzhou port", "Shanghai port" and "Shenzhen port". Favorable geographical location and efficient inland transportation network of these Chinese ports have resulted in significant development of the port hinterland (Shi & Li, 2016). Below is the table of keywords degree in the third period.

As is shown in the table, the degree centrality of keyword "intermodal transport" is 0.191 which increased obviously comparing to the second period value 0.082 while the degree centrality of keyword "dry port" increased from 0.066 to 0.094. This indicates that more researchers focused on the connection and transit

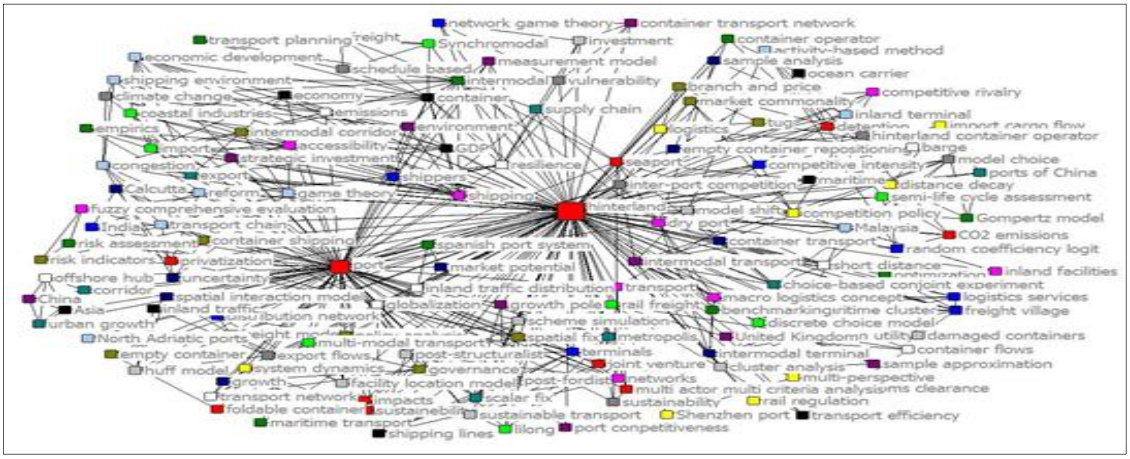

Fig. 4. Result of visualizing keywords in 2010-2018

system between dry port and sea port. In other words, the combined transit system of rail freight transport and shipping was widely studied. Containerization and wide spread use of container are the precondition of intermodal transport. At the same time, keywords like “rail”, “railway freight” and “port railway project” indicate the research concentration of intermodal transport too.

As we can see in centrality result, we could see the studies of port hinterland are becoming more systematic and integrated.

Table 3. Normalized data of 3 centrality 2010-2018

No.	Keywords	Deg.	Close.	Bet.
1	hinterland	0.951	0.954	0.776
2	port	0.532	0.681	0.177
3	intermodal transport	0.191	0.548	0.016
4	seaport	0.101	0.527	0.005
5	container	0.094	0.525	0.017
6	dry port	0.094	0.525	0.005
7	shipping	0.079	0.52	0.001
8	infrastructure	0.064	0.512	0.002
9	intermodal	0.064	0.516	0.015
10	short sea shipping	0.052	0.51	0.001
11	containerization	0.049	0.509	0.001
12	container shipping	0.049	0.509	0.001
13	globalization	0.049	0.509	0
14	congestion	0.045	0.511	0
15	resilience	0.045	0.511	0.005
16	inland terminal	0.041	0.507	0
17	customs clearance	0.041	0.498	0
18	competitiveness	0.037	0.506	0
19	container transport	0.037	0.497	0.006
20	corridor	0.037	0.506	0.006
21	green freight logistics systems	0.034	0.5	0
22	transport external costs	0.034	0.5	0
23	Inter port model	0.034	0.5	0
24	generalized total logistic cost	0.034	0.496	0
25	hub-and-spoke distribution network	0.034	0.496	0
26	regional logistics system	0.034	0.496	0
27	rail freight	0.034	0.505	0
28	supply chain	0.034	0.509	0
29	rail	0.034	0.505	0
30	port-centric logistics	0.034	0.505	0
31	regional	0.034	0.505	0
32	economy	0.034	0.509	0
33	economic development	0.034	0.509	0
34	export	0.034	0.509	0
35	import	0.034	0.509	0
36	GDP	0.034	0.509	0
37	coastal industries	0.034	0.509	0
38	terminals	0.034	0.505	0
39	shipping lines	0.034	0.505	0
40	inter-port competition	0.034	0.505	0.001
41	France	0.03	0.504	0
42	intermodal terminal	0.03	0.495	0
43	oil industry	0.026	0.494	0
44	Rotterdam port	0.026	0.494	0
45	rail network enhancement	0.026	0.503	0
46	greater pearl river delta	0.026	0.503	0
47	container distribution	0.026	0.503	0
48	cars transportation	0.022	0.494	0
49	total social generalized logistics cost	0.022	0.494	0
50	multi-modal transport	0.022	0.502	0

5. Conclusion

This paper analyzed the research trend of port hinterland using the SNA from 1990 to 2018 which the

time span is divided into three periods. The first period is from 1990 to 1999, the second period is from 2000 to 2009 and the third period is from 2010 to 2018. Studies about port hinterland in the first period (1990-1999) mainly focused on keywords such as “containerization”, “transport infrastructure” and developed countries related keywords like “Italy”, “Canada”, “Germany” and “UK”. In the second period (2000-2009), the research trends turned to keywords such as “regionalization”, “competitiveness”, “Asian consolidation” and “economic”. Finally, in the third period, the research trends shifted into keywords such as “intermodal transport”, “dry port”, “rail freight”, container related keywords like “container transport” and “container terminal” and shipping related keywords like “inland shipping” and “shipping lines”

This study provides some important implications for both academic and industrial viewpoints. These dynamics in keyword changes indicate that the studies about port hinterland focused on the influence brought by containerization and the development progress of developed countries due to port development. Furthermore, port hinterland development caused regionalization and port competition became the new research concentration. Lately, the studies about intermodal transport and dry port have become popular. The research trend of port hinterland shows that the studies of port hinterland are becoming more systematic and integrated. Under the globalization context, ports are connected to one another, and the port hinterland is also connecting to other regions economically and physically. For other researchers, the analysis of research trend of port hinterland can provide an overall perspective of the changes in this field which is really helpful for them to better understand the research concentrations from time to time.

However, the study also has some limitations. 116 academic papers from 1990 to 2018 were utilized for SNA analysis. It is needed to gather more related academic researches for increasing more reliability of research. In addition, analyzing periods, which was 10 years for this research, have to be more detailed depending on major logistics strategies.

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