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A Study on Port Cooperation in the Tianjin and Hebei Areas Using Factor Analysis

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When China switched its economic development focus from the Changjiang-Zhujiang Delta to the Bohai Sea, Tianjin and Hebei became two of the fastest developing areas in the country. As the hub of logistics, the port system plays an important role in increasing the region's economic development. This paper reviews port logistics in Hebei and Tianjin, and explains the necessity of port cooperation in these areas. An index system for port logistics competition is proposed using factor analysis. The results can be used to guide the positioning and development of each port based on its individual strength, thereby improving the port logistics of the entire area.

1. Introduction and Literature Review

Ports have significantly facilitated foreign trade in the Hebei and Tianjin areas by providing important resources for the development of energy and chemical industries. The development of port logistics also greatly stimulated the economic growth of these areas. Presently, there are five ports along the 640 km coastline of Hebei and Tianjin. They are Tianjin Port (the largest man-made deepwater port in China), Qinhuandao Port (the country's largest energy exportation port), Huanghua Port (a coal exportation port for Shenhua Group), Jingtang Port (a regional industry port), and Caofeidian Port (the key investment project of the National Eleventh Five-Year Plan). However, due to the lack of cooperation among ports, insufficient investment and superfluous construction has led to a tremendous waste of resources. Cooperation among the five ports is necessary in order to enhance the prosperity of these areas.

Due to the strong ties between Beijing and Tianjin, Tianjin port plays an important role in the dual-nuclei urban group for the development of Beijing, Tianjin, and Hebei (Meng, 2008). Tianjin's many advantages (e.g. geographic location, trade status, economic basis, marketing carrier) may enable it to become a leader in the Jing-Jin-Ji economy. However, the lack of overall planning, the same industrial structures, and disjointed industrial linkages are among the factors hindering cooperation among Beijing, Tianjin, and Hebei. It is therefore necessary to develop relationships between the ports and the hinterland, and to define Tianjin's leading status in the Bohai region. From the perspective of domestic and international macro-economic development, and in order to promote the Bohai region's rapid development, the logistics and industry resources of the Jing-Jin-Ji region should be integrated. This will enhance economic development competition and strengthen economic cooperation (Jiao, 2008). The 2008 Beijing Olympic Games, as well as national and local governments' development plans, brought unprecedented opportunities for the Tianjin Binhai New Area and Hebei Caofeidian zones. This, in turn, enhanced the feasibility of logistics integration of the Jing-Jin-Ji region (Jiao, 2008).

The importance of these ports is described in the literature. Caofeidian's natural conditions and regional advantages are important to the economic development, industrial adjustment, industrial layout, and shipping transport of the Bohai economic circle. It is considered a key area for spurring economic development and enhancing economic integration in the region (Yu, 2006). Wang and Qu (2008) emphasized that harmonious development of the Jing-Jin-Ji Port Group has a significant effect on the hinterland's economic development, which is limited by poor coordination of its ports. The authors recommended establishment of regional coordination mechanisms in order to strengthen the complementarity of the port group and advance market development in the Jing-Jin-Ji region. Qinhuangdao Port was considered a main hub for coal transport (Zhao, 2005). The port has been an important supplier to the world's coal market, especially in Southeast Asia. However, Qinhuangdao has the disadvantages of a lack of storage capacity and long land-rail distances. Finally, Tianjin port has unique conditions and a tremendous potential to promote development of the Tianjin Binhai New Area. This, in turn, would be conducive to enhancing the international competitiveness of the Jing-Jin-Ji and Circum-Bohai Sea regions, and to implementing a national strategy for harmonious regional development (Wang, 2008).

2. Index System for Port Logistics Competition

Port logistics competition refers to the capacity of a port to provide improved logistics services during present and future development when compared to its competitors (Feng, 2005). It is described by the following (Zhao, 2006):

(1) A large harbor capacity and strong assembling/distributing capacity to ensure a continuous growth of throughput.

(2) A complete infrastructure. For example, the channel's water depth and port berth should satisfy the needs of ships and have appropriate redundancy. Port devices should suit the development of modern integrated logistics.

(3) A logistics service level that ensures high customer satisfaction.

(4) A superior environment for port development, such as the natural environment of the port's location, a prosperous hinterland economy, and advanced coastal industry.

(5) Sustainable development capacity of the port. This is important for steady

increases in throughput and rapid development of logistics value-added services.

Using these features, an Index System for Port Logistics Competition was designed in Table 1.

Table 1: Index system for Port logistics competition

Primary Index	Secondary Index
Hinterland Economy	Hinterland Economic Strength(X1)
	Extraversion of Hinterland Economy(X2)
Port Logistics Infrastructure	Water Depth of Channel and Berth(X3)
	Number of Deepwater Berth above 10000 Tons(X4)
	Area of Storage Storeroom and Field(X5)
	Throughput Capacity of Berth(X6)
Port Logistics Condition	Throughput of the Port(X7)
	Oneness of Goods(X8)
Service Level of Port Logistics	Shipping Service(X9)
	Customer Satisfaction(X10)
Potential of Port Logistics Development	Average Growth Rate of the Throughput in the last 5 years(X11)
	Development Level of Logistics Value-Added Services(X12)

Table 2 shows data for the evaluation index of the Tianjin Port and ports in Hebei province evaluated according to this index system.

Table 2: Data for the evaluation index of Tianjin Port and Ports in Hebei province

Index	Tianjin Port	Qinhuangdao Port	Huanghua Port	Jingtang Port	Caofeidian Port
X1	4337.73	571.56	1281.67	2361.68	2361.68
X2	645.73	28.93	10.63	34.64	34.64
X3	10	16.5	13	10	25
X4	65	42	9	17	2
X5	240	220	199.4	120	58
X6	23388	22641	6785	3115	3000
X7	25760	20489	8145	4066	1005
X8	0.231	0.864	0.984	0.354	1
X9	1	0.6	0.3	0.2	0.2
X10	99	95	95	95	95
X11	0.158	0.125	0.509	0.298	0.5
X12	1	0.78	0.34	0.25	0.18

All data were from statistics reported in the 2006 China Annals of Statistics and Transportation except the data for Shipping Service and Development Level of Logistics Value-Added Services. In order to warrant the objectivity of these two indexes, the data resulted from consulations with 50 shipping dispatchers from the Sino Charter Company. Total GDP of 2006 and the ratio of import and export to GDP of the port cities were used to calculate the index of Hinterland Economy. Index of Oneness of Goods was computed by the ratio of quantity of goods with maximum throughput to the overall throughput of the port.

3. Factor Analysis and Evaluation Results

3.1. Standardization of Original Data

The original data were first standardized to eliminate the influence of different dimensions. Standardized data obtained via SPSS13.0 are shown in Table 3.

Table 3: Standardized data for the evaluation index of Tianjin Port and Ports in Hebei province

Index	Tianjin Port	Qinhuangdao Port	Huanghua Port	Jingtang Port	Caofeidian Port
X1	1.51281	-1.13120	-0.63268	0.12554	0.12554
X2	1.78772	-0.44072	-0.50683	-0.42009	-0.42009
X3	-0.78413	0.25604	-0.30405	-0.78413	1.61626
X4	1.45777	0.57544	-0.69052	-0.38362	-0.95906
X5	0.95067	0.68849	0.41844	-0.62242	-1.43518
X6	1.11689	1.04956	-0.48210	-0.83662	-0.84773
X7	1.29304	0.80154	-0.34949	-0.72984	-1.01526
X8	-1.24422	0.48447	0.81218	-0.90831	0.85588
X9	1.57200	0.40756	-0.46578	-0.75689	-0.75689
X10	1.78885	-0.44721	-0.44721	-0.44721	-0.44721
X11	-0.87794	-1.05901	1.04804	-0.10974	0.99865
X12	1.36111	0.75000	-0.47222	-0.72222	0.91667

3.2. Factor Analysis and Interpretation of Common Factors

Through correlation tests performed in SPSS13.0, factor analysis was verified as being appropriate for analyzing the standardized data. Tabulating major factors (Table 4) shows that the cumulative variance contribution of the first three common factors reached 95.45%. Since 95.45% of the original information was reflected by the first common factors, these three factors were used to evaluate the port logistics competition, referred to as first, second, and third major factor, respectively.

The factor loading value reflects the correlation between the common factor and an original variable index. A negative factor loading value represents negative correlation. The higher the factor loading value, the closer the correlation between the index and the common factor, and the more information the common factor reflects (Zhang and Fang, 2003). Table 5 lists the factor loading matrix after 25 iterations. Data in this matrix were then used to analyze detailed information reflected by the three common factors.

Table 4: Major Factors

Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
8.422	70.185	70.185	6.194	51.620	51.620
1.975	16.454	86.639	3.468	28.900	80.520
1.057	8.810	95.450	1.792	14.930	95.450

Extraction Method: Principal Component Analysis.

Table 5: Factor Loading Matrix

	Component		
	1	2	3
X6	.985	.158	-.025
X7	.954	.252	-.154
X12	.939	.320	-.125
X5	.860	-.014	-.350
X4	.855	.429	-.263
X9	.855	.506	-.094
X11	-.790	-.127	.355
X1	-.011	.987	-.158
X2	.499	.846	-.153
X10	.505	.836	-.157
X3	-.264	-.153	.926
X8	-.177	-.638	.703

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

As shown in Table 5, all 12 indexes can be divided into three common factors. The first common factor (F1) includes Throughput Capacity of Berth (X6), Throughput of the Port (X7), Development Level of Logistics Value-Added Services (X12), Area of Storage Storeroom and Field (X5), Number of Deepwater Berth above 10000 Tons (X4), Shipping Service (X9), and Average Growth Rate of the Throughput in the last 5 years (X11). These seven indexes combined were named as Factor of Port Logistics Comprehensive Strength.

The second common factor (F2) includes Hinterland Economic Strength (X1), Extraversion of Hinterland Economy (X2), and Customer Satisfaction (X10). These three indexes combined were named as Factor of Development Environment of Port Logistics.

The third common factor (F3) includes Water Depth of Channel and Berth (X3) and Oneness of Goods (X8). These two indexes combined were named as Factor of Natural Condition and Specialization Degree of Port Logistics.

3.3. Analysis of Results

In order to compare port logistics competition, the regression method was used to compute factor scores based on the results from factor analysis. The comprehensive score of each port, as shown in Table 6, was obtained via weighted sum (F=51.62%xF1+28.9%xF2+14.93%xF3). The weights are the ratio of each factor's variance contribution rate to the three cumulative variance contribution rates.

Table 6: Comprehensive score of Tianjin Port and Ports in Hebei province

Ports	F1	F2	F3	F	Rank
Tianjin	1.20059	1.49593	-0.28032	1.010217	1
Qinhuangdao	0.90349	-1.08594	0.26946	0.192775	2
Huanghua	-0.27990	-0.67235	-0.12852	-0.35798	4
Jingtang	-0.91965	-0.08845	-1.31281	-0.69629	5
Caofeidian	-0.90453	0.35081	1.45218	-0.14872	3

The comprehensive score, F in Table 6, was used as the standard for quantitatively evaluating port logistics competition, which reflects the characteristics of port logistics competition of the Tianjin and Hebei area ports. Specifically:

(1) Overall, Tianjin Port leads in logistics comprehensive strength and development environment while the four ports in Hebei can be seen as feeder-service ports of the Tianjin Port.

(2) Individually, each port has its own comparative advantages. Qinhuangdao Port has the highest comprehensive strength in the Hebei area. Caofeidian Port, as a natural deepwater port, has the highest degree of specialization for iron ore and natural resources. Huanghua Port has the comparative advantage in specialization degree for coal output. Finally, the logistics development environment of Caofeidian Port and Jingtang Port is better than those of Qinhuangdao Port and Huanghua Port.

4. Discussion

According to the above analyses, this study proposes the following positioning and development strategies for ports in the Tianjin and Hebei areas.

4.1. International Hub Port: Tianjin Port

Tianjin Port is the core hub port of this area and is an appropriate choice for the International Logistics Center of Northern China. In order to achieve this goal, Tianjin Port should place its priority on developing container transportation, expediting the construction of its deepwater channel and berth for container/bulk cargo shipment, and establishing a logistics center for container/bulk cargo shipment. The goods structure should be adjusted appropriately. For example, domestic trade materials (e.g. energy materials and ore) that are transferred inland could be distributed to ports in the Hebei area. Bulk cargo transfer of foreign trade materials from inland could be distributed, and some moderate general cargo transfer could occur, in order to concentrate on international container transportation.

In the meantime, relying on the advantages of location, transportation, and information, Tianjin Port should reinforce its infrastructure, build a seaport and airport international logistics center, develop a Logistics Park, specialization logistics center, and distribution center, and form a modern logistic network by constructing a logistics information platform in order to promote its function in modern logistics and trade service.

4.2. Regional Hub Port: Qinhuangdao Port and Caofeidian Port

Qinhuangdao Port and Caofeidian Port should take full advantage of their high degree of specialization to further the development of a regional port and transportation hub for energy material and raw materials. They should hasten construction of port areas and improve the network for collection, distribution, and transportation. By developing the logistics of bulk cargo (e.g., coal and iron ore) and near-sea container transportation, these two ports can become the outport of the Tianjin International Logistics Center. Qinhuangdao Port's specialization gives it an advantage over the Tianjin port, while its selectivity gives it an advantage over the Huanghua Port. It should strategically reform the use of berths, types of coal, and the marshalling yards. It should also employ multiple means and adopt computer technologies for all processes. This will allow it to reach the highest level of efficiency, and ensure convenient operation.

Caofeidian Port has a sophisticated highway transportation system. Its deepwater advantage and geographical location make it an ideal place to develop large-scale heavy chemical industries such as iron and oil. Recently, an oil field has been found at Nanbao near Caofeidian Port, and Shougang Group is building new factories in the industrial park of Caofeidian Port. Consequently, Caofeidian Port is expected to become a port mainly for the transportation of oil, iron ores, and containers. A comprehensive transportation network should also be constructed to make Caofeidian Port complement Tianjin Port.

4.3. General Feeder Port: Jingtang Port and HuangHua Port

Jingtang Port is also located in Tangshan City and, therefore, has the same geographical location advantage as Caofeidian Port. It is expected to have an increased investment environment, develop the capability for container transportation, and have enhanced absorbing capacities for its resources. Jingtang Port should emphasize the construction of a modern open logistics service system and logistics network system to widely influence the eastern Hebei area.

Huanghua Port is strong in coal output. Relying on Shenhua Group's integrative management advantage of coal production and distribution, railway transportation, and port transferring, Huanghua Port could establish a large-scale coal port area with a high degree of specialization. Huanghua Port is expected to strongly support the hinterland's economic development and near-port industry.

5. Conclusion

This paper used factor analysis to analyze the strengths of ports in the Tianjin and Hebei areas, and proposed strategies for port decision-making. The ports should take advantage of their individual strengths so that they may complement each other, thereby increasing overall competence of ports in the area. The proposed strategy is to form a regional international logistics center in Tianjin Port (as the region's core), establish Qinhuangdao Port as a backbone, Huanghua Port and Jingtang Port as bases, and Caofeidian Port as a focus. The regional international logistics center will centralize and scale shipping elements, as well as assume a significant position in international container transportation and energy material transportation. This configuration will provide economic and social benefits through enhanced port cooperation and resource allocation, as well as infrastructure investment and hinterland economic development. Future research should focus on better quantifying the factors/indexes that can influence port logistics competition in order to further improve port decision-making.

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