ADB Project Document

TA–9036: Strategy for Liaoning North Yellow Sea Regional Cooperation and Development

Technical Report 4: Liaoning's Port Resources Management

September 2017

This report was prepared by Wang Weiguang under the direction of Ying Qian and Philip Chang.

We are grateful to Wang Jin and Zhang Bingnan for implementation support.

Special thanks to Edith Joan Nacpil and Zhuang Jian, for comments and insights.

Li Xiaomei, Zang Hongmin, Hu Huiya and Kang Peng provided indispensable research assistance

ASIAN DEVELOPMENT BANK

Asian Development Bank
6 ADB Avenue, Mandaluyong City
1550 Metro Manila, Philippines
www.adb.org

April 2015

ISSN 2313-6537 (Print), 2313-6545 (e-ISSN)
Publication Stock No. WPSXXXXXX-X

Note: In this publication, the symbol “$“refers to US dollars.

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Executive Summary

There are over 100 international and domestic shipping routes in Liaoning's cluster ports, covering over 300 ports and regions worldwide, undertaking about 98% of the import and export of internationally traded goods in the northeastern region, involving specialized oil, ore, containers, grain, coal, groceries and roll-on-roll-off (ro-ro) wharfs. Among these cluster ports, a hierarchical layout has been gradually formed with Dalian and Yingkou ports serving as the main ports, Dandong and Jinzhou ports as regionally important ports as well as Panjin, Huludao and Suizhong ports as general ports. However, Liaoning's port resources are facing a series of problems and challenges, including the mismatch between port resources and operations, severe homogeneity of port projects, fierce competition among ports and structural overcapacity and lack of supporting infrastructure etc. Ports are strategically important resources to Liaoning's development, acting as the economic engine while cities serving as important support for the development of ports and industries. How to integrate port resources in Liaoning Coastal Economic Belt, reduce internal competition, enhance the core competitiveness of Liaoning's port cluster, and elevate the port cluster's competitive position in Bohai Economic Rim, Northeast Asia and the world at large have become important practical problems that need to be solved.

By DEA analysis on the operation efficiency on Dalian port, Yingkou port and Jinzhou port, it has been observed that Dalian Port has shown the trend of declining first and then rising in recent 10 years; In 2007 and 2015, its overall efficiency value was 1 and achieved DEA efficiency, indicating that Dalian Port was at the forefront of production and had high operation efficiency in these two years; the overall efficiency value of Yingkou Port in recent 10 years fluctuated around 0.85, and reached DEA efficiency value of 1 in 2016. Yingkou Port may need to adjust its input structure to increase the overall efficiency value. From the pure technical efficiency i in 2014, 2015 and 2016, the port of Jinzhou has been viewed as efficient according to DEA. Compared with the ports of Dalian and Yingkou, the average pure technical efficiency of Jinzhou Port is relatively low, but it is very close to being efficient, indicating a high level of technology.

Through comparative analysis on operation efficiency of Bohai Rim region, Yangtze River and Pan-Pearl Delta River, Tianjin Port exhibits the highest overall, technical and scale efficiency among those port logistics enterprises, followed by Tielong Logistics, Rizhao Port, Yingkou Port, Jinzhou Port and Dalian Port. Empirical results indicate that the overall, technical and scale efficiency of Shanghai Lingang and Nanjing Port in the Yangtze River Delta region and Yantian Port, Xiamen Port and Xiamen International Airport in the Pan-Pearl River Delta region all reach the DEA optimal level.

By looking into both the current resources and operation efficiency along with resource integration and RCI, the technical study has come up with a series of proposals, including RCI into the OBOR initiative, innovate mechanism development, enhance operation efficiency, optimize resource allocation, realize scaled operation and technological efficiency; learn from international advanced experience, upgrade service efficiency; speed up industrial transformation and enhance informatization.

The study summarizes its conclusions in the end of the report.

By methods of literature analysis, field visits and investigation and quantitative evaluation, and through the quantitative evaluation method, niche theory and the comparative advantage theory, the study looks into the technical efficiency of Liaoning's port operation, pure technical efficiency and scale efficiency. Questions such as how to implement the input and output of resources to maximize operational efficiency is researched so as to find the improvement direction of port resources management, thus enhancing the functions and transport capacity of Liaoning's ports and meeting the demand of regional logistics integration (including logistics demand generated by the implementation of Japan-Mongolia Economic Partnership Agreement).

I. Introduction

A. Context and Objective of the Study

1. Ports are significant strategic resources for the development of Liaoning Province. As the only coastal province in Northeast China, Liaoning serves as an important channel to the sea for the three northeastern provinces (namely Liaoning, Jilin and Heilongjiang) and the four leagues (or three cities and one league) in Inner Mongolia (namely Chifeng, Tongliao, Hulunbuir and Xing'an League). With its abundant port resources, Liaoning also connects the water and land transport in the northeastern region. As China introduced *Several Opinions of the CPC Central Committee and the State Council on Comprehensively Revitalizing Northeast China and Other Old Industrial Bases*, Liaoning has ushered in a major historic opportunity for a new round of development and revitalization. In particular, after the publication of *Vision and Actions on Jointly Building Silk Road Economic Belt and 21st-Century Maritime Silk Road,* Liaoning has seized the favorable timing presented by the Belt and Road Initiative to: make full use of its location advantage of being along the coast and as the hinterland of Northeast Asia so as to promote its logistics development, changing the "big but not strong" situation in logistics in the region; actively participate in the construction of China-Mongolia-Russia Economic Corridor (CMREC); promote the interconnected development between the ports and the cities; undertake echelon industrial transfer, link domestic big markets; and develop "Liaoning-Manchuria-Europe" and "Liaoning-Mongolia-Europe" shipping channels, thus forming a new landscape of opening up to the outside world and integration of regional cooperation. This report is significant for the improvement of the practical and theoretical efficiency of Liaoning's logistic resources as well as to its economic development, which can, on the one hand, make up for the shortcomings of the existing theoretical research and, on the other hand, solve the major practical problems in Liaoning's current economic development.

2. At present, there are over 100 international and domestic shipping routes in Liaoning's port cluster, covering over 300 ports and regions worldwide, undertaking about 98% of the import and export of internationally traded goods in the northeastern region, involving specialized oil, ore, containers, grain, coal,

groceries and roll-on-roll-off (ro-ro) wharfs. In the cluster, a hierarchical layout has been generally formed with Dalian and Yingkou ports as the main ports, Dandong and Jinzhou ports as regional important ports as well as Panjin, Huludao and Suizhong ports as general ports. After a survey of the development path of the containers in important ports such as Shanghai, Tianjin, Qingdao, Guangzhou and Dalian Port, the number of containers normally exceeds 100,000 within 7-12 years, 500,000 within 15-19 years, 1 million within 17-21 years, and 2 million within 20-25 years. It generally takes 5-9 years, 2-5 years, and 3-4 years respectively to go from 100,000 to 500,000, from 500,000 to 1 million and from 1 million to 2 million.

3. However, Liaoning's port resources are facing a series of problems and challenges, including the mismatch between port resources and operations, severe homogeneity of port projects, fierce competition among ports and structural overcapacity. In 2015, in the three northeastern provinces, the degree of dependency on foreign trade was 14.6%, 21.8 percentage points lower than the national average; their total import and export volume took up 3.4% of the country's total; the import and export volume of new and high-tech products in Liaoning and Jilin accounted for 9.6% and 10.9% of the total foreign trade volume respectively, 20.8 and 19.6 percentage points lower than the national average. Ports are strategic resources of great significance to Liaoning's development with port industries as the driving force and cities as important support for the development of ports and industries. Currently, how to integrate port resources in Liaoning Coastal Economic Belt, reduce internal competition, enhance the core competitiveness of Liaoning's port cluster, and elevate the port cluster's competitive position in Bohai Economic Rim, Northeast Asia and the world at large has become an important practical problem that needs to be solved. Based on the above, this report comprehensively studies Liaoning's port resources management to provide support for the overall revitalization of the old industrial bases in Liaoning through the integration of its port resources and regional cooperation on the integrated development of ports, industries, and cities.

B. Research Rationality and Methodology

4. This report is divided into 6 parts. Part I is an introduction to the background and purpose of the report, the ideas and methods, definitions of related concepts and the functional orientation of port logistics, including transport and transshipping, service, trade, national defense and military functions.

5. Part II gives an overview of Liaoning's port resources development, including the port development status, its layout and planning, infrastructure building, and problems in port resources management, and proposes a comprehensive assessment approach to Liaoning's port resources.

6. Part III evaluates the operation efficiency of Liaoning's core ports, including Dalian, Yingkou and Jinzhou Port. Aspects to be analyzed include the status of port operation, internal and external environment, influencing factors, the scale efficiency of technologies and input-output resources, etc.

7. Part IV compares and analyzes the operation efficiency of ports in Bohai Economic Rim, the Yangtze River Delta region and the Pan Pearl River Delta region, including an input-output redundancy analysis of the optimization of the efficiency of state-owned logistics enterprises in the three regions mentioned above.

8. Part V covers the measures and suggestions to improve Liaoning's Port Resources management, including innovating systems and mechanisms, optimizing port resources allocation and port structures, establishing Liaoning Port Group, constructing "Liaoning-Manchuria-Europe" and "Liaoning-Mongolia-Europe" corridors as well as the North-east Passage, promoting the port informatization level and speeding up the development of talent teams.

9. Part VI is the conclusion of this report.

10. The report adopts the methods of literature analysis, field visits and investigation and quantitative evaluation. The method of quantitative evaluation mainly uses data envelopment analysis (DEA), which overcomes the subjectivity of qualitative methods such as analytic hierarchy process and fuzzy comprehensive evaluation. Through estimating effective production frontiers based on the observed values

of input and output, whether the corresponding point of the decision unit is located on the effective production frontier can be judged using linear programming and meanwhile a lot of useful management information obtained. Through literature analysis and field visits and investigation, the development status of and main problems in Liaoning's port resources management are analyzed; through the quantitative evaluation method, niche theory and the comparative advantage theory, the technical efficiency of Liaoning's port operation, pure technical efficiency and scale efficiency are analyzed, and meanwhile how to implement the input and output of resources to maximize operational efficiency is analyzed so as to find the improvement direction of port resources management, thus enhancing the functions and transport capacity of Liaoning's ports and meeting the demand of regional logistics integration (including logistics demand generated by the implementation of Japan-Mongolia Economic Partnership Agreement).

C. Definitions of Related Concepts

1. Definition of port logistics and its characteristics

11. Modern logistics is in essence a comprehensive system linking transport, procurement, storage, manufacturing, distribution processing, sales, service and information, which is a circulation activity based on clients' demands to rationally arrange and meanwhile effectively control service costs. Port logistics is the logistics formed in the process of loading and unloading, transport, storage, processing and so on. Modern port logistics also includes many financial services such as financing, insurance and many other services that just thrive in recent years, with emphasis on seamless connection between all logistics links. In short, the functions of port logistics are the operation and composition of modern logistics at ports, which are to realize goods transport, storage, distribution, processing, packaging, customs declaration, commodity inspection, insurance and modification of commodity information, such as service exchange in the whole supply chain. With the support of information technology, the goal is to optimize the integration of port resources and to make the comprehensive port service system cover the entire supply chain.

12. Port logistics is different from other types of logistics because of its unique geographical position, whose uniqueness lies in:

a) Firstly, internationalization.

13. With the development of globalization and integration of world economy, ports are playing an increasingly more important role in transport as connecting points. Many large ports have made international logistics services their priority. Distribution centers provide one-stop service for imported goods, with some even offering order and charge services.

b) Secondly, multi-functionality.

14. Port logistics is developing toward an intensified and multifunctional one. An integrated center will be set up to provide storage, transport, goods preparation, distribution, and other services. Service functions of ports will be strengthened to promote the production and sales based on the specialized division of labor, shifting from the multi-level circular road transport, goods warehousing and wholesaling them to the retail points to providing integrated services in the port and door-to-door customer services, thus increasing social economic benefits.

c) Thirdly, systematization.

15. Port logistics is spreading toward production and customers and has gained new contents, from the unitary function of storage and transport to possessing various functions combining storage, transport and so on. The subsystems control the flow of all goods so as to realize the maximization the benefits or reduce costs and satisfy customers' ever-changing needs.

d) IT applications.

16. Global economic integration enables products and production factors to circulate at a fast speed worldwide. The popularization of advanced electronic science has increased the logistics efficiency, making commodity circulation much easier and faster.

e) standardization.

17. Port logistics requires standardization in the process, namely, applying international standards in the circulation of commodities, which makes it convenient to join in regional, international logistics systems as well as the economic cycle of materials.

2. Domestic and foreign research on the efficiency of port resources management

18. The concept of logistics was originally put forward by the military logistic support services in WWII, after which this concept was applied to the economic realm. In China, the concept was first adopted in 1980s. Logistics enterprises refer to economic organizations who at least undertake either transport or storage business and can organize and manage transport, storage, loading and unloading, packaging, distribution processing, distribution and other basic functions according to customers' needs. Efficiency, from the perspective of management, refers to the ratio relationship between various outputs and input values, generally including technical efficiency, scale efficiency and comprehensive efficiency. Technical efficiency is the ratio of an enterprise's possible input and actual input on the premise of the same output. British scholar Farrell was the first one to measure technical efficiency. Scale efficiency refers to the variable relationship between output increments and input increments. When the input increment is greater than output, it shows diminishing returns to scale. When the former is less than the latter, it shows increasing returns to scale. Comprehensive efficiency is Pareto efficiency, which investigates the optimization of resource allocation [1]-[2].

19. Foreign scholars have made many researches on the efficiency of logistics enterprises. As early as in the 1960s, American and European scholars started to explore methods to evaluate the efficiency of logistics enterprises. Carlos (2015) used the production frontier analysis to conduct an empirical research on the efficiency of a Portuguese port according to the sample data of the port. The result showed that the inefficiency of management was the main reason for the low efficiency of the port [3]. Trujillo (2007) conducted an empirical research using SFA on the sample data from 22 port enterprises [4]. Liu (1995) established a stochastic frontier production function model[4] for the evaluation of port enterprise efficiency through the panel data of 28 British port enterprises between 1983 and

1990, with the turnover as the output index, the total amount of wage payment as human resources input, and the net book value of fixed capital as capital input. Zhang Fuming and Meng Xianzhong (2010), using super efficiency DEA method, analyzed the efficiency changes of our publicly listed logistics enterprises. By calculating the Malmquist TFP index, they commented on the sustainability of their efficiency and analyzed the dynamic change trend of their efficiency. After empirical research, they concluded that the efficiency of Chinese listed logistics enterprises is fairly low at present with the contribution rate of technological progress greater than that of scale efficiency [6]. Kong Yuan (2013) used two-stage DEA approach to measure the operation performance based on the sample data of 32 publicly listed logistics enterprises. The result showed that: the efficiency of our logistics enterprises are on the decline in the long run; the main reason for the high scale efficiency is the fast expansion of external market demand; the low pure technical efficiency of those enterprises led to the decrease of operation efficiency year by year[7]. Zhang Yi, Li Jingfeng and Niu Chonghuai (2013), on the basis of the latest progress in diversification strategy research in recent years, took cost efficiency as the mediator variable of the diversification strategy and performance of Chinese listed logistics enterprises to test whether it had functioned well. The result showed that the diversification strategy exerts a marked influence on cost efficiency and enterprise performance [8]. Ma Yueyue and Wang Weiguo (2015) studied the total factor productivity of China's regional logistics industry using metafrontier Malmquist-Luenberger (MML) index and combined this with the "ratio of technical gap" to measure the gap between the logistics production technology in the three regions and the potential optimal level countrywide. The result showed: the overall technical efficiency of China's logistics industry is generally low; the differentiation among regional and inter-provincial logistics productivity levels is obvious; the optimal production technology has been realized in the east and the middle and western regions are still lagging far behind [9].

20. After a review of literature, it can be seen that literature related to the research methods of logistics efficiency mainly employ quantitative and qualitative methods and that the quantitative evaluation method includes the single-objective and multi-objective methods. The commonly used are the analytic hierarchy process (AHP), fuzzy comprehensive evaluation, principal component analysis,

SFA method and data envelopment analysis (DEA). Among them, SFA and DEA are the main methods to evaluate efficiency, both of which belong to frontier analysis. In DEA, there are CCR (constant returns to scale) and BCC (variable return to scale) models; through estimating effective production frontiers based on the observed values of input and output, whether the corresponding point of the decision unit is located on the effective production frontier can be judged using linear programming and meanwhile a lot of useful management information can be obtained [10] - [12]. It overcomes the subjectivity of qualitative methods such as analytic hierarchy process and fuzzy comprehensive evaluation. Therefore, it is superior to other methods. This report analyzes the competitiveness differences between state-owned logistics companies in different regions from the perspective of efficiency based on the panel data of 18 A-share listed logistics companies and proposes corresponding ways of reform, providing valuable reference for the development of logistics enterprises in different regions.

3. Port resources

21. Port resources refer to natural resources such as coasts, bays, river banks and islands that meet the navigation and mooring conditions of ships of specific specifications and possess port construction and land conditions for port construction and use under specific standards as well as certain port hinterland conditions, which are critical to the construction and development of ports. Requirements for port resources development include: (1) Navigation conditions. It must be ensured that ships of specific specifications safely and quickly sail in and out of the harbor regardless of season and time; (2) Mooring conditions. Sufficient water should be available for vessel anchoring and mooring as well as loading, unloading and refuting operations; (3) Port construction and land conditions. Plane layout of various equipment, facilities and other structures as well as the feasibility and availability of connecting them with the hinterland under surrounding natural conditions should be satisfied; (4) Hinterland conditions. It refers to the size of the hinterland, the transport conditions between the port and the hinterland, the abundance and development level of various resources in the hinterland, its economic development level and structure and the major production and marketing links.

22. Due to their different geographical locations and surrounding natural environment, port resources fall into different types. According to geographical locations, there are four types, namely coasts, islands, estuaries, and inland rivers. According to their causes, dynamic processes and different forms, coasts can be divided into five types, namely the smooth coast, the sea eroded outer bay, the sea eroded basin, the sea eroded bay reef and the sedimentary coast; islands can be divided into the island near the land and the oceanic island according to the distance from the continent; according to differences in geological structures, estuaries can be divided into the river delta estuary and the islet delta estuary.

4. The Silk Road Economic Belt and the 21st Century Maritime Silk Road

23. On September 7th, 2013, President Xi Jinping proposed the concept of the "Silk Road Economic Belt" in the speech delivered in Steiner Zal University of Kazakhstan Nazarbayev. Later on October 3rd, President Xi stated when addressing the Congress of Indonesia that China is ready to strengthen maritime cooperation with ASEAN countries and jointly build the 21st Century Maritime Silk Road, opening up China's new economic strategic layout, namely, the Belt and Road Initiative. The construction of the Maritime Silk Road will have a profound influence on ports and their surrounding cities, and will also improve the quality of the functions of ports and cities. With the outbreak of the global financial crisis, China's port industry has been unprecedentedly impacted. The problems of disordered competition and structural overcapacity in ports have been gradually emerging and port development started to slow down. The Belt and Road Initiative provides a good opportunity for the restructuring of ports and a huge market for solving overcapacity. In the long run, this initiative will expand the supply market for ports, particularly, topographical and regional hub ports, enhance interaction and trade with industries in the economic hinterland and markedly promote the throughput of the ports.

D. Functions of Port Logistics

1. Transport and transhipment function

24. The function of transport and transhipment is the most basic function in the integrated logistics network system, providing transport service to passengers

and cargoes. A port cannot immediately handle all the goods transported to it by land or water. Instead, it needs to provide loading and unloading services to the cargoes at the port, temporary storage in the warehouses, reprocessing of the goods and other services. In the end, all goods are to be transferred to other means of transport and continue their journey, which reflects the transhipment function of ports. The transportation and transhipment function of a port is mainly measured by the length of residence time of vehicles, ships and goods there; the shorter the time, the better the co-operation between the vehicles, ships and goods, the higher the efficiency of loading and unloading, and the stronger the functions of transport and transhipment of the port.

2. Service function

25. When a ship docks at a port, the port is expected to provide a series of services, including but not limited to: pilotage for the ship; water supply; refuelling; providing supplies for the crew; maintenance and repairing of the ship; preparation against bad weather at the sea and salvage; handling, storing and reprocessing of cargoes for their transhipment; etc. The service function is also one of the important functions of port logistics, not only guaranteeing the normal and safe operation of the ships in need of port services and providing two-way information for the ships and the goods to help strike deals, but also providing necessary port services for non-cargo ships. On the one hand, the service quality and efficiency of a port will affect its transhipment function; on the other hand, it will directly affect the customers' comprehensive evaluation of the port and ultimately affect the port's development.

3. Industrial function

26. The industrial function of ports is the premise and guarantee for the development of the industries around the ports and along the coastal areas. Ports can provide necessary raw materials and fuels for the industrial development in these areas, and facilitate the long-distance sale of the finished and semi-finished goods through the transport and transhipment services of the ports. At present, most countries in the world have specialized industrial docks for the processing of raw materials, and production and export of manufactured goods. When all the facilities in a port are serving industrial production, it is called an industrial port.

4. Trade function

27. Ports are the hubs of domestic and foreign business network. The trade function of ports is generally reflected in the economic and trade links established by the ports with other countries. Ports can facilitate and support the export of most goods and commercial exchanges. When the prices of a country's production factors are low, other countries will import such low-cost production factors to reduce the overall cost of production. Due to the advantages of the large volume and low cost of sea transport, it has become the major way for importing most production factors. For instance, a big proportion of China's total foreign trade volume is imported and exported by sea transport through ports.

5. National defence and military function

28. The defence and military function of ports is not just for war years. In peacefultime, such function of ports is also irreplaceable. During war years, specialized military ports are built to meet the needs of the combat forces for military items and daily necessities, while in time of peace, military wharfs and berths will also be set up at most ports for military transport.

29. By analysing the functions of ports, it can concluded that: the quality of the service function of ports will directly affect their attractiveness to customers; the transport and transhipment function will affect the residence time of vehicles, ships and goods at the ports, thus affecting the transport cost of both the ships and the goods, which will in turn affect the attractiveness of ports to customers. The development of ports can drive the development of the industries around them and along the nearby coast. The industrial function of ports contributes significantly to the prosperity of regional economy and trade, which is demonstrated by the phenomenon that ports are usually surrounded by large industrial belts; the trade function of ports will affect the investment environment of related industries in that a well-developed trade service function will boost confidence in foreign investment in the port and its surrounding areas; and the national defence and military function can ensure the stability and peace of a country. Therefore, the functions of transport and transhipment, service, industry, trade as well as national defence and military function of ports should be given full play so as to enhance their competitiveness.

E. Analysis of the development of ports: efficiency-benefit

30. The fundamental role of a port is a gateway for trade. Without this role, goods could not be exchanged at the port, and transport would stop. For port enterprises, logistics is their life, their source of benefit. The following is a discussion on the relation between efficiency and benefit under the premise of normal logistics.

31. First, efficiency is the core factor of a port. On many occasions, especially when certain goods are undersupplied, traders can always transfer prices during the process of exchange, so they do not necessarily pay primary attention to prices. Instead, traders and logistics enterprises take efficiency as their core goal, and time prevails over price as the primary factor. With the development of the economy and society, the prices of commodities are no longer determined by its rarity, and mass production of diversified goods has driven the enterprises to shift from skim pricing to sales and promotion strategy, leading to the lowering of prices. Given this, benefit can only come from efficiency. Therefore, high attention must be paid to efficiency for the development of ports, for without efficiency, the ports will be gradually phased out.

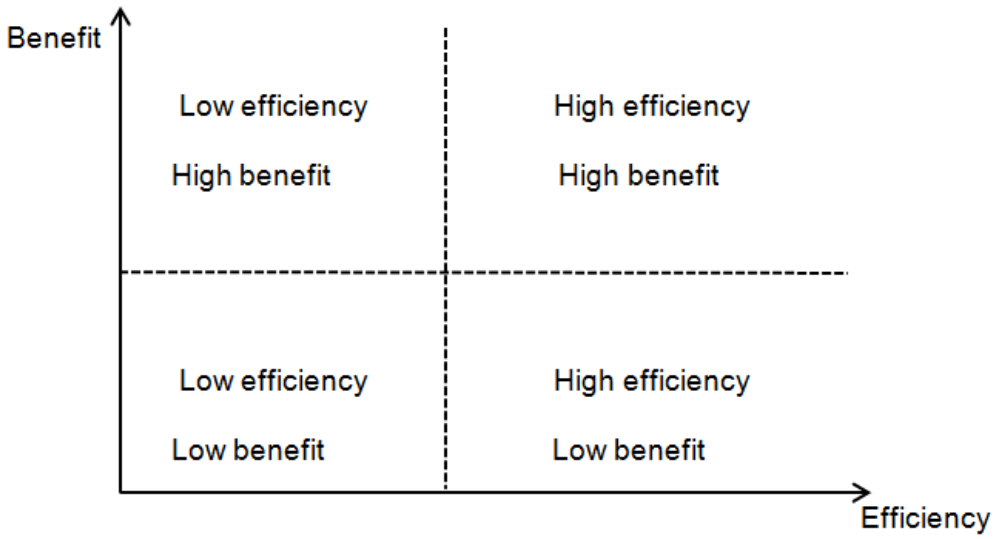


Figure 1 Diagram on the efficiency-benefit relation of ports

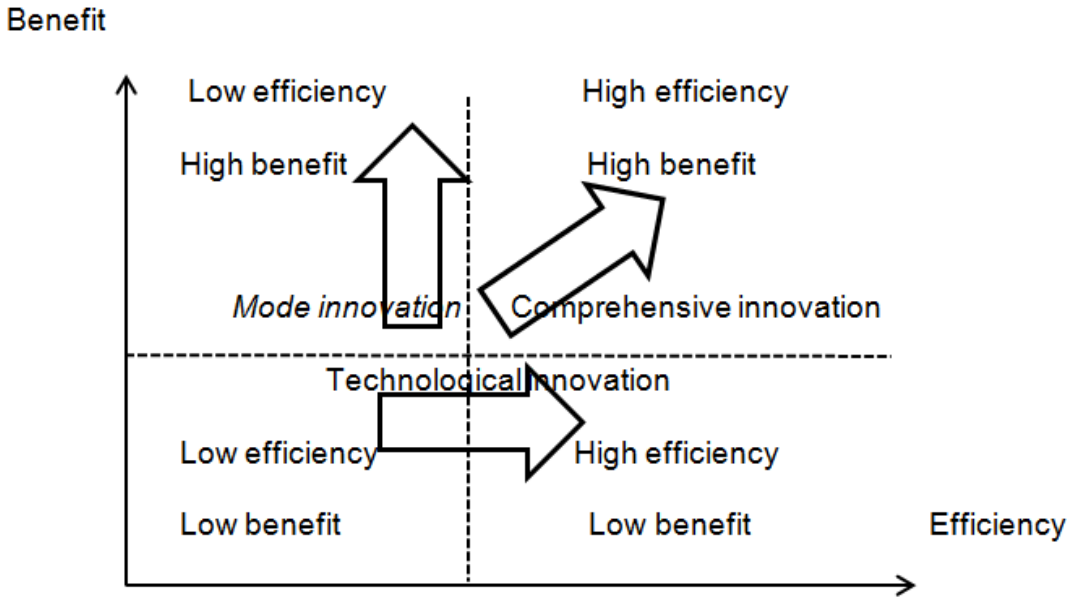


Figure 2 Diagram on the stages of evolvement of port enterprises

32. Figure 1 shows the four states of the efficiency-benefit relation, basically covering the development phases of all types of ports. Meanwhile, we can also see clearly from it the development phase of a specific port and its future goals. The state of low efficiency and low benefit refers to the phase of port enterprises when they have backward facilities and charge low prices. Such port enterprises can only attract traders who value the fluctuation of prices very much but have no strict requirements to keep the goods within their expiration dates. This mainly occurs to the trading of traditional goods. For port enterprises at this phase, a slight rise in their efficiency will bring significant benefits and sense of satisfaction to traders. The mode of low efficiency and low benefit can be transformed to the mode of high efficiency and low benefit through technological innovation, or to the mode of low efficiency and high benefit through service innovation, as is shown in Figure 2.

33. The state of high efficiency and low benefit means that thanks to technological innovation, the efficiency of the port has been improved, better satisfying the primary product traders and thus bringing in more benefit. However, due to the low added value of the primary products, traders can barely accept the high-price service, so the port has no choice but to maintain the state of high efficiency and low benefit. This is the phase of basic maintenance. Such goods are often

affected by the fluctuation of their prices, so any drastic changes in the international commodity prices will lead to dramatic changes in the shipping orders of the port. In particular, when other ports lower their freight and miscellaneous charges, new small ports are built or new roads (railways) to the port are built, it will exert a great impact on the existing port. At present, many domestic ports and cargo wharfs are still at this phase.

34. The state of low efficiency and high benefit occurs mainly after service innovation, and as the service mode is renewed, the pricing of the service shows distinctive features of the phase, which is often higher. Meanwhile, as the service is new, it is easier to be accepted by customers, and as there are few followers or competitors, there is little comparability or reference for the pricing, the port enterprises have a bigger say in it. However, as the service mode is newly developed, the port cannot operate with its optimal efficiency, which means there is big potential for improving the efficiency through technological innovation and upgrading. Therefore, this phase is defined as the low-efficiency-high-benefit phase.

35. The phase of high efficiency and high benefit is direction and goal for the development of ports, and is also the optimal state for the future construction and development of ports. For now, there may be few ports at this phase, but it is the ultimate goal for all port builders. At this phase, the port service is very efficient and the price is relatively high, bringing remarkable benefit to port enterprises, especially at the stage of rapid social and economic development and general prosperity.

36. The four states of ports mentioned above are not fixed forever. With the overall economic and social development, a port may adapt itself to the development and transform from the state of low efficiency and low benefit to that of high efficiency and low benefit. However, if port enterprises do not make continuous improvement, a port may also degenerate from the high-efficiency-low-benefit phase to the low-efficiency-low-benefit phase.

II. Overview of Port Resources of Liaoning Province

A. The Layout and Development Plan of Ports in Liaoning Province

37. Liaoning province has planned a 1400 kilometers long, 30 to 50 kilometers wide, port-based Coastal Economic Belt, comprising 21 urban districts and 12 coastal counties under the jurisdiction of 6 coastal cities including Dalian, Dandong, Yingkou, etc. Liaoning provincial government has made a detailed plan for the layout of the ports along the coastline. There are 7 major ports in the province: Dalian, Yingkou, Jinzhou, Dandong, Huludao, Panjin and Suizhong Port, and 15 large-scale port areas – Dalian Port Area, Xianglujiao Port Area, Heizuizi Port Area, Dashihua Port Area, Ganjingzi Port Area, Heshangdao East Area, Heshangdao West Area, Sankuangzhongzhuan Port Area, Beiliang Port Area, Dayaowan Port Area and Nianyuwan Port Area of Dalian Port; Bayuquan Port Area of Yingkou Port; East Port Area of Jinzhou Port; Dadong Port Area of Dandong Port; Suizhong Port Area of Huludao Port. At Present, a general development layout has taken shape based on Dalian Port and Yingkou Port, supported by Jinzhou Port and Dandong Port and supplemented by Huludao Port, Panjin Port and Suizhong Port.

38. The hinterland of Dalian Port includes the provinces of Heilongjiang, Jilin and Liaoning, and the east area of Inner Mongolia, for which Dalian Port serves as a major transhipment port for the transport of raw materials and energy. It is also an important port for Dalian Northeast Asia International Shipping Centre. Dalian Port, focusing on the port areas in the “One island and three bays” (namely Changxing Island, Taiping Bay, Daya Bay and Dalian Bayarea) and the Changxing Island Port Area, has established 7 specialized transport and transhipment systems for containers, petroleum, iron ore, grains, commercial vehicles, ro-pax and cruise ships, and built 4 port-centered coastal industrial bases featuring respectively petro-chemical industry, facility manufacturing, ship building and shipping commerce, which have formed a well-functioning modern port service system, laying a solid foundation for Dalian Northeast Asia International Shipping Center.

39. Yingkou Port mainly takes Shenyang Economic Circle (Shenyang, Fushun, Anshan, Liaoyang, Benxi, Yingkou and Tieling) as its hinterland, and is an

important transhipment port for the transport of raw materials and energy for Liaoning Province, as well as a key feeder port for containers. Centering on Bayuquan and Xianrendao Port Area and focusing on the transport of domestic trade containers, iron ore, petroleum, iron and steel, Yingkou Port has comprehensively developed its transport capacity for grains and groceries, expanded its modern port services, port functions and port-based industrial functions, gradually growing into a comprehensive port with advanced facilities, well-developed functions, efficient management and high level of safety and environmental friendliness.

40. The hinterland of Dandong Port mainly covers the eastern part of Liaoning province. The construction of the supporting technological transport channels has enabled the port to expand its hinterland effectively to Jilin Province and east of Heilongjiang Province, thus becoming important strategic resources of Dandon city and eastern Liaoning area for promoting their economic competitiveness and pushing forward the process of economic globalization. Based on Dadong Port Area and Haiyanghong Port Area, Dandong Port aims to serve the eastern area of Northeast China by developing port-centred industries. Focusing on the transport of coal, metallic ores, grains, oil products and containers, the port has gradually developed into a comprehensive multifunction port that is capable of handling passengers and cargoes, serving domestic and foreign trade.

41. Jinzhou Port has a hinterland covering the five cities of east Liaoning Province, the mid-western areas of Jilin and Heilongjiang Province and east of Inner Mongolia. It is a regional port of China as a key development area in the north and a key point for the development strategy of Liaoning Coastal Economic Belt. Based on Bijiashan Port Area and Longqiwan Port Area, Jinzhou Port focuses on the transport of bulk cargoes such as petroleum, coal and grain, as well as domestic trade containers. The port has gradually developed into a comprehensive multifunction port that is capable of handling passengers and cargoes and serving domestic and foreign trade, and concentrates on developing its logistics, trade, port and port-centred industrial functions, gradually growing into a comprehensive multifunction port.

42. Mainly serving the city they are based, Huludao Port, Panjin Port and Suizhong Port,are important pillars for local economic and social development and

gateways for opening up. Based on Rongxing Port Area, Panjin Port mainly develops petro-chemical industry and transports bulk cargoes, and has developed step by step into a comprehensive multifunction port serving both domestic and foreign trade.

43. With the implementation of the great strategy of revitalizing the old industrial base of the Northeast, ports in Liaoning have enjoyed a favorable environment for development. The advantages of the port cluster along the coast of Liaoning are further promoted, making it the most competitive port cluster in northeast Asia. In 2016, Dalian Port registered a cargo throughput of 355 million tons, representing a 5.5% growth year on year, and a container throughput of 9.441 million TEU, a year-on-year growth of 1.5%, making Dalian Port a modern, specialized and intensive port cluster with scientific layout, clear structure and precise distribution of work. In the same year, Yingkou Port registered a total throughput of 352 million tons, representing a 4% growth year on year, and a container throughput of 6.08 million TEU, a year-on-year growth of 2.8%. The throughput of other ports in Liaoning is also consistent with the economic growth trend of the province, indicating that the ports at present have strong business capability and outstanding performance in the actual business operation.

B. Status of the Management of Port Resources in Liaoning Province

1. Integration, merger and restructuring of the port cluster

44. In December 2008, Jinzhou Port made Dalian Port Corporation as its domestic strategic investor through the issuance of 246 million non-public shares at 7.77 RMB per share, which were acquired by Dalian Port Corporation with 1.911 billion RMB in cash, making the Corporation the 2nd largest shareholder of Jinzhou Port with 18.9% of the total share capital. This marks a formal “marriage” between Dalian Port and Jinzhou Port. In May, 2012, Jinzhou Port State-owned Assets Operation and Management Co., Ltd, the 3rd biggest shareholder of Jinzhou Port, transferred its 78.5579 million shares of Jinzhou Port (5.03% of the total share capital) to Dalian Port Corporation, making Dalian Port Corporation the biggest shareholder with 24.47% of the total shares. Besides, before 2012, Dalian Port Corporation had been continuously enhancing its relationship and cooperation with Dandong Port and Huludao Port through merger, restructuring,

joint venture and joint operation before retreating from the construction of Dandong Port and Huludao Port due to capital and other reasons and transferring the construction task to Yingkou Port.

45. In March 2007, Yingkou Port and Panjin Port jointly formed Panjin Port Co., Ltd, realizing the sharing of port resources on both sides of Liao River for common prosperity. In May 2012, Yingkou Port Corporation reached a framework cooperation agreement with Dalian and Dandong Municipal government on the construction of Dandong Haiyanghong Port Area. In June 2012, Yingkou Port Corporation respectively signed agreements with Huludao municipal government and Suizhong county government on the construction of Huludao Port's Liutiaogou Port Area and Suizhong Shihe Port. Since then, Yingkou Port has been accelerating its development. It took over the construction projects of Dandong Haiyanghong Port Area and Huludao Port's Suizhong Port Area so that it has port areas in Yingkou, Panjin, Huludao and Dandong city, 4 of the 6 cities in the Liaoning Coastal Economic Belt. In particular, Yingkou Port has built over 70 production wharfs for 9 types of goods – containers, vehicles, coal, grain, ores, steel, large facilities, crude oil, and refined oil and liquid chemical industrial products – at Yingkou, Bayuquan and Xianrendao Port Area in Yingkou city.

2. Status of the construction of port resources

46. As the construction of ports has become a key sector in the economic and social development of China and many development policies have been rolled out, Liaonong Province has new opportunities for the development of its ports. The construction of ports in the province is developing rapidly and the total scale continuously growing. The province has invested 5.37 billion RMB for the construction, a 72% year-on-year growth, and Panjin and Jinzhou Port have received remarkable capital investment. Upon the completion of modern ports, many deep-water berths have been put into production, gradually optimizing the port structure of Liaoning Province. Although lots of advanced technologies have been gradually adopted, there are still problems: there lacks priority in the construction, leading to repetition and waste of resources; and as there is no coordinated planning; the structures and functions of the ports are similar, limiting the future development of the ports and cities of Liaoning Province.

47. There are 196 production births in Dalian Port, of which 78 are above 10-thousand-ton level and 78 are specialized, enabling the port to prevail among the 7 ports in the Liaoning Coastal Economic Belt and win a place worldwide. At present, there are over 150 km of designated railways, 1.8 million square meters of goods yard, 1000 sets of loading and unloading machinery, 557,300 square meters of production storage area, 56,317,000 cubic meters of oil storage capacity, 2,881,800 cubic meters of silo capacity, 3,699,300 square meters of stock yard of which 1.04 million square meters are for containers. There are 35 tugboats and 10 engineering and technical ships in operation, more than 80 specialized berths for containers, crude oil, refined oil, grain, coal, loose ore, chemical products, passenger and cargo ro-pax, of which more than 40 are 10-thousand-ton berths.

48. Yingkou Port now has 61 berths for production, the biggest one being a 200,000-ton ore terminal. There are 4 million square meters of container yard, 3 million square meters of full-function Logistics Park with advanced facilities, and the port is equipped with thermostatic warehouses, steel warehouses, transaction warehouses for corn futures, bonded warehouses and export supervised warehouses capable of tax refunding upon entering.

49. There are 42 existing productive berths in Dandong Port with a coastline of 886 meters. No. 1 floating anchorage of Zhongshuidao, No. 6 floating anchorage, No. 14 and No. 1 anchorage of Xindao are respectively located at the estuary of Yalu River and Xindao Island, which are all sand-bottomed. The departure channel of Langtou Port Area is the Yalu River, which is 2-4 meters deep and equipped with navigation assistance facilities. The departure channel of Dadong Port Area is 10 nautical miles long with an average water depth of 9.1 meters. This Port Area has 10,400 square meters of production warehouse and 162,000 square meters of storage yard. There are 94 sets of loading and unloading machinery, the biggest one having a lifting capacity of 36 tons. There are 9476 linear meters of designated railways, 4 loading and unloading lines, adding up to a total of 4310 extension meters. In the next 3-5 years, Dandong Port will continue to improve its port functions and supporting facilities with the goal of building a logistics and transport hub in the eastern part of Northeast China and Northeast Asia. It will also enhance its automation, management and informatization level, and build

mega-level specialized deep-water berths and ancillary facilities for oil, ore, containers, grain, car ro-ro, cruise ships and others. More than 60 large-scale deep-water berths will be built, with an annual throughput of 400 million tons. By 2020, the throughput of Dandong port will have reached 500 million tons, making it a major port for integrated logistics and transactions in Northeast Asia.

50. The main channel of Jinzhou Port is 31 kilometres in length with a 320-meter-wide bottom and a -17.9-meter water depth, allowing the one-way navigation of load-shedding 250,000-ton oil tankers and the two-way navigation of 50,000-ton-and-below vessels. Jinzhou Port has set up three anchorages with an area of 32.31 million square meters and a water depth of -11 to -20 meters. The anchorages are all sand-bottomed, providing good anchoring force. The port has 24 berths, including a 250,000-ton oil berth, five 100,000-ton bulk cargo berths, four 100,000-ton container berths, with the largest one capable of docking 150,000-ton tankers and 100,000 tons of bulk cargo ships. The port is now using GPS system for piloting, which is capable of berthing operations around the clock. At present, Jinzhou Port is carrying out the expansion of No. 3 anchorage and the construction of No. 4 anchorage.

51. Huludao Port currently has a considerable scale of production and operation capacity, with 4 existing production berths, of which 2 are million-ton berths and the other two 5,000-ton berths. The annual integrated throughput of the port is over one million tons. It is a bulk cargo port mainly for transporting petrochemical products, grain and building materials. By far, Huludao Port has completed its first phase expansion project, and in the second phase, three 70,000-ton berths will be built and the original channels and dock basins with a total amount of work of about 14 million cubic meters will be expanded so as to provide access to 70,000-ton ships. The project is an important part of Liaoning Province's strategy of building a "five point and one line" coastal economic zone. Upon completion, the project will substantially increase the cargo throughput of Huludao Port and play an active role in promoting the economic development of Liaoning Province.

52. Yingkou Port has 9 types of specialized wharf for containers, automobiles, coal, grain, ore, steel, large equipment, refined oil, liquid chemicals and crude oil, of which the ore and crude oil wharfs are 300,000-ton ones, and the container wharfs are capable of docking the fifth-generation container ships. The main

cargoes handled in the port include iron ore, steel, coal, grain, non-ore cargo, refined oil, chemical products, fertilizers, crude oil, commercial vehicles for domestic trade, containers and so on. There are 4 existing direct foreign trade routes, namely Southeast Asia route, Japan Kanto route, South Korea Busan route and South Korea Incheon route (regular international route for passengers and cargoes). There are also 4 extended foreign trade routes bound for other cities around the world through Tianjin, Dalian, Ningbo and Shanghai. There are over 50 voyages monthly through the direct foreign trade routes and the extended domestic routes for foreign trade. The existing domestic container routes have covered 30 main ports along China's coast, and the frequency of the voyages has reached more than 420 per month, accounting for 2/3 of the traffic volume of the ports in the Northeast China. In particular, there are at least two ships to Guangzhou and Shanghai every day, and at least one to Ningbo, Fuzhou and Quanzhou.

53. The construction of Suizhong Port started in September 2012, and was planned to start with three 50,000-ton general berths of gravity block structure along 800 meters of coastline, covering a land area of 2.4 square kilometres with a designed annual throughput of 4.3 million tons. Since Suizhong Port was formally put into operation, it has greatly promoted the rapid development of port-centred industry in Huludao, and enhanced the strategic position of Huludao in Liao Ning Coastal Economic Zone and even in Bohai Economic Rim, optimized the strategic layout of ports in Liaoning province, improved the collection, distribution and transport system of ports in west Liaoning, and enhanced the overall service function of the port cluster, and provided important support and guarantee for the development and opening up of Liaoning Coastal Economic Belt.

54. The lack of coordination and cooperation between local governments and ports has caused duplication of ports and waste of resources. For example, Dalian Port has built a 300,000-ton ore wharf, yet Yingkou has also built a 200,000-ton one, and as Benxi Steel Group Corporation has been relocated to Dandong, Dandong also plans to build a 200,000-ton ore wharf. Similarly, both Dalian and Jinzhou have built oil wharfs, respectively of 300,000 tons and 250,000 tons, while Yingkou, Huludao and Dandong also plan to build oil wharfs.

3. The status of the internal management of ports

55. The internal management of Liaoning Port is loosely organized and inefficient. There's a lack of strategic positioning and planning with overlapping functions of several ports. Separately, each port is scientifically planned and designed, but the whole picture is a total mess: the hinterlands of the ports overlap with each other; the cargo supplies are the same; the development plans are similar; they all have wharfs for bulk cargoes, containers and oil with little differentiation. At the same time, the internal management of the port enterprises is also chaotic and lack of modern systems. Since 2012, the main persons in charge of Dalian Port, Yingkou Port and Jinzhou Port have been prosecuted due to violation of laws and regulations, which also shows the weak internal management of port enterprises and the urgent need to strengthen management.

4. The status of the supporting external resources of the port

56. At present, there is only *Port Law of the People's Republic of China* for the administration of ports in our country. The imperfect law system has led to many problems for the development of the ports in Liaoning Province. Although Liaoning Provincial Government has issued *Plans for the Layout of Coastal Ports in Liaoning Province*, yet on the whole, the province still has weakness in terms of its port management system and related documents. There are conflicts between ports and enterprises, the macro regulation of the government is not strong and there is no supervising administration. The "visible hand" of the government has weak control over port enterprises, and the macro regulation of the local governments, especially the provincial government, on the development of port enterprises needs to be strengthened, which can be seen from the following aspects: (1) all coastal cities have proposed "to develop the city by developing the port", and compete with each other with no dialogue mechanisms, while the provincial government has no unified administration over all the ports in the province; (2) some port enterprises in Liaoning Province are privately controlled, and private enterprises tend to pursue maximum profit. So the government is weak in coordinating these enterprises for port planning and construction.

C. Management Problems

1. The planning and layout of ports and the port systems and mechanisms in Liaoning Province

57. With the implementation of the Liaoning Coastal Economic Belt, it has become clear that the productive forces in Northeast China will become more concentrated in the coastal areas in the future. The port-centred industries will gradually agglomerate at multiple bases, putting forward new requirements for port transport services. At present, ports are intensively laid out along the transport channels, which will not be able to meet the needs of the coastal areas where industries tend to be scattered and the transport demand is fragmented. In addition, with the rapid construction of the railways in the eastern area of Northeast China and the channel to transport the coal in east Inner Mongolia through waterways, the sea passage in the northeast will no longer be confined to the Harbin-Dalian channel, but further diversified. In particular, the service areas of the ports on the east and west coast of Liaoning will be further expanded and their service function enhanced, and the role of the ports will change significantly. To this end, the layout of the ports needs to be adjusted accordingly and optimized. The development of new ports is an important measure to implement the Liaoning Coastal Economic Belt planning, but at present, there are still some problems such as too many in number and lack of focus. In order to further promote the coordinated development of new ports and coastal industries, and to rationalize the inter-relationship between new ports and the existing ports as well as between the new ports, it is necessary to further clarify the layout and positioning of the new ports. It is one of the important tasks of the coastal ports in Liaoning Province to make full use of the opportunity presented by the rapid development of the key new ports, actively adjust themselves to the redistribution of productive forces in coastal areas, and give full play to the leading role of the ports in the adjustment of urban planning, especially the urbanization of port areas. For example, as Dalian International Shipping Centre has made some achievements, compared with the shipping centres in Shanghai and Tianjin, its development process is slower and the development level is lower. In particular, the shipping equipment and facilities are smaller in scale and less intensive, and the shipping, logistics and port and other ancillary service systems need to be improved in general. The layout of the port needs to be further adapted to

changes in the distribution of productive forces along the coast and the integrated transportation system.

58. In addition, the internal ownership structure of port enterprises in the province is also complicated, and there are some differences between enterprises in their management systems. Meanwhile, for some of the ports, the cities where they are based have a certain weight of ownership by the SASAC. As a result, the port enterprises have great reliance on local governments, and even local governments may directly participate in the internal operation and management of the port enterprises through the port authority. In the process of effective integration and management of port resources, the local governments place more emphasis on long-term social and economic benefits. Therefore, they tend to realize rational development of port resources and the sharing of resources through coordination of port functions and scientific investment so as to promote the coordinated growth of regional economy. On the contrary, what the port enterprises pursue is the maximization of profit. Thus it can be seen that the diversification of participants in the management of port resources based on their respective economic interests will lead to dual failure of the market and government regulations. This will result in the government not being able to enhance social benefits by leveraging port resources, and the enterprises not being able to achieve optimal allocation of operational resources. In the course of port resources management, it involves the interests of many industries and sectors such as relevant regulatory departments, transportation and port-centred industries. As a result, the management of port resources will inevitably be overwhelmed by the interests of different parties or sectors. Therefore, it is an urgent problem to be solved for the port development of Liaoning Province as to how to strengthen the coordination between port authorities in different cities and break the barrier of administrative division.

2. Unreasonable positioning of the ports

59. At present, the positioning of the ports in Liaoning Province is unreasonable, and they are having more competition than cooperation with each other. As a result, there are some discordant factors in the process of development of the ports. The ports, driven by their own interests and divided by the administration system, have neither unified planning for their construction nor clear and reasonable

cooperation relationship. Port enterprises continue to increase their investment, blindly enhancing the throughput of containers, and unreasonably expanding deep-water wharfs, leading to the similarity of port functions and causing serious waste of resources. In addition, types of goods in the major ports in Liaoning Province are similar: the main types of goods in Dalian Port are grain, steel, metal ore, petroleum and coal; in Yingkou Port they are metal ore, fertilizer, grains, coal and steel, and in Jinzhou Port, they are oil, minerals, coal and grains. It can be seen that similar port functions and a homogeneous business models cause harsh competition between ports, making it impossible to create scale merits or raise profits.

3. Port resources and structural capacities

60. When the transport authorities develop and utilize port coastlines, the wharfs are often developed in a continuous manner with a high utilization rate of the coastlines. However, the goods, materials and industries are scattered, the coastline occupied by the factories or wharfs is too long, and there are often phenomena of over-occupation, public-owned land used for private purposes, deep-water areas used as shallow ones, and vicious exploitation, holding the ports back from forming a mutually complementary and reasonably coordinated situation, neither in the hardware facilities nor in the software environment. As a result, the structural contradictions have become increasingly prominent-the major ports and specialized wharfs are stretching themselves, while the new small and medium-sized ports are underused. Due to the increasing of investment in infrastructure in the past few years, the impulse to make investment has led to a rapid increase in the overall capacity of ports. The ports competed for the expansion of port areas, waterways, wharfs and berths. In the case of insufficient cargo supply, the ports often reduce their charges for loading, unloading, storage yard and allow the customers to pay afterwards so as to attract more customers. Such vicious competition has severely hindered the overall development of the ports in Liaoning Province, and greatly weakened the competitive advantages of other ports at home and abroad.

4. Internal management of the ports

61. An analysis of the internal management of the major ports in Liaoning Province has revealed that there are common problems in the ports such as unreasonable

organizational structure. The original longitudinally distributed organizational structure of the ports has created independent systems according to the professional scopes, leading to the problem that many departments are responsible for one task at the same time. Although this seems meticulous and helpful to improve the speciality and level of business of the ports, it has led to the deeper problem of single management and too lengthy vertical structure, making it very difficult for senior managers to skip the low, middle and high administrative levels and directly find the problems that arise in the grass-root work, thus leading to failure to respond to new problems in time. Therefore, the coordination of the ports is seriously lagging behind. In the meantime, the ports also have the problems of complicated organizational structure and serious waste of human resources.

5. The ports' capacity to support port-centred industries

62. Among the seven major ports, port-centred industries in Yingkou Port, Jinzhou Port and Huludao Port are developing at the slowest speed. Although these three major ports have good resources conditions and industrial advantages for developing port-centred industries, there are still problems that cannot be ignored. First, the industrial layout is not reasonable, and the guiding role of the development plan has not fully come into play, which will hinder the introduction of future projects and the development of regional industries. Second, the industries are not quite linked to each other, and most of the industrial chains of the port-centred heavy and chemical industries are short, weakening its influence over other industries outside the area. As a result, no large-scale industrial clusters have been formed. Third, the core enterprises in each port-centred industrial area are small in size, and the existing small and medium-sized enterprises are small in scale and few in quantity, so the dominant industries have very limited driving force for regional industrial development; finally, the supporting capability of resources and the environment is weak, constraining the development of the port-centred industries.

D. DEA Method of the Comprehensive Evaluation of Port Resources in Liaoning Province

1. Data Envelopment Analysis (DEA)

63. DEA refers to Data Envelopment Analysis, which is proposed by the famous operations research scientists A. Charnes and W. W. Cooper et al. It is a new research field in the intersection of operations research, management science and mathematical economics, and an effective non-parametric approach to measure the relative efficiency of multi-productive and non-productive sectors and units with the same type of multiple inputs and outputs. If a sector or unit is efficient, then it is called DEA efficient, and the efficiency value is 1. The basic idea of DEA method is to establish the efficiency evaluation model of mathematical programming according to the input and output indicators of the system being evaluated. Then, the efficiency of each evaluation unit in the same system is analysed separately, and then the different efficiency value of each evaluation unit is obtained. And each DMU is sorted according to the efficiency evaluation value, and DMU with the highest relative efficiency is the most efficient DMU, and the inefficient programs of other inefficient DMU and the reasons for their inefficiency are analysed accordingly. In the meantime, within the scope of the definition of the productions possibility sets, we can fix the input of a certain DMU and increase its output, or fix the output of a certain DMU and decrease its input. For ease of understanding, we can illustrate the basic idea of data envelopment analysis by a simplified input-output relationship, as shown in Figure 3.

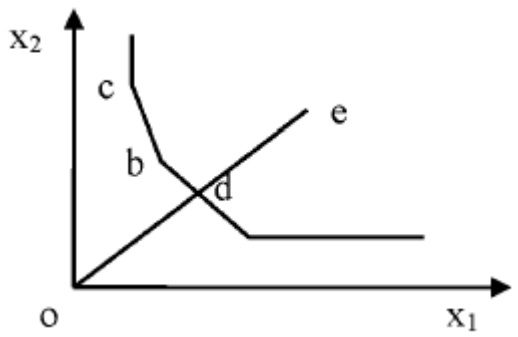


Figure 3 The Basic Idea of DEA Efficiency Evaluation

64. Assume that there are only two input factors $(x_{1,}x_2)$ in one production activity, and one output y can be obtained. Three are five evaluation units, namely a, b, c, d and e. As can be seen from the figure, the production frontier of the evaluation system consists of a series of segment lines of equal output lines. The evaluation units a, b, c and d are located on the surface of the production frontier, while point e is located above the frontier. This shows that under certain output, the two inputs $(x_{1,}x_2)$ consumed by point e are much greater than the input of points on the surface of the production frontier, so the evaluation unit e is technically inefficient. Its production activity wastes too many resources, and the degree of inefficiency can be measured with de/oe. Similarly, the relative efficiency of all evaluation units in the whole evaluation system can be analysed in this way.

65. Based on the above idea, DEA method constructs the mathematical programming model through the distance ratio of the evaluation units and the linear combination of its corresponding production frontier, and evaluates the relative efficiency of each evaluation unit. Through the relative efficiency analysis, the relative efficiency value of each evaluation unit can be obtained, and these efficiency values can reflect the input-output and resource redundancy status of these DMUs.

2. Basic Concept of DEA

66. In order to better extend the basic principles of DEA, now we introduce the DEA model and clarify the economic implications EDA efficiency, and illustrate the following concepts.

1) Input and output

67. Input and output in the production process are commonly referred to as production input and production output. As there are several inputs and outputs, we express them in the form of general vector. Input and output is free to handle and dimensional irrelevant. The former means that the factors are free to deal with in the production activities, namely, the increase of input does not result in the decrease of output. Meanwhile, input means the use and consumption of resources, which is negative; and output means the generation of value, which is positive. Dimensional irrelevancy means the resulting efficiency value is irrelevant

with the dimensions of the input and output data, but the dimensions of the same input or output for different DMUs should be the same.

2) Decision-making unit (DMU)

68. DMUs are entity units, which describe the process of how the input is transformed into the output. DEA efficiency is the comparative value of the input-output ability of a DMU relative to the DMU on the surface of the production frontier. A selected set of DMUs must have the same objectives and tasks, namely they must be comparable and homogeneous. In this paper, the input and output values at different time points in the same port are used as a set of DMUs.

3) Production possibility set

69. Assume the input of a production activity is $X = \left(x_{1,} x_2, \Lambda\, x_m\right)^T$, the output is $Y = \left(y_{1,} y_2, \Lambda\, y_s\right)^T$, and point (X, Y) is the production activity. The production activity composed of the set $T = \{(X, Y) input\ x\ and\ generate\ y$ is the production possibility set.

4) Technically efficient, the production function and returns to scale

70. Assume that for any $(X, Y) \in T$, if $(X, Y_1) \in T$ does not exist and $Y \leq Y_1$, then $(X, Y) \in T$, is called technically efficient production activity. The curved surface $Y = f(X)$ composed of all efficient production activity points (X, Y) in the production possibility set T is the production function. The production function means that under certain technical conditions, when the production is in an ideal state, the maximum output that can be obtained by the input X is Y, that is, the production activities in the production function are technically efficient.

3. The Basic Idea of DEA

71. Conduct linear combination of the known DMUs on the boundary of the production possibility set, and construct DMUs better than the non-boundary DMUs. Then, by combining with the linear planning, conduct comparative analysis for the relative efficiency of various DMUs.

Set the DMUs as follows: $DMU_1, DMU_2, \cdots, DMU_n$

Input indicators: $X_j = (x_{1j}, x_{2j}, \cdots, x_{mj})^T, j = 1,2,\cdots,n$, $j = 1,2,\cdots,n$, and x_{ij} represents the input of the j th DMU in the i th indicator;

Output indicator: $Y_j = (y_{1j}, y_{2j}, \cdots, y_{sj}), j = 1,2,\cdots,n$, and y_{ij} represents the output of the j th DMU in the i th indicator;

For the DMU $j_0 (0 \le j_0 \le n)$, we can explore the idea of DEA method from the input and output perspectives:

① For DMU j, without adding more inputs than DMU j_0, we can find a linear combination that can get the maximum possible output by changing the linear combination of various input factors. If this value is greater than the original output value, then original production combination is defined as inefficient. The model is as follows:

$$\max \omega$$

$$\text{s.t.} \begin{cases} \sum_{j=1}^{n} \lambda_j x_{ij} \le x_{ij_0}, i = 1,\cdots,m \\ \sum_{j=1}^{n} \lambda_j y_{kj} \le \omega y_{kj_0}, k = 1,\cdots,s \\ \lambda_j \ge 0, \omega \ge 0, j = 1,\cdots,n \end{cases} \qquad (2.1)$$

wherein: x_{ij} is the i th input of DMU_j, and x_{ij0} is the i th input of DMU_{j_0};
y_{kj} is the k th output of DMU_j, and y_{kj0} is the k th output of DMU_{j_0};
ω is the target value;
λ_j is the linear combination variable.

② For DMU j, under the precondition of ensuring at the least the same output for DMU j_0, the input factor amount is reduced as much as

possible and the minimum output amount is found, if this value is smaller than the original input amount, then DMU j_0 is inefficient. The model is as follows:

$$\min \phi$$

$$\begin{cases} \sum_{j=1}^{n} \lambda_j x_{ij} \le x_{ij_0} \phi, i = 1, \cdots, m \\ \text{s.t.} \quad \sum_{j=1}^{n} \lambda_j y_{kj} \le y_{kj_0}, k = 1, \cdots, s \\ \lambda_j \ge 0, \phi \ge 0, j = 1, \cdots, n \end{cases} \quad (2.2)$$

Wherein: x_{ij} is the i th input of DMU_j, and x_{ij0} is the i th input of DMU_{j_0};

y_{kj} is the k th output of DMU_j, and y_{kj0} is the k th output of DMU_{j_0};

ϕ is the target value;

λ_j is the linear combination variable.

72. The basic idea of DEA method is to find out the eternal envelop surface based on the input and output of actual sample points by evaluating the relative efficiency of input and output of each DMU in the evaluation system. For the DMU that is not on the envelop surface, we can know the distance relative to the envelop surface.

4. The Efficiency Evaluation Model of DEA

73. CCR model and BCC model are the two most commonly used models of DEA. CCR model is a data envelop model with constant returns to scale, and BCC model is a data envelop model with variable returns to scale. The efficiency of solving BCC model is the pure technical efficiency (PTE) of the evaluation unit, which takes into account the situation where the returns to scale of the evaluation unit increase or decrease. In this paper, BCC model with variable returns to scale is adopted. Assuming there are m independent DMUs, and each DMU has n factor inputs and k outputs, then we build a model:

$$\min \theta$$

$$s \cdot t \cdot \begin{cases} \sum_{j=1}^{m} \lambda_j x_{ij} + S_i^- = \theta x_{i0}, (i = 1, 2, \cdots, n) \\ \sum_{j=1}^{m} \lambda_j y_{hj} + S_h^- = y_{h0}, (h = 1, 2, \cdots, k) \\ \sum_{j=1}^{m} \lambda_j = 1 \\ \lambda_j, S_i^-, S_h^- \geq 0 \end{cases} \qquad (2.3)$$

Based on the above model, we can calculate the optimal solution $\lambda^*, s_n^{-*}, s_m^{+*}, \theta^*$, in which case its efficiency can be analyzed:

When $\theta^* = 1$且$s_n^{-*} = s_m^{+*} = 0$, DMU is DEA efficient in both technology and scale. This shows that DMUs are highly efficient and resources are optimally allocated. Operating points are on the surface of the production frontier, all input factors are given maximum play, and on this basis the obtained output will also reach the optimal level. At this point, the production scale is also relatively in the optimal state;

When $\theta^* = 1$且$s_n^{-*} \neq s_m^{+*} \neq 0$, DMU is weak EDA efficient, which means that it is efficient in technology but inefficient in scale. If $s_n^{-*} > 0$, then the redundancy of the nth input factor is s_n^{-*}; if $s_m^{+*} > 0$, then the deficit of the mth output factor is s_m^{+*}. In this case, if DMU wants to be DEA efficient, it needs to make the following adjustment: one is to keep the existing output unchanged and reduce the input amount of s_n^{-*} for the nth input factor; the other is to keep the input amount of the existing factor unchanged, and increase the output amount of s_m^{+*} for the mth output factor;

When $\theta^* < 1$且$s_n^{-*} \neq s_m^{+*} \neq 0$, DMU is DEA inefficient in technology and scale. This means that under existing technology conditions, the current DMU has a problem

of resource waste or insufficient output, that is, there are too many input factors and too few output factors. In addition, the smaller the efficiency evaluation indicator θ^* is, the lower the operation efficiency of DMU is. The larger s_n^{-*} and s_m^{+*} is, the larger the space to adjust the DMU to DEA efficient is.

Analysis on the economies of scale:

If $\lambda^*/\theta^* < 1$, then the DMU efficiency increases;
If $\lambda^*/\theta^* = 1$, then the DMU efficiency remains unchanged;
If $\lambda^*/\theta^* > 1$, then the DMU efficiency decreases.
Thus, we can get:

(1)When the economies of scale are unchanged and DMU is technically efficient, the output has reached the maximum scale based on this input.

(2)When the economies of scale decrease and DMU is technically inefficient, it means that if the input is increased, then the increase in output is lower than the increase in input. In this case, we should not increase the input; instead, we should strengthen the management of the input resources, so as to improve the utilization efficiency of existing resources, and strive to achieve the maximum output level and effectively improve the DEA efficiency.

(3)When the economies of scale increase and DMU is technically inefficient, it means that we should increase the input of factors, and also strengthen the management of input resources, so as to improve the output efficiency.

(4)When the economies of scale increase and DMU is technically effective, it means that insufficient input is the most important reason for DEA inefficiency. In this case, we should increase the input of resources and achieve DEA efficiency [14].

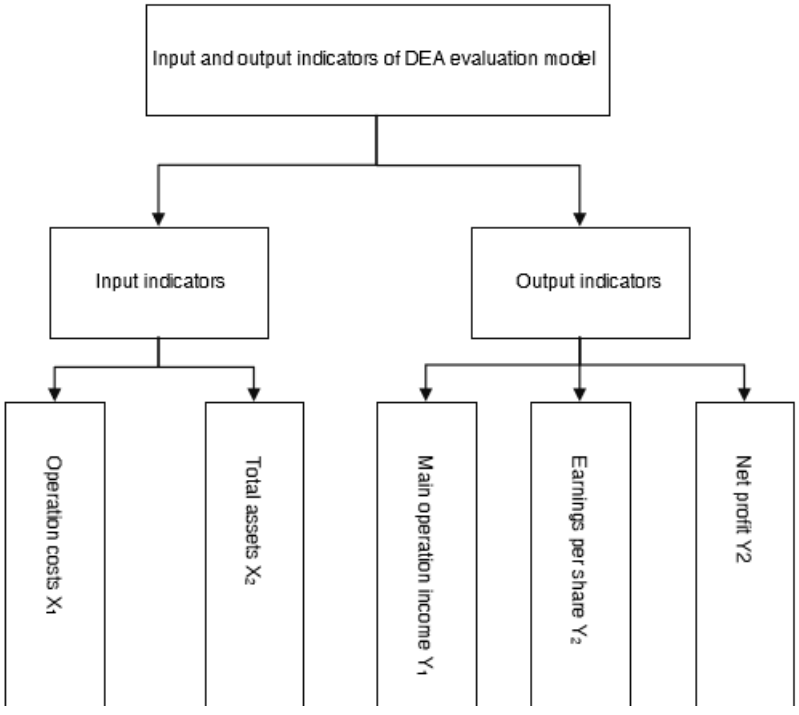
5. Input-output Indicator Selection based on the Variable Model of Economies of Scale

74. According to the economic principle of BCC-DEA, from the perspective of financial efficiency of various ports in Liaoning Province, input indicators are

generally cost indicators, such as asset size indicators and operation costs. Output generally focuses on profitability indicators and debt-paying ability indicators, such as operation income, net profit and earnings per share. At the same time, according to the requirement of the variable model of economies of scale for the input and output indicators, the principle of input indicator is “the smaller, the better”; and the principle of output indicator is “the bigger, the better”. In selecting input indicators, this paper mainly selects the total assets and operation costs that can reflect the operation input of port enterprises, and operation costs refer to costs of goods or services provided by enterprises. In terms of output indicators, we choose the three indicators that can reflect the profitability of ports, namely, operation income, net profit and earnings per share. Operation income refers to the total inflow of economic benefits formed by an enterprise in the daily operation of the business, such as selling goods, providing labor services and transferring the right to use assets. These input and output indicators can fundamentally reflect the performance of the basic input and output in ports in Liaoning Province.

6. Input and output indicators of DMU data sample

75. The main principle of DEA is: from a certain point of view, each DMU must have the same inputs and outputs. Take the indicators selected by the Economic Efficiency Analysis of China’s High-tech Industries from the Perspective of Technical System as reference (Li Xiaomei), and according to the indicator selection requirements, select output indicators from the profitability indicator and debt-paying ability indicator, and select input indicators from the cost indicator and asset scale indicator. The principle of selecting input indicators is “the smaller, the better”; while the principle of selecting output indicators is “the bigger,



the better". So we select total assets and main operation costs as the input indicators, and net profit, main operation income and earnings per share as output indicators, as shown in the Figure 4.

Figure 4 Input and Output Indicators

III. Operation Efficiency Evaluation of Core Ports in Liaoning Province

A. Introduction of SWOT Analysis

76. SWOT is an analytical method used to determine the competitive strengths and weaknesses of the company and the opportunities and threats faced by the company, so as to integrate the company's strategy with its internal resources and external environment. SWOT represent: internal strength, meaning the aspects with obvious advantages in the competition; internal weakness, meaning the aspects with disadvantages in the competition; external opportunity, meaning opportunities that can be more easily obtained and easily bring benefits compared with competitors; and external threats, meaning unfavorable trends or challenges brought about by the development. This is a set of methods to conduct a comprehensive systematic evaluation with the comprehensive consideration of various factors including internal conditions and external environments, which utilizes the internal strengths, overcome the inherent weaknesses, grasp external opportunities, avoid competitor's threats and develop the analysis and decision-making system in line with the company's future development strategy by adopting the strategy matching method. Based on SWOT analysis, we can get four sets of strategies, namely, SO strategy, WO strategy, TS strategy and WT strategy. SO strategy is to grasp external opportunities and seek rapid development relying on internal strengths; WO strategy is to utilize external opportunities to improve internal weakness and enhance the overall capabilities; TS strategy is to utilize the company's strengths to avoid or reduce the combat from external threats; WT strategy is to avoid or respond to external threats by overcoming internal weaknesses. SWOT analysis system is shown in Figure 5.

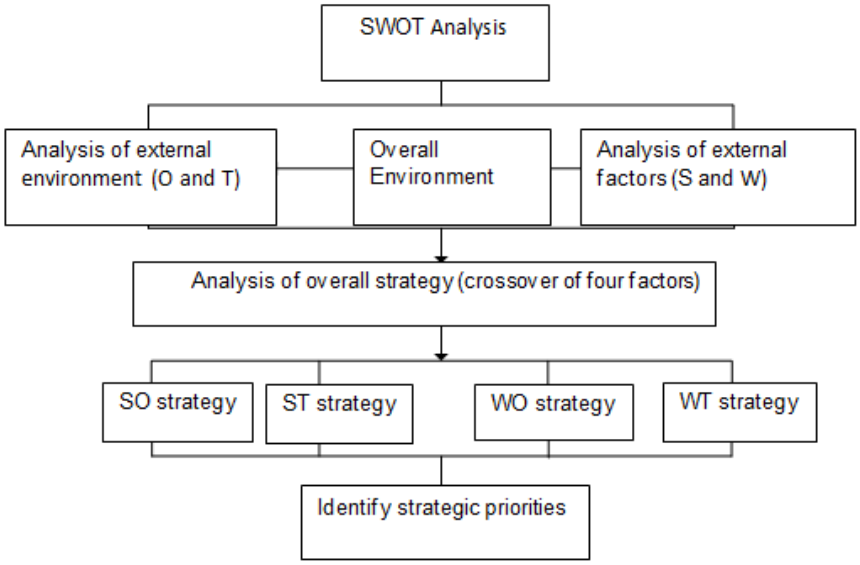


Figure 5 SWOT Analysis System

SWOT analysis steps:

(1)List the strengths and weaknesses, possible opportunities and threats of the enterprise;

(2)Combine strengths, weaknesses, opportunities and threats, and form SO, ST, WO and WT strategies;

(3)Screen and select from SO, ST, WO and WT strategies, and determine the specific strategies that enterprise should adopt.

B. The Operation Efficiency Evaluation of Dalian Port

1. Analysis of the Operation Status and Internal and External Environment in Dalian Port

77. There are China's biggest and the most advanced tens-thousand-ton crude oil quays and tens-thousand-ton ore terminals in Dalian, which is a domestic port with the largest reserve for self-owned storage tanks. Dalian port focuses on the handling, transport and storage of crude oil, refined oil and liquid chemical engineering products, accommodating 300-thousand-ton tankers with loading efficiency up to 12 thousand tons per hour. The capacity of oil tanks in its harbor district is more than 3 million cubic meters and its annual comprehensive

throughput is above 56 million tons. Dalian Port is Asia's most advanced transit base of bulk liquid chemical products and also China's largest roll-on-roll-off transportation port for marine passenger vehicles. There are seven shipping channels in the whole port, with a well-developed transport network. Its existing railway special lines inside harbor are more than 150 kilometers, its warehouse more than 300,000 square meters, its goods yard 1.8 million square meters and all kinds of handling equipment up to over 1000 units. It is now equipped with containers and more than 80 modern professional berths for roll-on and roll-off of customers' goods of crude oil, refined oil, grain, coal, loose-packed ore and chemical products, with more than 40 tens-of-thousand-ton-and-above berths. Its port throughput capacity reaches 240 million tons, and its container throughput capacity nearly 8 million TEUs. In 2015, the total throughput capacity of whole port goods at Dalian Port reached 415 million tons, ranking the eighth in China and eleventh in the world.

a) Strength

78. Dalian is the core area of opening up in Liaoning Province. With superior geographical location, it has vast waters opening to Japan, DPRK and ROK. It is also an important city driving the economic development of surrounding regions. Dalian Port is a vital hub for exchange of resource, capital and experience in the peripheral zones, as well as the channel connecting the North and the South for grain, wood, oil and other raw materials. Dalian Port has now become the largest port in terms of trading volume and share in Liaoning Province.

79. Dalian port has excellent natural conditions with affluent resource along the coastline. With wide area of waters including the free sea area covering 346 square kilometres, domestic tens-of-thousand-ton cargo ships come and go freely in the sea. There is no freezing phenomenon in winter here. Its great geological conditions promote the further expansion of the port, which provides adequate room for its growth.

80. Its transportation routes extend in all directions. Located on the southern tip of Liaodong Peninsula and adjacent to the Yellow Sea and the Bohai Sea, Dalian Port has obvious strengths in modern logistics by sea, land and air.

81. It has high level of information input, modernization and intelligence. Dalian Port is now equipped with the operation mechanism and management system catered for four-generation ports.

b) Weakness

82. The capacity of Dalian Port's basic supporting facilities is not good enough. The maximum depth of water in Dalian Port channel is only -13.5 meters. Without professional berths adapted to international transportation, the channel cannot meet the needs for large container ships to get under way for all-weather trade activities.

83. In Liaoning region, besides Dalian Port, other ports in Liaoning Province, such as Panjin Port and Yingkou port, inadvertently poses a serious threat against Dalian Port; in particular, the recent rapid growth of annual throughput of Yingkou Port is puts considerable pressures on Dalian Port.

84. Affected by political factors, Dalian Port Group is transformed from a planned state-owned enterprise. The backward management concepts restricted the development of Dalian Port.

85. Modern logistics system has complex process and demands for professional technology. However, Dalian Port lacks compound specialists, especially, logistics professional.

c) Opportunities

86. Global economic integration has led to the development of trade and logistics. After China's access to WTO, affluent resources are brought around the world, which has provided more room for expansion of import and export of harbor.

87. During the implementation of The Belt and Road Initiative, the support of national policies on the development of harbor has provided brand new opportunities for Dalian Port, which is a large port with geographical advantages and ability to promote the economic development of the surrounding area.

88. The development of local industry in Liaoning region has provided great room for growth of import and export goods at Dalian Port, where advanced high-tech

industry, agricultural processing industry and modern service industry have improved the market capacity and development space.

d) Threats

89. Ports compete with each other. Located in the southern tip of Liaodong Peninsula, Dalian Port is adjacent to the foreign advanced ports of Japan and ROK, and to the domestic ones such as Yingkou Port, Jinzhou Port and Jingtang Port. In the meantime when Dalian Port goes on a rapid rise, other ports are also looking for opportunities to develop themselves.

90. The impact of economic crisis is also a challenge confronting Dalian Port. The financial crisis will cause instability in financial markets and unstable future prices, and thus affecting the development of Dalian Port in different aspects.

2. Analysis of Pure Technology Efficiency and Scale Efficiency of Dalian Port Operation

91. Based on the selected input and output indicators from 2007 to 2016 (specific data are seen in the attached table), take the data into the model to calculate the comprehensive efficiency value ρ^* and pure technology efficiency value θ^* of Dalian Port from 2007 to 2016 with Deap2.1 software, and calculate the pure scale efficiency with $S^* = \rho^* / \theta^*$. In addition, ports with the need for the financial redundancy adjustment of each year will also be displayed in the results. The specific results are shown in Table 1.

Table 1 The Optimal Solutions of Model 1 and Model 2: ρ^*, θ^* and S^*

port	Dalian Port		
year	ρ^*	θ^*	S^*
2007	1.000	1.000	1.000
2008	0.872	0.993	0.879
2009	0.839	0.980	0.856
2010	0.837	1.000	0.837
2011	0.790	1.000	0.790

2012	0.759	0.987	0.769
2013	0.832	1.000	0.832
2014	0.947	1.000	0.947
2015	1.000	1.000	1.000
2016	0.974	1.000	0.974
average	0.885	0.996	0.888

Note: ρ^* represents the overall efficiency value, θ^* represents pure technology efficiency value, and S^* represents scale efficiency.

92. From the overall efficiency value in Table 1, the overall efficiency value of Dalian Port in recent 10 years shows the trend of declining first and then rising; In 2007 and 2015, the overall efficiency value was 1 and achieved DEA efficiency, indicating that Dalian Port was at the forefront of production and had high operation efficiency in these two years; in 2016, the overall efficiency value was 0.974, which was very close to the efficiency value of 1. This slight decline was due to the change of the company's input and output utilization rate and scale.

93. From the pure technology efficiency in Table 1, the pure technology efficiency value of Dalian Port in recent 10 years did not achieve DEA efficiency only in 2008, 2009 and 2012, but the value was very close to the efficiency value of 1 in these three years, and the average value of pure technology efficiency in recent 10 years was also very close to the efficient state. The high technology level benefited from the support of the national policy of "Belt and Road" and the policy of revitalizing Northeast old industrial bases. From this we can see that the low comprehensive efficiency value in Dalian Port is not due to the pure technology efficiency. In order to improve their performance, simply upgrading the technical level may not be able to achieve the desired effect. So the company needs to make adjustment according to its own conditions to greatly enhance the operational performance of Dalian Port.

94. From the pure scale efficiency value in Table 1, the average value of scale efficiency in Dalian Port in recent 10 years was 0.888, and the scale efficiency in Dalian Port reached the efficiency value only in 2007 and 2015. For the analysis of the economies of scale, if the scale efficiency value gradually increases, it

means that the returns to scale of the port are gradually increasing. In this case, the port can increase the input to obtain the highest profits. If the scale efficiency value gradually decreases, it means that the returns to scale of the port are decreasing. In this case, the port can reduce the input to reduce unnecessary resource waste. If the value remains unchanged, it means that the port achieves scale efficiency. From the table we can see Dalian Port achieved scale efficiency only in two years. In 2016, the returns to scale of Dalian Port increased, so the port can increase the input, gain high profits and achieve scale efficiency. In other years except 2016, the returns to scale of Dalian Port decreased, so the port should reduce the input, reasonably arrange resources and make reasonable adjustment to the scale of the company.

3. The Redundancy Analysis on the Input and output Resources to Improve the Operation Efficiency of Dalian Port

95. In the past 10 years, the overall efficiency value of Dalian Port Company did not achieve DEA efficiency, reflecting the waste of resource input and rising operation costs. As a result, the output indicator did not reach the expected optimum, and there was redundancy for the input and output. From Table 2, we can see that the input and output of Dalian Port Company in recent 10 years did not reach DEA efficiency in the overall efficiency value, so we should adjust the selected indicators. In the input indicators, the target value of the total assets in 2008 should be 28.80520 billion RMB, so the radial variable of the output should be reduced by 324.67 million RMB to achieve the DEA optimum of the comprehensive efficiency. In the output indicators, the target value of operation income should be 724.8 million RMB, so the radial variable of input should increase by 65.47 million RMB. The target value of earning per share is 1130 RMB, so the radial variable of input and output should increase by 100 RMB and 200 RMB respectively. The target value of net profit should be 451.79 million RMB, so the radial variable of input and output should increase by 4.19 million and 151.47 million RMB respectively to achieve DEA efficiency.

Table 2 Analysis and Adjustment of the Financial Redundancy of Dalian Port Company (Unit: 10,000 RMB)

	s^-	s^+	p^*	s^-	s^+	p^*	s^-	s^+	p^*
Y_1	6547	0	895164	16029	0	810275	5020	0	400559
Y_2	0.01	0.02	0.113	0.002	0.007	0.13	0.02	0.028	0.180
Y_3	419	15147	72480	1222	12017	73806	961	0	76707
X_1	0	0	743166	0	0	656756	0	0	248775
X_2	0	-32467	2880520	0	0	2784405	0	-193475	2523910

Note: s^- input slack, s^+ output slack, p^* target value.

C. The Operation Efficiency Evaluation of Yingkou Port

1. Current Operation Status of Yingkou Port and Analysis on its Internal and External Environment

a) Current status of the geographic environment

96. Yingkou Port sits in Yingkou city in Liaoning Province in Northeast China and lies at the intersection of Northeast Economic Zone and Bohai-Rim Economic Circle. It's the nearest transport port to the economic hinterland of the three north eastern provinces and the hinterland of the four leagues in east Inner Mongolia. Also because of its lower transportation costs compared with other ports in Bohai-Rim Economic Circle, Yingkou Port enjoys an advantageous position in competition and shows an outstanding location advantage.

97. Yingkou Port plays an important role among the 20 major ports in coastal areas of China and is a highly potential one in Bohai area with great convenience for sea-going. It currently covers seven port areas including Yingkou, Bayuquan, Xianrendao, Panjin, Haiyanghong, Suizhong Shihe and Liutiaogou in Huludao. Bayuquan, the core port area, covers a land area of over 20 square kilometres and is equipped with plenty of transport equipment such as containers and rolling trucks. Goods that are transported mainly include coal, food, ores, large equipment, product oil, liquid chemicals and crude oil. Currently, Yingkou Port

has become a new pass connecting China with Eurasian Land Bridge and also an important hub in the east line of the New Silk Road of China.

b) Economic hinterland-based development

98. Development of a port depends on many factors, such as geographic advantage, development status of the economic hinterland and support of national policies. Economic hinterland is critical to an inland like Yingkou Port. The development status of the economic hinterland determines structural changes of the transport environment in the neighbouring cities of the port. Transport advantages help transport goods from inland areas to Yingkou Port rapidly and conveniently, which accelerates goods transportation at the port and boosts market response. Meanwhile, developing economic hinterland of the port can drive its scale upgrading in an industrialized way.

99. Yingkou Port enjoys a major development advantage of hinterland, but the economic development of its hinterland lags far behind coastal areas in the south. Unlike coastal areas, major advantages of Yingkou Port lie in the abundance of crops and mineral resources of the economic hinterland. Therefore, relying on the development of its economic hinterland, Yingkou Port will step up to a higher level.

c) *Support of national policie*s

100. Since 2002, in order to revitalize the Northeast old industrial bases, China proposed to greatly develop the economy in Northeast China. Driven by the initiative, the economy of the region develops dramatically and industrialized enterprises rise rapidly, providing guarantees in transport of goods resources for development of ports, especially Yingkou Port. As the weak international economy gradually betters off, domestic ports generally develop steadily and show a positive momentum. In order to boost industrialization adjustment, enhance the domestic demand and improve the economic development of ports that depend on goods for internal trade, China constantly strengthens goods connection with both inside and outside China, enhances in-depth cooperation, deepens business development and innovatively improves the optimization of industrial chains. It makes efforts to expand market, conduct optimal decision-making management in market and goods resources, streamline production

organization and improve operation decision-making. Regarding safety management, great efforts are made to improve safety awareness, boost production efficiency and upgrade services by relying on information-based development of ports. Yingkou Port, located at the intersection of Northeast Economic Zone and Bohai-Rim Economic Circle, shows a strong location advantage thanks to the geographic edge and policy support. It strives to provide customers with quality services in an all-round way. In recent years, as domestic demand surges, upgrading of the industrial structure drives the development of regional economy in the Yingkou Port area. Also as Bohai-Rim Economic Circle rises to the level of national strategy, Yingkou Port enjoys a promising development prospect in the long run and it will be improved in returns to scale and optimized in the industrialization structure.

2. Analysis of Influencing Factors on the Operation Efficiency of Yingkou Port

a) *Port Throughput*

101. As a vital factor for evaluation of Yingkou Port's performance, Yingkou port's throughput plays an important role in accelerating its containerization and internationalization. Located in Northeast China, Yingkou Port has an important position among the numerous ports of Liaoning. Under the circumstance of the gradual recovery of economic environment, the logistics industry at Yingkou Port also became vital. The accelerated growth of economic development expedited the domestic and international transportation of goods, which fueled the development of the whole industry chain, created job opportunities, increased per capita income, and thus driving the development of Yingkou city. This paper mainly makes theoretical research on the indicators of cargo throughput, cargo throughput YoY growth, container handling capacity and container handling capacity YoY growth at Yingkou Port. The throughput of Yingkou Port greatly increases with the economic development, which is likely to play a vital role in implementing the strategy of accelerating the economic development.

102. For the purpose of energetic growth, Yingkou Port continuously streamlined its industrial structure and made great efforts to expand its main business. Upon continuous struggling, Yingkou Port successfully made market expansion. The

continuous expansion of business brought huge prospect to the development of Yingkou Port, which is specialized in transportation of farm crops, mineral resources, large equipment and oil products. We can adopt the above-mentioned measures to increase the transport volume of Yingkou Port and its business income. In this way, we can rapidly upgrade Yingkou's advantages in transportation, optimize its industrial structure, reduce its transport costs, enhance its transport volume, make decisions on its throughput management, continue its simplified development mode and strive to improve its performance.

b) Human Resources of Yingkou Port

103. To accelerate the talent optimization system is the cornerstone of corporate success. Talents play an increasingly important role in the survival and development of enterprises. Yingkou Port Company Limited is no exception. Talent is the soul of an enterprise and the guarantee for the normal development of a company. However, high-level talents often have strong mobility, and they will choose positions with personal development potential. If their own advantages are not used reasonably, talents will make a quick decision whether to leave the enterprise or complain to the higher authorities. If the management can reasonably deal with it, they can retain the talents and save the company from economic losses. Due to various reasons of Yingkou Port, the low proportion of high-level talents is rather serious. According to the statistics, the proportion of high-level talents in Yingkou Port Company does not exceed 40%. This shows that Yingkou Port Company Limited needs to attract more high-tech, highly managerial and professional talents from the society, and must deepen the contacts with specialized schools in choosing talents. College students have strong plasticity before entering into the society, so it is easy to cultivate their affinity for the enterprise and a sense of honour. The company should also conduct specialized business operations training for the college students in a timely manner, and tap their own potential to maximize the economic profits for the company. At the same time, however, they should also establish a compensation mechanism to meet their life and cultural and emotional needs.

104. In modern enterprises, talent is competitiveness and the key to gain high efficiency. They know how to use their own advantages to get high remuneration, so these talents have a greater choice and development space. So Yingkou Port

should establish a reasonable talent selection mechanism and effective talent management methods. At the same time, the company should establish a reasonable remuneration system according to the performance of employees. In conclusion, Yingkou Port can win more opportunities in the future development only when it vigorously invests more in talent development.

c) Operation Costs of Yingkou Port

105. Due to the rapid development of China's economy, the future development prospect of the port is accelerated as a result of changes in the industrial structure and trade trends. The main business of Yingkou Port is the transportation of crops, mineral resources, oil products and large-scale equipment. It has considerable throughput, and its main business is continuously enriched, which also increased the main operation costs of Yingkou Port. On cost reduction, we can start from the operation costs of Yingkou Port. In order to embrace the future development opportunities, Yingkou Port should constantly optimize its industrial structure, make efforts to strengthen the regional cooperation, establish the market service agencies and reduce unnecessary losses. Therefore, Yingkou Port should continuously expand the scale of business scope, increase the industrial input, and constantly improve the quality of industrial services, so as to meet the customer's demand for timeliness, quality and information accuracy. In order to improve its own business performance, Yingkou Port can improve its overall operation income and gradually increase the profits only by optimizing the industrial upgrading and reducing its operation costs.

3. Analysis on Technical and Scale Efficiency of Yingkou Port Operation

106. Based on the selected input and output indicators from 2007 to 2016 (the specific data are seen in the attached table), take the data into the model to calculate the comprehensive efficiency value ρ^* and pure technology efficiency value θ^* of Yingkou Port from 2007 to 2016 with Deap2.1 software, and calculate the pure scale efficiency with $S^* = \rho^* / \theta^*$. In addition, ports with the need for the financial redundancy adjustment of each year will also be displayed in the results. The specific results are shown in Table 3.

Table 3 Optimal Solutions of Model 1 and Model 2: ρ^*、θ^*、S^*

port	Yingkou Port		
year	ρ^*	θ^*	S^*
2007	0.873	0.974	0.896
2008	0.886	0.987	0.897
2009	0.869	0.981	0.886
2010	0.901	1.000	0.901
2011	0.898	1.000	0.898
2012	0.904	0.999	0.905
2013	0.894	0.973	0.919
2014	0.865	0.937	0.924
2015	0.873	1.000	0.873
2016	1.000	1.000	1.000
Average value	0.896	0.985	0.943

Note: ρ^* represents the overall efficiency value, θ^* represents pure technology efficiency value, and S^* represents scale efficiency.

107. In Table 3, we can see that the overall efficiency value of Yingkou Port in recent 10 years fluctuated around 0.85, and reach DEA efficiency value of 1 in 2016. Yingkou Port may need to adjust its input structure to increase the overall efficiency value. The pure technology efficiency value of Yingkou Port in 2010, 2011, 2015 and 2016 was 1, which was DEA efficient. There are a total of 14 DEA efficiency values, accounting for 46.7% of all samples. The development level of Dalian in all aspects is among the best in Liaoning Province, so the average value of pure technology efficiency in Yingkou Port is lower than Dalian, but is very close to the efficiency value. The technical efficiency value of Yingkou Port has small fluctuations. Yingkou Port developed steadily in recent 10 years, and stabilized to the efficiency value in 2015 and 2016, so it needs to make improvement decisions in technology and scale according to its actual conditions, so as to maintain its stable development trend. From the pure scale efficiency value in Table 4.3, the average value of the scale efficiency in recent 10 years in

Yingkou Port is 0.943. Yingkou Port reached the scale efficiency value in 2011, 2012, 2015 and 2016, and the returns to scale decreased each year, so it should reduce the input, reasonably arrange resources and make reasonable adjustment for the size of the company.

4. Analysis on the Input and Output Resources Redundancy of the Operation Efficiency of Yingkou Port

108. Redundancy adjustment should be made for the years in which DEA did not reach the efficiency value of 1. The table below shows the financial redundancy adjustment for Yingkou Port.

Table 4 Financial Redundancy Analysis and Adjustment of Yingkou Port (Unit: 10,000 RMB)

Adjustment year		s^-	s^+	p
2007	Y1	9817	0	376376
	Y2	0.02	0.155	0.237
	Y3	1362	2426	54657
	X1	0	0	247162
	X2	0	0	1652761
2008	Y1	4953	0	383729
	Y2	0.001	0.158	0.239
	Y3	686	240	53374
	X1	0	0	256171
	X2	0	0	1632973
2009	Y1	7766	0	398816
	Y2	0.02	0.148	0.230
	Y3	1118	0	57424
	X1	0	0	269305
	X2	0	-193475	1722295
2012	Y1	343	0	291757
	Y2	0	0.160	0.370
	Y3	32	11757	39268

	X1	0	0	201560
	X2	0	0	1133244
2013	Y1	6593	0	240911
	Y2	0.006	0.128	0.333
	Y3	638	13365	1351
	X1	0	0	155417
	X2	0	0	1019950
2014	Y1	12687	0	200269
	Y2	0.012	0.037	0.230
	Y3	10636	0	31961
	X1	0	0	123017
	X2	0	-201381	905612

Note: s^- input slack, s^+ output slack, p^* target value.

109. In the past 10 years, the overall efficiency value of Yingkou Port Company did not reach DEA efficiency, and the output indicators did not reach the expected best conditions. There was redundancy in input and output. From Table 4 we can see adjustment is needed for relevant indicators. In the input indicators, the target value of the total assets in 2009 should be 17.22295 billion RMB, and the radial variable of the output should be reduced by 1.93475 billion RMB to reach the optimal DEA of the comprehensive efficiency. In the output indicators, the target value of operation income was 3.98816 billion RMB, and the input indicator variable should increase by 77.66 million RMB. The target value of earnings per share was 2300 RMB, and the radial variable of input and output should increase by 200 and 1480 RMB respectively. The target value of net profit was 574.24 million RMB, and the input radial variable should increase by 11.18 million RMB to reach DEA efficiency. The target value of the total assets in 2014 was 9.05612 billion RMB, and the output radial variable should reduce by 2.01381 billion RMB to reach the optimal DEA of the comprehensive efficiency. In the output indicators, the target value of the operation income was 2.00269 billion RMB, and the input indicator variable should increase by 126.87 million RMB. The target value of earnings per share is 2300 RMB, and the input and output radial variables should increase by 120 and 370 RMB respectively. The target value of net profit was

319.61 million RMB, and the input radial variable should increase by 106.36 million RMB.

D. The Operation Efficiency Evaluation of Jinzhou Port

1. Current Operation Status of Jinzhou Port and Analysis on its Internal and External Environment

110. Jinzhou Port started construction in October 1986, was officially opened to navigation in October 1990 and was approved by government as first-class open commercial port in December of the same year. In 1993, it experienced shareholding reform and became China's first port subject to joint-stock operation by government and enterprise separately. In May 1998 and June 1999, Jinzhou Port B stock and A stock were respectively traded at Shanghai Stock Exchange. In December 1998, Jinzhou Port took the lead among its peers to pass the ISO9002 international quality system certification. The port is the most convenient sea gate in the west of Liaoning, the middle and west of Jilin and Heilongjiang, the east of Inner Mongolia, the north of North China and even the Siberia area of Russia. It's a northern regional port prioritized by Liaoning Province for development and a major part in the development strategy for Liaoning Coastal Economic Belt. Jinzhou Port covers a planned land area of 24.3 square kilometres and water area of 32 square kilometres, has a planned coastline of 14,018 meters and plans for 52 berths. So far, it has covered a land area of around 9 square kilometres, has a 4,998 meters of coastline in total and has 20 for-profit berths with a designed annual throughput capacity of 42.95 million tons and 600,000TEU containers. The berths include 250,000t tanker berths and 100,000t bulk & general cargo berths that can accommodate 150,000t tankers and 100,000t bulk & general cargo carriers and container berths that can accommodate the sixth-generation container vessels with a handling capacity of up to 70 million tons and a container throughput capacity of 700,000TEU. Currently, Jinzhou Port has become available for container transport for internal and foreign trade, handling, warehousing, transport and service for oil products, chemicals, large bulk & general cargo and break bulk cargo and bagging of bulk cargo. It is mainly divided to five function areas including petrochemicals, containers, break bulk & general cargo, ship service and port industry. Ultimately, it will be developed into a modernized international commercial port with

diversified service functions integrating large-sized oil chemical port, comprehensive container port and regional bulk & general cargo port. Throughout 2011, Jinzhou Port accumulatively finished up to 75.8212 million tons of goods throughputs, including a coal throughput of 22.9654 million tons and a container throughput of 839,900 TEU.

111. On July 25th, 2017, at the 58th standing committee meeting of Jinzhou municipal government, the Opinions Regarding Support for the Development of Container Logistics Industry at Jinzhou Port (draft) was discussed and passed in principle. On August 16th, No. 82 Document issued by Jinzhou Government (2017) was officially released. The policy will provide container shipping enterprises and logistics fleets with policy subsidies that are unprecedented in effect and coverage.

a) Strength

112. Jinzhou Port is located at the north bank of Bohai Gulf. There are many wholesale markets and refineries with enormous transaction value in the city and the location advantage for Jinzhou to develop logistics is retained. The “Five Points and One Line” policy of Liaoning facilitates Jinzhou to grow bigger and stronger and eventually develop into a major energy port in North China on the basis of current advantages.

113. With the temperate monsoon climate, Jinzhou Port sits at the traffic artery of Liaoxi Corridor. As it is free from attacks of typhoon throughout the year and the sea area is frozen but not closed in winter, it is in effective operation every day. With a competition advantage of broad land area, the Port can accommodate 45 berths.

114. Since China started to implement the plan of revitalizing the old industrial bases in Northeast China, Jinzhou started to carry out the strategy of “Developing the City with Ports”. With proper market positioning and development objectives, Jinzhou Port makes great efforts in market development and strives to extend the industrial chain and expand the operation scope.

b) Weaknesses

115. In the process of developing port logistics, Jinzhou Port encounters the problem of fund shortage in the port construction. Especially in order to introduce advanced port facilities, build large-scale specialized container terminals and enable large ships to enter the waterway, large amount of fund is required to widen and deepen the waterway.

116. Jinzhou Port needs specialized talents in logistics. The majority of employees lack expertise in modern logistics and lag behind in mentality. The management also lacks specialized talents, especially in logistics.

117. Regarding port infrastructure, Jinzhou Port lags behind in the level of modern logistics. The current waterway cannot meet the navigation demand of large berths and large ships, which reduces the trading volume of bulk cargo and oil products and the container throughput to some extent and affects profit making of the Port.

c) Opportunities

118. The development of Jinzhou Port gains great support from government in both policy and fund, which consolidates the foundation of the development.

119. The rapid development of e-commerce in recent years is a tremendous measure for the Port. Online third-party logistics accelerates development of websites and offers port companies sizeable profit.

120. The rapid economic growth provides the growth space for the Port. In recent years, The GDP growth of Jinzhou city speeds up and therefore, stable development of other industries offers stable source of goods for the improvement of Jinzhou Port. Advantageous geographic position makes logistics faster and more convenient.

d) Threats

121. Ports in Bohai Gulf show a disordered trend of development, which severe redundant construction, unclear regional division of labour and positioning and excessive market capacity. Compared with Dalian Port, Jinzhou Port lags further behind and shoulders greater competition pressure.

122. Demand of customers is further individualized, which is a headache for ports. Their need for better services and individualized products should be addressed by Jinzhou Port along its development path.

123. Sea routes of Jinzhou Port are mostly domestic ones with little outward land transportation and its few international routes are just for transfer, not direct navigation to the outside. Consequently, foreign ports exert certain influence on domestic ones.

2. The Analysis of the Factors Affecting the Operation Efficiency of the Port of Jinzhou

a) Establishing a Port Logistics System with Clear Division of Labor

124. There are only two ports in the west of Liaoning province: the port of Jinjiang and the port of Huludao. As it is small in scale, the port of Huludao does not pose a threat to the port of Jinjiang. However, some of the goods such as oil and food may be diverted from the port of Jinzhou to the port of Huludao as the latter gradually develops in the future. In order to build a better port cluster in Liaoning and to strengthen and expand the port of Jinjiang, it is necessary to integrate the resources of the two ports so that the two have clear division of labour, remain competitive in different and respective areas and form a port logistics system of a reasonable layout. As for the way of integration, the previous discussions between the two sides have failed due to different local interests. So it would be difficult for the local governments of Jinzhou city and Huludao city to push ahead with the integration of the ports. A more plausible way is to look to the port of Dalian to take the lead, draw on its experience of the integration with the port of Jinzhou and rely on the strength of Dalian port to integrate the port resources of the port of Dalian and the port of Huludao. Such integration will make the port of Jinzhou and the port of Huludao as two feeder ports with equal status in the important layout of Dalian as the North eastern International Shipping Centre. In order to avoid homogeneous competition and make sure that the two ports have their own non-overlapping advantages, the bulk cargoes and containers of domestic trade transferring at Dalian Port will be diverted to both ports. The integration between Jinzhou Port and Huludao Port can not only ease the competitive pressure on Jinzhou Port, but also form a port logistics system with a

clear division of labour in the west of Liaoning province, thus accelerating the economic development in the region.

b) Cutting the Logistics Cost of the Port

125. After Japan merged Osaka, Kobe and Amagasaki-Nishiaza-Nishinomiya Ashiya ports into Hanshin Port, ships can enter the three ports with only one approved application. Also, after the merger, for the ships entering the port, the taxes and charges, which are determined based on the weight of the ship, are collected only once, reducing the total cost by 15% and resulting in a substantial increase in the business volume of Hanshin Port. The port of Jinzhou can learn from this experience. As the side wing of the port of Dalian, it should increase its cooperation in port businesses with Dalian port and streamline the entry procedures as soon as possible. After going through the procedure for entry application at Dalian port, ships can enter the two ports so as to reduce time and logistics. In addition, the port of Jinzhou and Dalian can consider jointly collecting the taxes and charges so as to reduce the logistics cost of the shipping companies. Less burden can be attractive to shipping companies, hence more shipping companies and port businesses. In this way, the direct revenue of the two ports might reduce, however, the facilitated procedure and the cost cut would attract more shipping companies to transit. The increase in the tonnage-based tariff on foreign ships would make up the loss of revenue. Jinzhou port and Dalian port, with their reforms of the application procedure and port charge, can enjoy closer cooperation, more port business and stronger competitiveness as higher efficiency of clearance and lower charge can greatly reduce the logistics cost. In the future, Jinzhou port and Dalian port can even cooperate in regional clearance, under which the enterprises can “file declaration at its registration location and get release at the port”. Enterprises can file the import and export declarations at the registration location and go through the checks at the product entry/exist customs. In this way, the time for customs clearance and the time at the ports have been cut dramatically.

c) Building Logistics Facilities

126. Without the investment in and construction of logistics infrastructure, there is no development of port logistics to speak of. The port of Jinzhou should make the most of its own resources, continue to deepen waterway construction, speed up

the deep-water port development, and constantly improve the port's handling capacity with the cargo throughput expected to reach 100 million tons and container throughput 1 million TEU in 2013. Therefore, the port of Jinzhou should increase investment in logistics machinery, logistics system engineering, channel depth and terminal infrastructure, and promote the interconnected development of port, warehousing as well as logistics industries and organizations. The following constructions should be completed as soon as possible: an oil terminal for the 250,000-ton class and four coal terminals for the 50,000-ton-class in the western sea, two coal terminals for the 100,000-ton-class, container terminals and a 600,000-li crude oil storage and transit base. In addition, a land of larger capacity should be used to build the logistics centre. Based on the combination of the development plan of Jinzhou city's modern logistics and the development plan of Liaoning province's coastal ports, logistics service centres dedicated to container, coal, grain and oil should be built step by step. Meanwhile, the port of Jinzhou needs to further improve the collection and distribution network by constructing the railway leading to the port and the road accessing the port so as to improve the scale and service efficiency of the integrated logistics service.

d) Establishing the Logistics Chain for the Main Cargoes

127. The port of Jinzhou mainly handles crude oil, grain, ore and coal. By way of investment promotion, policy support, joint venture and cooperation, enterprises producing or processing these goods can be attracted to the vicinity of the port to provide logistics storage and processing services. In this way, the logistics services occurring in the upstream and downstream transportation, processing and distribution are transferred to the port area and the establishment of such a supply chain system will improve the logistics services of the port area. At present, PetroChina has started the construction of a crude oil storage facility. The port of Jinzhou can take this opportunity to further work with petrochemical enterprises to consider the feasible plans of oil refining and processing projects in the port area so as to establish a logistics chain of oil products. In addition to the establishment of upstream and downstream supply chain for oil products and grain, the establishment of similar supply chains for other imported and exported bulk cargoes such as the copper and zinc concentrates should also be considered so as to give the Port of Jinzhou a unique advantage in logistics service and sharpen the competitive edge of the port.

e) Building an Information Network for the Port Logistics

128. IT application is the necessary condition to realize efficient logistics service. The port of Jinzhou should strengthen the application of information technology and establish an information platform that can be operated by logistics enterprises and be connected with networks of shipping, economy and trade as well as port information. This information platform should be made up of three parts: the public information of the port, logistics information and the information of logistics enterprises. For the establishment of the port information platform, we can draw lessons from the mode and experience of Dalian Port Logistics Network and adopt the mode of "government coordination and business operation" to build the port electronic network system. The logistics enterprise information platform is an operating platform which can be used to search for information about the terminal, airport, shipping company, freight forwarding, fleet, warehouse and train, and it also offers the entrusted trading platform.

f) Improving the Quality of Logistics Service

129. The port of Jinzhou Port should strengthen its close cooperation with shipping enterprises, railway enterprises and highway enterprises to integrate their respective advantageous resources and provide integrated logistics services so as to jointly form a fast and convenient logistics chain system. At present, the port of Jinzhou has realized the direct access of the national railway locomotives. It should build on this and make good use of the wide network coverage of the railway system. It should continue to strengthen cooperation with the railway companies to jointly discuss about feasible strategies to expand the logistics service scope and manage the overall logistics process.

g) Establishing the Port-vicinity Industrial Cluster

130. The establishment of the port-vicinity industrial cluster not only helps to stabilize the supply of the port's freight, but also helps to provide a complete package of services through a more integrated product supply chain, hence a better service of the port. Therefore, the port of Jinzhou should pursue the development of port logistics as a priority of the port-vicinity industry, speed up the establishment of the west sea industrial zone and take proactive measures to attract large enterprises to settle in the port through investment attraction and

preferential policies. According to the rationale behind the industrial cluster, the key is to attract and develop refineries and chemical industrial enterprises. The port of Jinzhou can also learn from the experience of the coastal industrial cluster of the port of Rotterdam in Europe, which actively attract the food industry such as grain, fruit and vegetable and attracts trading, storage, processing and transportation companies to come to the port area so as to form an industrial chain of food. In addition, port-related companies such as ship building and maintenance, port machinery and equipment manufacturing can also be set up in the port industrial zone to facilitate the development of the export and processing of the warehouse logistics. As for the construction of the west sea industrial zone, the port of Jinzhou should attach importance to nurturing industry focus and develop the port industry with the port's main business at its core to build an industrial logistics chain so that the port industry can facilitate the port logistics. As for how to attract enterprises to settle in the port, the landlord port model can be adopted. Under this model which is characterized by a large amount of land, the port of Jinzhou can attract strong logistics enterprises with cheap lease and a concession of large land. Preferential policies can be extended to the internationally renowned logistics enterprises and leading enterprises in the field so that they can drive the economic development of the port and improve the port's logistics service and competitiveness.

3. The Analysis of the Technical Efficiency and Scale Efficiency of the Port of Jinzhou

131. Data of the target output and input from 2007 and 2016 are imported into the model (see the attached table for details) and the port's overall efficiency and pure technical efficiency of those years are calculated with the software Deap2.1. The ration of overall efficiency to pure technical efficiency provides scale efficiency, as indicated in $S^* = \rho^* / \theta^*$. In addition, the results also reveal the years of financial slack and the port needs adjustments. Refer to Table 4 and Table 5 for detailed information.

Table 5 The Optimal Solutions ρ^* θ^* S^* in Model one and two

Port	Port of Jinzhou		
Year	ρ^*	θ^*	S^*
2007	0.713	0.794	0.898
2008	0.697	0.783	0.891
2009	0.748	0.830	0.901
2010	0.742	0.817	0.908
2011	0.697	0.792	0.880
2012	0.856	0.948	0.903
2013	0.956	0.978	0.978
2014	1.000	1.000	1.000
2015	1.000	1.000	1.000
2016	1.000	1.000	0.931
Average	0.834	0.969	0.929

Note: ρ^* =the overall efficiency, θ^* =pure technological efficiency， S^* =scale efficiency.

132. From the pure technical efficiency in Table 5 we can see that in 2014, 2015 and 2016, the port of Jinzhou has been viewed as efficient according to DEA. Compared with the ports of Dalian and Yingkou, the average pure technical efficiency of Jinzhou Port is relatively low, but it is very close to being efficient, indicating a high level of technology. According to DEA, Jinzhou port has not been considered as effective in many years, with a relatively low technical efficiency from 2007 to 2012, which indicates a relatively low level of technology. To enhance the competitiveness, the first and foremost is to upgrade the technology and then, adjustment to the scale is needed. From the pure scale efficiency in Table 4 and 5 we can see that in the past decade the port's average scale efficiency is 0.929 and the port is viewed by the model as scale effective in 2014 and 2015. In the case of Dalian and Yingkou, they have two years of being

scale effective. In the case the port of Jinzhou, it has a decreasing returns-to-scale each year, so the port should reduce input and rationally arrange the resources and make reasonable adjustments to it size.

4. The Analysis of the Factors Affecting the Operation Efficiency of the Port of Jinzhou

Table 6 Analysis and Adjustment of the Port's Financial Slack (Unit：10,000 RMB)

Year		s^-	s^+	p
2007	Y1	66399	0	321666
	Y2	0.008	0.313	0.351
	Y3	1303	34731	41045
	X1	0	0	226974
	X2	0	0	1223845
2008	Y1	50162	0	230717
	Y2	0.017	0.128	0.205
	Y3	3597	29557	46100
	X1	0	0	136744
	X2	0	0	1200416
2009	Y1	47582	0	260280
	Y2	0.025	0.074	0.208
	Y3	5188	12385	40766
	X1	0	0	160815
	X2	0	0	1219501
2010	Y1	37835	0	222338
	Y2	0.021	0.080	0.201
	Y3	3471	20614	40990
	X1	0	0	132341

	X2	0	0	1119838
2011	Y1	30777	0	147646
	Y2	0.021	0.079	0.180
	Y3	3662	31292	48860
	X1	0	0	75400
	X2	0	-17915	1007406
2012	Y1	6499	0	125307
	Y2	0.009	0.011	0.180
	Y3	1390	9871	36664
	X1	0	0	63215
	X2	0	0	784697
2013	Y1	1925	0	88317
	Y2	0.003	0	0.143
	Y3	493	0	22630
	X1	0	0	41199
	X2	0	-93625	565533

Note：s^- =input slack，s^+ =output slack，p^* =target indicator.

133. From Table 6, it can be seen that in the past ten years, the overall efficiency of Jinzhou Port Co.,Ltd. has not reached the optimal score identified by the DEA model, indicating that there is a waste of the input resources. As the output indicators failed to reach the optimal results, there is output redundancy. In terms of the input indicator, the target of total assets in 2011 is 10074.06 million RMB and to reach the optimal overall efficiency identified by DEA, the output radial variables need to be reduced by 179.15 million RMB. In terms of the output indicator, the target of operating revenue is 1476.46 million RMB and the input variable needs to be increased by 307.77 million RMB. To reach the target earning per share of 1800 RMB, the input and output radial variables need to be increased by 210 RMB and 790 RMB. The target net profit is 488.86 million RMB

and the input and output radial variables need to be increased by 312.92 million RMB to reach the optimal results in DEA. The target total asset of 2013 is 5655.33 million RMB and the output radial variables need to be reduced by 936.25 million RMB to realize the optimal overall efficiency in DEA. In terms of the output indicator, the target operating revenue is 883.17 million RMB and the input indicator variable needs to be increased by 19.25 million RMB. To reach the target earning per share of 1430 RMB, the input radial variables need to be increased by 30 RMB.

E. SWOT Analysis of the Other Ports of Liaoning Province

1. SWOT Analysis of the Port of Dandong

a) Strengths

134. Firstly, the port of Dandong is located in the north-eastern point of Liaodong Peninsula. To its east, Yalu River empties into the sea. It borders Dalian and has Yellow sea on its south. Facing Korean Peninsula on its right, it is 119 nautical miles away from the port of Nampho, North Korea, 232 nautical miles away from the port of Incheon, South Korea and 844 nautical miles away from the port of Kobe, Japan. It directly serves the economic hinterlands of Dandong city and Benxi city and its radiation range covers the relatively well-developed three-dimensional transportation network of the four provinces including Liaoning, Jilin, Heilongjiang and Inner Mongolia.

135. Secondly, the railway of the port area is connected with the main lines such as the eastern part of the Northeast China railway, Shenyang-Dandong railway, Beijing-Haerbin railway, Changchun-Dalian railway and linked with Korean Peninsula via the Yalu bridge, and is able to carry out international intermodal transport. Highways lead to Northeast China and Inner Mongolia through the main lines such as Shenyang-Dandong highway, Hegang-Dalian highway, Dandong-Xilinhaote highway, Dandong-Tonghua highway and Dandong-Helinhe highway.

b) Weaknesses

136. Of the three major ports in Liaoning Province, the port of Dalian has a diversified development mode. The port of Yingkou mainly handles the export of

food from the Northeast China. The port of Jinzhou mainly handles the export of minerals and energy. The three ports act as three pillars in the region.

137. Infrastructure. The ports in Liaoning province face fierce competition in terms of the construction of land ports along the routes, the upgrading of infrastructure and equipment, the optimization of the design and construction of the inland railway and road routes as well as the carrying capacity and service life of the highways, therefore, the development is affected.

c) Opportunities

138. In the Plan for the Development of Logistics in Northeast China (Plan) issued by NDRC, the Port of Dandong was included in the layout of major logistics corridors in Northeast China and Dandong was also included in the second-tier logistics node cities in Northeast China. The "Plan" emphatically points out that according to 12th Five-Year Plan, the eastern part of Northeast China will enjoy clear and smooth logistics corridors, railways of improved capacity and accessibility, upgraded highways and the accelerated expansion of Dandong port which is the sea port on the east corridor. There will be strengthened planning and construction of the west corridor linking the east of Inner Mongolia, Mongolia, and the three provinces of Liaoning, Jilin and Heilongjiang and enhanced transport capacity of the Huolinguole-Tongliao-Shenyang-Dandong Channel. The port of Dandong, with food and steel as its focuses, should join "North grain South shipped" port logistics system, build new ore terminal and take part in the establishment of the supply logistics system of iron ore.

139. We will capitalize on the coastal advantages and bonded logistics policies of northeast China to speed up the construction of infrastructure at the border ports such as the Yalu River Highway Bridge, enhance the capacity to handle border crossings and apply ICT to work. We will develop the border logistics between China and DPR Korea by relying on such ports as Dandong and Huichun.

d) Threats

140. Firstly, the ports of Dalian, Yingkou and Jinzhou in the province have similar operations and businesses with the port of Dandong. To rise above in the competition, it will have to offer differentiated and distinctive business and

services. As the mode is already set, major reforms are bound to meet some obstacles.

141. Secondly, in 2015, there are many key construction projects at Dandong port including bulk cargo berths, container berths, waterways for 10,000-ton-class , general berths, yards dedicated to enterprises, berths for roll-on/roll-off vehicles, berths for roll-on/roll-off passengers, roads, yards, power supply, water supply and firefighting. Better infrastructures and facilities will gradually raise the port of Dandong to a higher platform. If it wants to go farther and farther, its facilities and equipment need to meet many more challenges.

2. SWOT Analysis of the Port of Huludao

142. The port of Huludao is located in Bohai Liaodong Bay, which is in the southwest of Huludao, and is in the district of Longgang. During Ming dynasty, it is called “hulutao” (meaning the cover of a calabash) as the shape of the place is like a calabash. The port features a wide bay and deep water. In summer, the wind and wave are not strong and in winter, it only freezes a little and is almost ice-free. The annual throughput exceeds 30 million tons. The Liutiaogou and Suizhong port areas under construction are expected to handle 300 million tons in the long term, becoming another major energy port in Bohai. With Shen Shan Railway and the branch line of Huludao on its back, the port of Huludao is connected with Jinhu Road and Shenshan Road. The convenient traffic makes it the marine node of Northeast and North China. The port of Huludao was originally for commercial use and then transformed to a military port after the founding of the People's Republic of China. In 1984, the port was transformed to one jointly used and developed by the military and civilian. Domestic trade and transportation were carried out at the port. After nearly a hundred years of continuous construction and maintenance, the port of Huludao has a production and operation capacity of a considerable scale. It now has four berths for production use, with two for 10,000-ton-class and two for 5000-ton-class. Its annual overall handling capacity totalled more than 1 million tons. It is a port for general cargoes with petrochemical products, food and building materials as its main business. Its cargo businesses extend to major domestic ports in Shanghai, Guangdong, Fujian and other places. In terms of the first phase of the port’s expansion project, the terminal for 10,000-ton-class and the access road leading

to the port have been completed and the terminal for 20,000-ton-class and the terminal for 35,000-ton-class are under construction. During the second phase, six berths are for the 10,000-ton-class and the total investment of the project reaches 100 million RMB.

a) Strengths

143. Firstly, Huludao city enjoys favourable geographical condition. It is located in the southwest of Liaoning Province. It has Jinzhou on its east, Shanhaiguan on its west and Liaodong Bay of Bohai Sea on its south. Together with Dalian, Yingkou, Qinhuangdao, Qingdao and other cities, Huludao city is a part of the Bohai Economic Circle. It is rich in natural resources, with a variety of mineral resources. The city enjoys rapid economic development and well-developed agriculture. The city formed a wide-ranging industrial system of both light and heavy industry, with the petrochemical industry as the main body, and metallurgy, building materials, machinery, shipbuilding and power generation as the key focus. The city's traffic extends in all directions and the city enjoys an integrated transport layout of a set of railways, roads, highways and pipelines. Huludao city has a coastline of 261 km, offering a wealth of resources along the shoreline.

144. Secondly, the city enjoys the support of policy. It is one of the strategic focuses of Liaoning Province's "five points, one line" development strategy and is also a key development zone in the coastal economic belt. In its overall planning of the ports in Liaoning province, the Liaoning provincial government has determined the nature of the port of Huludao (It is an important part of the ports of Liaoning province and of the coastal ports in the west of Liaoning province; it offers strong support for Huludao city's layout of port-vicinity industry and its further opening up; it serves as the basic resources to safeguard the coordinated and sustainable development of the coastal ports and coastal economic zones in Liaoning province, and provides a convenient outlet for the transport of materials from the east of Inner Mongolia. In the short term, the port is mainly involved in serving the economic development and industrial layout of Huludao city and acts as the downstream port of Mengdong Coal. In the long term, the port will gradually develop to be a modern and comprehensive port area of a relatively large scale, distinctive specialization and strong comprehensive service.) Now the port has a clear direction of development. At the same time, Huludao city,

with the economic situation of the city in mind, has formulated a “three points, one line” development strategy to develop the port economy and the port-vicinity economy, create a coastal economic belt of fast growth, and further straighten out the development pattern. At its northern end, it has actively developed the north port industrial zone in the Jinzhou Bay area. At its southern end, it has developed forward-looking plans to build Suizhong coastal economic zone.

b) Opportunities

145. There has been a gradual increase of the throughput of Huludao port. Especially since the 21st century, the annual growth rate has been relatively high. However, due to its small size, its contribution to the marine industry of the city still remains small. In 2001, the city’s GDP totalled 18.4 billion RMB and the total output value of the marine industry reached 7.085 billion RMB, of which 1.315 billion RMB was from the port and ship building industry, accounting for 18.56% of the total output value of the marine industry and 7.15% of the city's GDP. From 1989 to 2001, the throughput of the port increased rapidly, registering a growth rate of 8.09%. However, due to its small base, its contribution to the city’s marine industry remains small. At the same time, due to the small size and low level of modernization, the port of Huludao is not in a good position to compete and its development is limited. At the end of 1999, the port’s terminal for 10,000-ton-class was officially put into operation. Now, the port has two berths for 10,000-ton-class and two berths for 5,000-ton-class, with its throughput totalling 5.008 million tons. Its direct economic hinterlands include Huludao city, Fuxin city, Chaoyang city and Chifeng city and its indirect economic hinterlands are Inner Mongolia, Jilin province and the west of Heilongjiang province. The major cargoes include petroleum, chemical products, grain, fertilizer, cement, steel, ore and building materials, with corn accounting for 55%, oil for 27-28%, and the rest being zinc ingots, chemical products, salt and groceries. The port mainly serves large and medium-sized enterprises and the agricultural enterprises in Huludao city.

c) Weaknesses

146. The port of Huludao is adjacent to Jinzhou and Qinhuangdao ports, and has a comprehensive hinterland. In comparison with other ports, Huludao port is less competitive. The port is both for commercial and military use, so its openness is

greatly limited, handling basically zero foreign trade cargo. Of the 258 kilometres of coastline of Huludao city, 6 are suitable for port construction. At present, only one port is built, namely, the port of Huludao (the port of Suizhong is a supporting facility for power plants). The port has a small handling capacity, a far cry from the port of Qinhuangdao, the port of Dalian and the port of Bayutu, the first two of which handle more than one hundred million tons of throughput and the last of which more than 30 million tons of throughput. This situation fails to match the actual needs of socio-economic development in the region. At present, the annual import and export volume of Huludao city alone reaches 3 million tons. As for the hinterlands including the east of Inner Mongolia Autonomous Region and the west of the provinces of Liaoning, Jilin and Heilongjiang, the annual import and export volume totals 30 million tons. So it is urgent to expand and improve the existing ports and build new ports. Meanwhile, the major function of the port of Huludao now is concerned with transportation. With this single function, the port's role in industry and trade has not been brought into full play. The vast majority of goods handled by the port are transit flows, which are rarely stored and processed. Experience of port economic development shows that storage and processing are important links for the port to boost regional economy. In addition, the port's equipment is aging and its infrastructure is yet to be improved, so it is urgent to realize the modernization and informatization of port facilities.

3. SWOT Analysis of the Port of Panjin

147. Located in the centre of the Liaohe River Delta, Panjin city enjoys a favourable geographical location. It is one of the nearest estuaries for the Panjin city and the urban clusters of the middle of Liaoning province. It enjoys access to its vast economic hinterlands through convenient land transportation such as highways, national highways and railways. However, now the port of Panjin is only involved in the import and export of some domestic and foreign trade of Panjin city, and its potential is not fully tapped. At present, the four berths at the inland river port are for below-3,000-ton-class, with the designed annual capacity standing at 700,000 tons. Over the years, the goods handled by the port of Panjin are oil, which accounts for more than 80% of the total throughput. This indicates that the port handles a single type of cargo. Panjin is an important petrochemical base of Liaoning province with heavy traffic of cargoes. The economic

development of Panjin mainly relies on crude oil resources, but the port offers no obvious impetus to urban development. The coastal industry has just started and there is an urgent need for the support of the deep-water port.

a) Strengths

148. Firstly, the port of Panjin enjoys favourable geographical condition. Located in the Liaodong Bay New Area of Panjin, it is situated in the southwest of Liaoning province. It is in the centre of urban clusters of the middle of Shenyang, the economic circle of western Liaoning and the coastal economic belt of Liaoning. As an important node of regional economic development, it is found at the junction of Shenyang Economic Zone and Beijing-Tianjin-Tangshan urban clusters and at the intersection of the economic circle of Northeast Asia and the Bohai Economic Rim. It enjoys convenient transportation. On its west, it is 65 nautical miles away from the port of Jinzhou and on its south, it is 37 nautical miles away from the port of Youyuquan. In terms of the land distribution, the port distribution road behind the port of Panjin is connected with Panying road, which is connected with State Road 305. In addition, the port distribution road is directly linked with Binhai Avenue, which is a key road of the province and leads to major coastal cities of Liaoning province. The port distribution railway leads from Bohai Station on the Haicheng-Gou Bangzi route. Starting in 2009, the project was complete and open to traffic in May 2012.

149. Secondly, in recent years, the port of Panjin has been committed to upgrading its hardware and software facilities. Its hardware facilities have begun to take shape. As the berths under construction are put into operation, the port can handle the 100,000-ton bulk cargo ships and the 300,000-ton crude oil vessels. In terms of soft environment, the promotion of the port was approved in 2016; companies dedicated to port trade and port logistics have been established. Meanwhile, the approved 50,000-square-meter bonded warehouse and export supervision warehouse were put into use and the construction of a 500,000-square-meter bonded logistics center is being accelerated. An electronic trading platform of commodity is established to provide the information of the commodity market and transactions. The port has worked with a number of banks to provide the clients with logistics financial services such as pledge by warehouse receipts so as to help the clients with capital shortage. Inland ports have been built to

cooperate in the port operation and to expand the business in the hinterlands. As the hardware and software facilities continue to improve, the service sector is taking off and in a stage of rapid development.

150. Thirdly, Panjin city enjoys a coastline of rich resources, vast beaches, flat terrain, and its potential is yet untapped. The port of Panjin has a land area of 30 square kilometres. Abundant land resources not only greatly reduce the cost of land development in the coastal areas, but also provide sufficient space for the development of the port and the gathering of related industries. The depth of water near the port of Panjin is ideal and the coastline is rich in resources. According to the Master Plan of the Port of Panjin (Revised), during the planning period, the port area of Rongxing will construct 65 berths for production use with a total quay length of 39.0 km, a planned land area of 44.7 km2 and an expected throughput capacity of 300 million tons in the long term. The port of Panjin is located in Liaodong Bay New Area, with a planned area of 400 square kilometres and rich resources in water and electricity, capable of meeting the needs of the future development of the port of Panjin.

b) Weaknesses

151. Firstly, a vague understanding of the port leads to its weak functionality. The port of Panjin is not just a port or a logistics centre. It is a hub for water and land transportation and involves a series of industries. It should be seen as the centre of finance, information, economy and trade, which offers logistics services, information services, business and financial services and industrial functions. However, at present, the port is only utilized in the field of logistics. The vague position of the port results in a lack of functions in Panjin City.

152. Secondly, the port does not serve the economy of hinterland very well and its overall competitiveness is weak. The port of Panjin is not recently constructed and is located at the northernmost part of Liaodong Bay, so the water area on the south side of the port is very narrow, which has restricted the port development. Due to this limit, the port’s demands for development cannot be met and the port's role in boosting the regional economy is not obvious. At present, due to the influence of the distribution system, fee collection, the set freight route and the structure of goods, the port only has limited carrying capacity for enterprises in

the hinterland limited. So the enterprises have to resort to farther neighbouring port of Yingkou and Jinzhou. Market mechanism has not been given full play to guide the pricing of the port. Due to market rules, this has resulted in a lack of overall competitiveness.

153. Thirdly, there's a mismatch between the ports and the waterway facilities. Since the "12th Five-Year Plan" period, the port of Panjin has a waterway for 50,000-ton-class, while the waterways for 100,000-ton-class and 250,000-ton-class have been constructed as planned. However, the designed scale of some terminals reached 70,000 tons, 100,000 tons and 300,000 tons. The construction of waterway severely lags behind. There's been a mismatch and discordance between the waterway and berth.

154. Fourthly, railway distribution channel is yet to be further extended. Since the "12th Five-Year Plan" period, the port of Panjin has successively built railways into the port and dedicated port distribution railways through which the port plans to further connect to Shenpan railway and Fu-Pan Railway so as to expand the hinterland. However, due to various reasons, the construction of these external corridors of the railways lag behind and the expansion of port into its hinterland is limited.

155. Fifthly, port logistics and IT application are yet to be improved. As the port speeds up the construction of hardware facilities such as terminal, its soft environment is still weak. The IT application needs to be expanded and the port needs to be further modernized. In terms of services, the port's main port business needs to be strengthened and its logistics expanded. The port's business system is relatively simple and the port service facilities still need to be improved.

c) Opportunities

156. Firstly, the support of national development strategy and good policy guidance. Against the backdrop of strong policy support to revitalize NEA, the "Belt and Road" initiative, the strategic platform for the coordinated development of Beijing, Tianjin and Hebei, the China-Mongolia- Russia Economic Corridor and the establishment of a China-Korea FTA, Liaoning province has built an important corridor connecting Asia and Europe. In order to be further integrated into the

opening-up landscape of the province and the country province with a broader scope, wider range and deeper level, the port of Panjin, located in Liaodong Bay, should actively follow the national strategy and build itself to be an important node of the shipping system in Northeast Asia.

157. Secondly, the economic, social and industrial Development in Northeast China is promising. There is an increase of the international cooperation in Northeast Asia, which adds new impetus to the overall revitalization of the region. Adhering to the principle of orderly, optimal, coordinated and green development, the coastal ports maintained a healthy and sustainable development, with enhanced ability to support the transport of key goods and better service. Progress has been made in green development. The ports played a bigger role in supporting the development of the regional economy and industrial agglomeration and can better meet the needs of economic and social development.

158. Thirdly, the development of coastal economic belt drives the industrial development of the port. As Liaoning's coastal economic belt was elevated to be a part of national strategy, Shenyang economic zone was also designated as a pilot area of comprehensive reform. Liaoning has put forward the development pattern of "twin engines linked by one axis ", with the Shenyang economic zone being the link, the coastal area and the hinterland as the two engines. This planning promotes the development of the province. In addition, the development of the coastal economic belt has led the development of many industries in which the province enjoy advantages such as petrochemical, building materials, automobiles, steel and power.

159. Fourthly, the development of the port-vicinity industry in Panjin Liaodong Bay New Area accelerated. Panjin city will continue to make all efforts to develop Liaodong Bay New District. To show the government’s close attention to the port, it has declared that during the "13th Five-Year" period, it will continue to speed up the construction of port facilities, improve the collection and distribution system and perform well in the work related to port’s upgrading to the first class. It will also comprehensively improve the port’s capability and level and make major efforts to open up new routes and inland dry ports. It will insist on the combination of responsibilities, rights and interests, implement target management and

facilitate the port to truly act as an important node of Northeast Asia shipping system.

160. Fifthly, the function adjustment of the port of Yingkou Port has resulted in the transfer of freights. On January 26, 2007, the port of Yingkou and the port of Panjin have signed a joint venture contract for coordinated development. From the perspective of the port of Panjin itself, the purpose is to make full use of the resource advantages of the port of Yingkou such as the freight, deep-water channel, tugboat and barges, increase the throughput of Panjin Port and speed up the construction of the port so that the two ports can enjoy their complementary advantages.

d) Threats

161. Firstly, there is fierce competition from the surrounding ports. While serving the local economy, the port of Panjin is capable of serving a broader hinterland. As the constructions of terminal facilities and the external collection and distribution channels speed up, the port of Panjin will enjoy a higher standing in the coastal ports of the province. It will not only become a pillar for the leading industries in the Panjin area, but also become an important part of the regional port cluster. With a higher status and a broader service range, the port of Panjin is bound to encounter some overlapping with other ports. It is certain that it will face some competition from certain ports including Dalian, Yingkou, Jinzhou, Dandong and Huludao ports.

162. Secondly, the development of the industry is facing challenges. As the construction of hardware facilities such as terminal continues to accelerate, the development of soft environment lags behind. The IT application in the port business needs to be advanced and the port needs to be further modernized. In terms of the service, the port needs to strengthen its main business and expand its logistics function. Port business system is yet to be diversified and port service facilities need to be improved. The high port charges may result in a loss of freights.

163. Thirdly, the port has a great responsibility to protect the ecosystem. The port construction occupies a large number of beaches. The large-scale reclamation damages the environment of coastal wetland, resulting in lower carrying capacity

of the environmental. There is increasingly sharper contradiction between the port construction and marine ecological protection. There are prominent environmental problems such as oil and gas pollution and dust pollution. The environment of the port needs to be further improved.

4. SWOT Analysis of the Port of Suizhong

164. On the morning of September 29, 2014, the "Anping 5" vessel, a 50,000-ton bulk cargo ship, was steadily anchored at the general terminal of the port of Suizhong, marking the official opening of the port. The opening ceremony was presided over by Cao Yingfeng, general manager of Suizhong Port Group. Liu Huanxin, director of Department of Transportation of Liaoning Province, Gao Baoyu, chairman of Yingkou Port Group and Suizhong Port Group, Yang Cuijie, deputy mayor of Huludao government and Guo Lun, secretary of Suizhong County Committee, attended the ceremony and delivered speeches.

165. The construction of Suizhong Port, whose prospective design is undertaken by CCCC First Harboar Consultants Co Ltd, started in September 2012. The initial construction projects include three general berths for 50,000-ton-class, with a quay length of 800 m and a land area of 2.4 km2. The designed annual throughput is 4.3 million. Hydraulic structure takes the form of gravity caisson wharf. The official operation of Suizhong port will further promote the rapid development of port-vicinity industry in Huludao and comprehensively enhance the strategic position of Huludao in the Liaoning coastal economic zone and even in the Bohai Economic Circle. Meanwhile, strategic layout of port development in Liaoning province is further optimized, the port collection and distribution system in western Liaoning province is improved, the overall service of Liaoning port cluster is enhanced, and the development and opening up of Liaoning coastal economic belt can be better bolstered and guaranteed.

a) Strengths

166. The port of Suizhong is located in Liaoxi Corridor, adjacent to northwest China, north China and eastern Inner Mongolia. Geographically, it is well-positioned and enjoys good natural conditions. It is planned to build 59 large-scale deep-water berths, with the throughput exceeding 100 million tons. The planned land area stands at 25 square kilometres. Suizhong and eastern Beidaihe new area look to

the port to realize the dream of “boosting the industry and the region with port”. Since September 22, 2012 when the construction of the port officially started, three projects of terminal for 50,000-ton-class have been going well; an investment of 1.5 billion RMB has been put into place; port dredging and channel dredging have been basically completed; 350 meters of terminal shoreline surfaced and the supporting facilities and constructions are under way including backfilling of the site, port yard, road and auxiliary production area. The establishment of a 10-square-kilometer port-vicinity industry zone at the back of the port area, port distribution railway and port distribution highway are all in the early stage.

b) Weaknesses

167. Firstly, the berth structure of our province is not suitable for international shipping. China is an importer of crude oil. Liaoning's crude oil processing capacity ranks first in the country. The imported oil comes from the Middle East, mainly transported by the 250,000-300,000-ton-oil tanker. The largest oil terminal in our province is the Tieyuwan oil terminal of the port of Dalian Port, which can only accommodate 150,000-ton oil tanker. As for the port of Suizhong Port, it even only has berth for the 80,000-ton cruise ship.

168. Secondly, the IT application in the port lags behind. The upgrading of the transportation system to the integrated logistics management should be synchronized with the IT application. Port business involves shipping companies, port stations, freight forwarding, shipping agencies, roads, railways, transportation, enterprises, banks, insurance, taxation, supervision, multinational corporations and other relevant departments of logistics. A large number of information and documents would be produced during the intricate operation revolving around the goods including acceptance check, discharge, storage, three inspections during customs clearance, packaging, processing, distribution and sales. To realize the above-mentioned information, we should process the documents electronically and the "paperless trade" will soon become a passport to enter the international trade and transportation system and an important symbol of high efficiency, management level and modernization. To realize the electronic processing of port information and documents as well as the “paperless trade”, Liaoning still has a long way to go.

c) Opportunities

169. At the same time, in order to further speed up the port development and give full play to the leading role of Suizhong Port in the economic and social development of the county, Dongdaihe New Area and Suizhong Port Group have been closely working with each other since the beginning of the year so as to speed up the construction of the logistics park in front of the port. At present, the constructions of six general-purpose warehouses have been completed with a total area of about 60,000 square meters. The general-purpose warehouses No. 1, 2 and 3 have been put into use and the general-purpose warehouses No. 4, 5 and 6 are expected to be handed over in June of next year. The supporting mobile warehouse for machinery, the warehouse for tools and attachments and the maintenance warehouse have been constructed. The 4,000-meter main road has been built and is open to traffic. A cargo yard of about 230,000 square meters has been established. The reclamation of a 450,000-square-meter-land has been completed and the land has gone through the basic treatment. In 2016, the total investment in the logistics park in front of the port amounted to approximately 630 million RMB and the park covers an area of approximately 437,000 square meters. The project started in 2014 and is expected to be completed in full. By then, it will become a modern port logistics park with complete functions, advanced facilities and first-notch service, adding momentum to the realization of “the interconnected development of the port” and boosting the rapid development of port-vicinity economy.

170. To sum up, the development of coastal economic belt of Liaoning province has both advantages and disadvantages. It not only faces opportunities but also challenges. The strengths go hand in hand with weaknesses and the opportunities coexist with and challenges. But on the whole, the advantages are more obvious and the opportunities outweigh the challenges. After the implementation of “Revitalization of NEA”, the northeast economic area is blessed with rare opportunities for development and the coastal economic belt of Liaoning province plays an increasingly important role in this region as it is Northeast China’s forefront of opening up to the outside world and international industrial transfer. It is also the international shipping center in Northeast China and the engine of the revitalization of the northeast old industrial base. As a leader in the economic growth and industrial development and a linkage of the

region, the coastal economic belt plays an important role in the “Revitalization of NEA”. All ports should fully capitalize on the existing advantages and make up for their deficiencies. They should seize the rare opportunities and embrace the challenges. By implementing the strategies of industrial cluster, internationalization, coordinated and interactive development as well as indigenous innovation, all ports should work hard to forge ahead in a firm way and build on the momentum so as to form a landscape where the ports enjoy benign and interactive development, which will in turn promote the common development and common prosperity of the northeast economic zone and promote the revitalization of the northeast old industrial base.

IV. Comparative Analysis on Ports Operation Efficiency among the Bohai Bay Economic Rim, the Yangtze River Delta and the Pan-Pearl River Delta Regions

171. The logistics industry covers transportation, storage, freight forwarding and information sector and is regarded as one of the National Emerging Industries. In 2015, China introduced a number of policies on the logistics industry. For example, the National Development and Reform Commission issued *the Notice on Accelerating Implementation of Major Projects Related to Modern Logistics*; the Standardization Administration of China jointly published the *Medium- and Long- term Development Plan for Logistics Standardization (2015-2020)* with multiple departments; and the Ministry of Commerce issued *the Implementation Opinions on Constructing Intelligent Logistics Distribution System*, etc. China's logistics industry should grasp the opportunities brought by the "One Belt One Road" (OBOR) initiative to vigorously develop modern logistics. It should also adapt to the requirements by OBOR initiative, increase its competitiveness and rapidly integrate itself into international logistics, so as to compete internationally, to provide good full logistics services for Chinese and foreign companies, and to earn market share.

172. As for regional development, the logistics industry is relatively mature in the Pan-Pearl River Delta region. For example, in 2014, Shenzhen issued *Measures on Promoting E-Commerce and Logistics Industry in Shenzhen*, which mainly includes facilitating innovation and integrated development, improving infrastructure construction, promoting industry regulation and administration, building friendly environment for development, and strengthening institutional protection for development. In 2003, Xiamen announced the *Opinions on Accelerating the Development of Modern Logistics Industry in Xiamen*, which is a key policy for logistics industry development. In 2010, the Xiamen Municipal Government issued *Opinions on Supporting the Development of Modern Logistics Industry*, which strengthened land use guarantee, as well as fiscal and taxation support for the industry. It also provided stronger support for economic and social development in Xiamen, and for the transformation and upgrading in the consumer industry. In 2015, Sichuan built "safety belt" for 6800 kilometers of road, and Chongqing introduced *Three-Year Action Plan for Promoting Modern Logistics Development*. Various measures to encourage modern logistics industry

development have also been taken in the Yangtze River Delta region. For instance, Jiangsu province published *the Opinions on Modern Logistics Industry Development Policies*, and specified the transformation and upgrading target of Suzhou port from 2015 to 2017. Shanghai implemented *Temporary Administrative Measures for Customs Bonded Logistics Center*, which specified 20 measures for maritime transport development and 10 principles for optimizing logistics operation. In the Bohai Bay economic rim region, various rules and regulations are also introduced one after another to vitalize the logistics industry. In particular, policies to support the joint-development of the manufacturing and logistics industries are introduced. In 2015, the State Council approved the *Outline of Cooperation and Development in the Bohai Bay Economic Rim Region*, which promoted OBOR and coordinated development of Beijing–Tianjin–Hebei (BTH) region. In the same year, Tianjin announced *Opinions on Promoting Logistics Industry Development*, which gave strong support for logistics companies to realize industrial consolidation, upgrading and restructuring through mergers and acquisitions. Liaoning province also published *Opinions on Accelerating the Development of the Service Industry* and the *Four-Year Action Plan for Promoting Transportation and Logistics Development*. Jilin province issued *Development Plan for Logistics Parks* to regulate logistics parks and accelerate the construction of Faw Volkswagen automobile logistics park and North Asia agricultural products logistics park. Heilongjiang province introduced the “Internet + circulation “plan.

A. The indicator system and data source

173. Based on the BCC model in the Data Envelopment Analysis (BCC-DEA), and from the perspective of the financial efficiency of listed state-owned ports companies, the input indicators are generally indicators of costs such as asset size index and operating costs. And the output indicators focus on profitability and solvency index, such as operating income, net profits and earnings per share (EPS). Based on the requirements on input-output index in the variable return to scale model, the principle of input index is the smaller the better, and output index is the larger the better. This report chooses two input indicators—total assets and operating costs, both of which reflect business investment of logistics companies. Operating costs refer to all costs resulting from selling goods or

services. As for output indicators, we choose three indicators—operating income, net profits and EPS, all of which indicate profitability of those state-owned logistics companies. Operating income refers to the total inflow of economic benefits from daily operation of the business such as selling goods, providing labor services and transferring the right to use assets. These input-output indicators can fundamentally reflect the basic input-output performance of port enterprises. Table 7 shows the indicators and abbreviations.

Table 7 Input-Output Efficiency Indicators for Port Enterprises

Input Index		Output Index		
Total Assets(in ten thousands)	Operating Costs (in ten thousands)	Operating Income (in ten thousands)	Net Profits (in ten thousands)	EPS
X_1	X_2	Y_1	Y_2	Y_3

174. In this report, a total of 18 port logistics enterprises listed in 2006-2015 are selected as the decision-making units. All input-output indicators are from the 2015 financial highlights, income statements and balance sheets of those listed logistics enterprises. The method requires that all input and output data are positive numbers. However, the output data of some port logistics enterprises are negative, which cannot meet the requirements of data envelopment method. In this report, the linear transformation invariance of data envelopment method is used to process the negative values. Research findings by Ali and Seiford (1990) prove that the data envelopment method does not change the efficient frontier when there is linear invariance [15]. Pastor (1996) also argues that data envelop method with variable output-scale returns can transform its output data without affecting the effective value [16]. The average original data of the sample port enterprises in 2006-2015 selected in this paper are shown in Table 8.

Table 8 Average Original Indicators Data for 18 Port Logistics Enterprises by Region from 2006 to2015

Region	Sample	Input Index	Output Index

	Enterprise	X_1	X_2	Y_1	Y_2	Y_3
Bohai Rim	Jinzhou Port	862648	72404	114885	16444	0.1
	Dalian Port	2233316	281874	397056	66578	0.2
	Yingkou Port	1114830	164710	248793	34401	0.64
	Tielong Logistics	427047	239496	298462	35464	0.3
	Rizhao Port	1069588	225322	311463	47361	0.4
	Tianjin Port	2275617	936085	1185741	116836	0.36
Yangtze River Delta	Shanghai Int'l Port Group (SIPG)	7457931	1261501	2123327	575425	0.14
	Shanghai Lingang	140942	78180	98433	1191	0.03
	Lianyungang	395017	86433	119692	10631	0.27
	China Shipping Develop Co.	4456693	572208	729622	99960	0.27
	Nanjing Port	87111	8522	14983	2299	0.13
	Wanjiang Logistics	958779	735277	771145	-5688	0.04
Pan-pearl River Delta	Yantian Port	533876	17489	41417	54005	0.57
	Guangshen Railway	3010460	953266	1234013	122260	0.17
	Beibu Gulf Port	353705	109107	145138	16714	-0.39

	Chongqing Port	438748	77741	105066	7831	0.15
	Xiamen Port	357664	286467	318685	20425	0.32
	Xiamen Int'l Airport	357664	41350	88202	31331	0.42

B. The Comparative Analysis of Efficiency among Bohai Rim, Yangtze River Delta and Pan-Pearl River Delta Regions

175. Based on the variable returns to scale model (1.1)and data calculation results by DEA software, the author concludes the comparison of the overall efficiency, technical efficiency and scale efficiency of port logistics enterprises in different regions from 2006 to 2015, which also reflects the differences in the competitiveness of enterprises from the efficiency point of view (see Table 9). Here, the overall efficiency value C_r^* technical efficiency value T_r^*, and the scale efficiency are calculated according to the formula of $E_r^* = C_r^* / T_r^*$. The trend of changing overall efficiency, technical efficiency and scale efficiency of port logistics enterprises in different regions from 2006 to 2015 are shown in Figure 3.

176. For the Bohai Rim region, Tianjin Port exhibits the highest overall, technical and scale efficiency among those port logistics enterprises, followed by Tielong Logistics, Rizhao Port, Yingkou Port, Jinzhou Port and Dalian Port. The line chart of the 10-year average overall, technical and scale efficiency of the selected enterprises from 2006 to 2015 shows that (see Figure 6) the differences in the three efficiency indicators of the six port enterprises are not obvious and have an upward trend. All overall efficiency values failed to reach the optimal level due to scale efficiency. The technical efficiency values of Tianjin Port, Tielong Logistics and Yingkou Port all reached 1. The scale efficiency values of port logistics enterprises failed to reach the optimal level, and were in the stage of decreasing returns to scale. It shows that these enterprises cannot effectively coordinate all lines of production due to excessive production scale, which reduces production efficiency.

Table 9 Average Efficiency Indicators for Port Logistics Enterprises from 2006 to 2015

	Sample Enterprise	Overall Efficiency C_r^*	Technical Efficiency T_r^*	Scale Efficiency E_r^*	Decreasing Return to Scale
Bohai Rim	Jinzhou Port	0.732	0.821	0.892	drs
	Dalian Port	0.690	0.811	0.851	drs
	Yingkou Port	0.798	1.000	0.798	drs
	Tielong Logistics	0.91	1.000	0.91	-
	Rizhao Port	0.846	0.909	0.930	drs
	Tianjin Port	0.948	1.000	0.948	drs
Yangtze River Delta	Shanghai Int'l Port Group (SIPG)	0.945	1.000	0.945	drs
	Shanghai Lingang	1.000	1.000	1.000	-
	Lianyungang	0.859	0.865	0.993	drs
	China Shipping Develop Co.	0.630	0.752	0.838	drs
	Nanjing Port	1.000	1.000	1.000	-
	Wanjiang Logistics	0.930	1.000	0.930	drs
Pan-pearl	Yantian Port	1.000	1.000	1.000	-

River Delta	Guangshen Railway	0.904	0.956	0.946	drs
	Beibu Gulf Port	0.922	0.927	0.995	drs
	Chongqing Port	0.773	0.782	0.988	drs
	Xiamen Port	1.000	1.000	1.000	-
	Xiamen Int'l Airport	1.000	1.000	1.000	-

Note: Drs: decreasing returns to scale, Irs: Increasing returns to scale

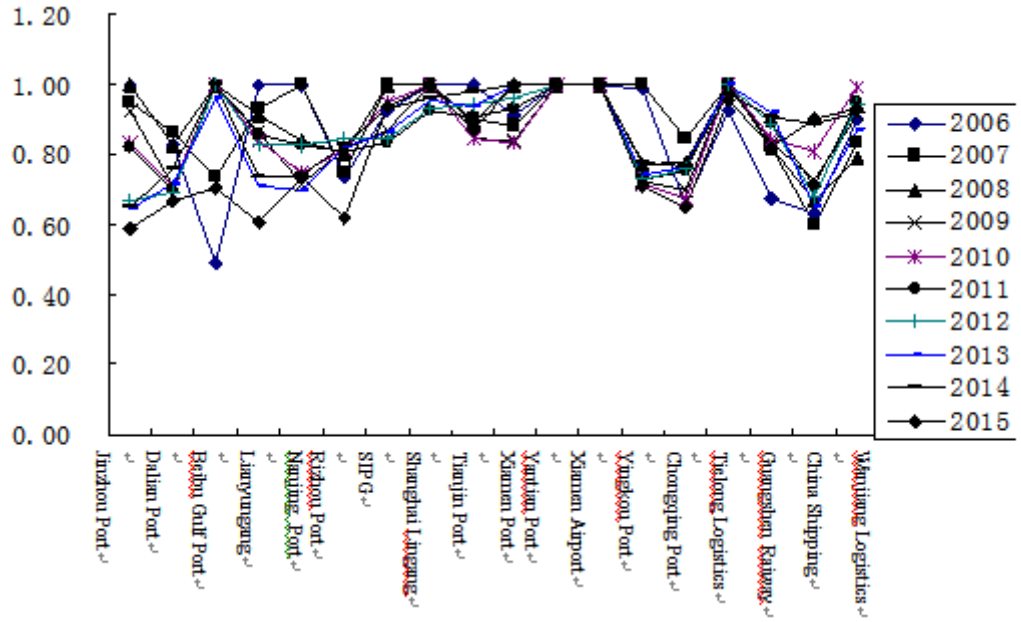


Figure 6 Trend in Efficiency Differences of State-owned Logistics Companies by Region from 2006 to 2015

177. For the Yangtze River Delta region, the overall efficiency, technical efficiency and scale efficiency of Shanghai Lingang and Nanjing Ports reached the optimum by DEA. The technical efficiency of Shanghai International Port Group and

Wanjiang Logistics also reached the optimum by DEA, while the overall efficiency of Lianyungang and China Shipping were relatively low. The reason why the overall efficiency of Shanghai Port, Wanjiang Logistics, Lianyungang and China Shipping did not reach the DEA optimum is mainly the inefficiency of scale. Besides, the four state-owned companies were all at a stage of decreasing returns to scale. It indicates such problems as excessive production scale and unreasonable division of labor within those companies. From Figure 6, we can see that average overall, technical and scale efficiency of China Shipping in the past 10 years were at a relatively low level, while the efficiency index of other state-owned logistics enterprises was relatively stable.

178. For the Pan-Pearl River Delta region, the overall, technical and scale efficiency of Yantian Port, Xiamen Port and Xiamen International Airport reached the DEA optimum. The overall efficiency of Guangshen Railway and Beibu Gulf Port indicated weak DEA efficiency. Both the overall and technical efficiency of Chongqing Port were relatively low. The overall efficiency of Guangshen Railway, Beibu Gulf Port and Chongqing Port did not reach DEA optimum mainly because of technical and scale inefficiency. All three companies were at the stage of decreasing returns to scale, indicating that imbalances in input-output still existed in these companies due to excessive production scale.

C. The Input-Output Redundancy Analysis for Port Logistics Enterprises to Reach Optimal Efficiency in Three Regions

179. In addition to analyzing the efficiency of each evaluation unit, the DEA method is more important in that it can identify the improvement direction of invalid units in DEA, and then provide the adjustment values of each invalid evaluation unit so as to achieve the best efficiency portfolio. This requires projection analysis of invalid DEA units.

180. Through the projection analysis of redundant inputs and insufficient outputs of the evaluation units, the absolute value of redundant inputs and insufficient outputs of each unit is obtained, which can be used to determine the effective adjustment direction and adjustment value of each unit. Furthermore, the input redundancy and output insufficiency ratio of each evaluation unit are analyzed, and the analysis results are compared with the remaining units in the evaluation

system in the same period to find the main cause of inefficiency and to remedy flaws in the investment decision-making process. It also enables each evaluation unit to tap into their own advantages, make reasonable use of the existing input resources, and try to get the maximum output with limited input resources. In addition, through the vertical analysis of the input redundancy and output insufficiency ratio changes of the same unit during the evaluation period, it is possible to obtain improvement in input redundancy and output insufficiency, to help port enterprises find out the direction to improve input-output relations, and to provide reference for making rational investment decisions.

181. Firstly, for the Bohai Rim region, Jinzhou Port, Dalian Port and Rizhao Port are three important ports, and they play a significant role as transportation bridges for industrial development and revitalization in the region. The overall efficiency of the three enterprises did not reach DEA optimum in recent years, indicating that the waste of input resources has led to the gradual increase of operating costs. As a result, the output fails to reach the optimal status, and the input-output redundancy exists. The adjustments made through redundancy analysis are shown in Table 10. Judging from the average input-output of Jinzhou Port in the past 10 years in Table 10, for the overall efficiency to reach DEA optimum, both input and output indicators need to be adjusted. On the input side, the target value of total assets should be 5,383,730,000 RMB, and the output radial variable needs to be reduced by 3,242,750,000 RMB in order to achieve the optimal overall efficiency by DEA. On the output side, the target value of operating income should be 1,399,980,000 RMB, and the input radial variable needs to be increased by 251,130,000 RMB. The target value of net profits should be 451,790,000 RMB and the input and output radial variables needs to be increased by 35,950,000 RMB and 251,400,000 RMB respectively in order to achieve DEA effectiveness. Due to space limitations of this report, Dalian Port and Rizhao Port follow similar analysis.

Table 10 Input-Output Redundancy Analysis for the State-owned Port Logistics Enterprises in the Bohai Rim Region （s^-、s^+、p^*） (in ten thousands)

	Jinzhou Port	Dalian Port	Rizhao Port

	s^-	s^+	p^*	s^-	s^+	p^*	s^-	s^+	p^*
Y_1	25113	0	139998	397056	92323	0	31256	0	342719
Y_2	3595	25140	45179	66578	15481	56528	4753	16710	68824
Y_3	0	0	0	0	0	0	0	0	0
X_1	0	-324275	538373	2233316	0	-476002	0	0	1069588
X_2	0	0	72404	281874	0	0	0	0	225322

Note: s^- inputslack, s^+ output slack, p^* target value

182. Secondly, for the Yangtze River Delta region, the overall efficiency of Lianyungang, China Shipping Development and Wanjiang Logistics do not reach the DEA optimum, and input-output redundancy analysis is shown in Table 11. Taking Lianyungang as an example, both the output and input indicators need to be adjusted in order to achieve optimal overall efficiency by DEA. For the input index, the target value of total assets should be 3,697,010,000 RMB, and the input radial variable needs to be decreased by 237,750,000 RMB to achieve optimal overall efficiency by DEA. Similarly, the target value of operating costs should be 233,090,000 RMB, and the input radial variable needs to be reduced by 14,990,000 RMB to achieve optimal overall efficiency by DEA. For the output index, the target value of net profits should be 118,030,000 RMB, and the output radial variable needs to be increased by 54,350,000 RMB. The target value of EPS should be 0.078, and the output radial variable needs to be increased by 0.018. China Shipping Development and Wanjiang logistics follow similar analysis.

Table 11 Input-Output Redundancy Analysis for the State-owned Port Logistics

Enterprises in the Yangtze River Delta Region（s^-、s^+、p^*） (in ten thousands)

	Lianyungang			China Shipping Development			Wanjiang Logistics		
	s^-	s^+	p^*	s^-	s^+	p^*	s^-	s^+	p^*
Y_1	25113	0	139998	397056	92323	0	31256	0	342719
Y_2	3595	25140	45179	66578	15481	56528	4753	16710	68824
Y_3	0	0	0	0	0	0	0	0	0
X_1	0	-324275	538373	2233316	0	-476002	0	0	1069588
X_2	0	0	72404	281874	0	0	0	0	225322

Note: s^- inputslack, s^+ output slack, p^* target value

183. For the Pan-Pearl River Delta region, the overall efficiency of the Guangshen Railway, Beibu Gulf Port and Chongqing Port do not reach DEA optimum. The input-output redundancy analysis is shown in Table 12. Taking Guangshen Railway as an example, to reach DEA optimum, the output indicators need some adjustments. The target value of operating income should be 12,911,070,000 RMB, and the input radial variable has to increase by 570,940,000 RMB. The net profits target should be 1,859,650,000 RMB, and both the input and output radial variables need to be adjusted. The input radial variable should increase by 56,570,000 RMB, and the output radial variable should increase by 580,480,000 RMB. Beibu Gulf Port and Chongqing Port follow similar input-output redundancy analysis with Guangshen Railway.

Table 12 Input-Output Redundancy Analysis for the State-owned Port Logistics

Enterprises in the Pan-Pearl River Delta Region（s^-、s^+、p^*） (in ten thousands)

	Guangshen Railway			Beibu Gulf Port			Chongqing Port		
	s^-	s^+	p^*	s^-	s^+	p^*	s^-	s^+	p^*
Y_1	57094	0	1291107	11485	0	156623	29334	0	134400
Y_2	5657	58048	185965	1323	10981	29018	2186	27384	37402
Y_3	0	0	0	0	0	0	0	0	0
X_1	0	0	3010460	0	0	353705	0	0	438748
X_2	0	0	953266	0	0	109107	0	0	77741

Note: s^- inputslack, s^+ output slack, p^* target value

D. Conclusion

184. First of all, the empirical results of the overall, technical and scale efficiency of port enterprises in the Bohai Rim, the Yangtze River Delta and the Pan-Pearl River Delta regions conclude that, most of the port efficiency values do not reach the DEA optimum mainly because of scale inefficiency, which may result from waste of resources input, unreasonable division of labor, and insufficient standardization of logistics infrastructure, leading to poor information acquisition needed for making production decisions in those state-owned logistics companies. These various reasons may lead to high investment in operating costs; hence the output fails to reach the optimal status. Therefore, as the leading

players in China's logistics industry, port enterprises must develop modern corporate system, strengthen the construction of modern logistics system, and promote the development of modern logistics industry toward the direction of centralization, scale effect and integration. For example, the Bohai Rim region should focus on port transformation, upgrading and innovation, and on operation efficiency improvement as well as operating costs reduction through strategic integration with large manufacturing companies. In this way, the Bohai Rim region can become a new engine for China’s economic growth, transformation and upgrading, and those companies will become demonstration enterprises for regional coordinated development.

185. Second, compared with the overall and scale efficiency, the technical efficiency of state-owned logistics enterprises in the three major regions has more room for improvement. In this era of "Internet +" and integration, science and technology shorten the space and time gap and make communication easier for logistics companies. Although technical inefficiency is not the main reason at the moment for the poor overall performance of state-owned logistics enterprises, it is part of it. Technology should be exploited to establish a smart logistics information service platform featuring interconnection and interworking, an efficient and smart terminal distribution network, and a smart logistics allocation and deployment system, so as to effectively improve information management and technological application capabilities of logistics companies. At the same time, focus should be given to enhance service innovation, to build a tiered team of high-end talents and basic technical personnel, and to create more value for clients.

186. Finally, empirical results indicate that the overall, technical and scale efficiency of Shanghai Lingang and Nanjing Port in the Yangtze River Delta region and of Yantian Port, Xiamen Port and Xiamen International Airport in the Pan-Pearl River Delta region all reach the DEA optimal level. Shanghai Lingang has been constantly improving its service innovation capability against the background of government policy support and rapid regional development. In particular, it has formed unique advantages in providing talent service, comprehensive production and life services, and financial investment services. The Yantian Port, Xiamen Port and Xiamen International Airport in the Pan-Pearl

River Delta are large state-owned enterprises. All three ports have strong geographical and technological advantages as well as transportation infrastructure. In recent years, the growth rates of three ports have been steadily rising. This phenomenon demonstrates that the overall efficiency of enterprises is affected both by its own operation status and regional development pace. Therefore, to improve the competitiveness of state-owned logistics enterprises, attention must be given to create favorable macro-environment for modern logistics, and to give full play to the service functions of modern government to improve macro-environment by exploiting the layout strategy of “integrated logistics” and building comprehensive logistics centers and bases, and by consolidating regional resources and developing smart logistics parks with rational layout and high efficiency. For instance, Jinzhou Port, Dalian Port and Rizhao Port take advantage of the geographical advantage of the Bohai Rim region and state preferential policies for modern logistics, to make reasonable development strategies and continuously improve the overall performance and core competitiveness of port enterprises.

V. Solutions and Suggestions for Improving Resources Management in Liaoning Port

A. Integrating into the Belt and Road Initiative and Promoting Coordinated Regional Development

187. The national "One Belt One Road" initiative (OBOR) emphasizes "interconnection and interworking". It connects the whole system just like the meridians and blood vessels connect all organs in our body. Integration into the OBOR initiative enables port logistics companies to give full play to the "interconnection and interworking" advantage of infrastructure facilities and to ensure the smooth progress of transportation, warehousing and distribution of industrial products, raw materials, and products from processing trade and other fields, which will help to ease the pressure resulting from overcapacity.Economic development is closely related to the interaction between various industries, and it becomes empty talk without industrial support. Similarly, any industry will be like water without a source and a tree without roots if there are no such factors as policies, environment (natural environment, social environment, etc.), and human resources in the economic development system to jointly facilitate industrial upgrading and development. To actively participate into the national initiative, Liaoning Province should focus on integration and connection between industries. The port logistics industry along coastal areas in Liaoning have natural resources and geographical advantages, and should play a supporting role in implementing the strategy of "Maritime Silk Road in the 21st Century" during the "13th Five-Year Plan" period. Qualified ports and logistics companies should conduct extensive international cooperation, to strengthen infrastructure construction, and to adapt to the pace of constructing terminals for coal, oil products and chemicals, with a focus on building terminals for public use and strengthening the construction of public fairway, breakwater and pavement. They should also develop rail-water combined transport and water to water transit and constantly enhance the leading role of ports in driving regional economic growth.

188. The OBOR initiative brings both new opportunities and more fierce competition to ports in Liaoning:

189. Firstly, active application of PPP as an investment and financing mode. PPP (public-private-partnerships) is a cooperative arrangement between government, profit-making enterprises and non-profit enterprises based on a certain project. Through this form of cooperation, win-win results can be achieved. In recent years, under the guidance of the OBOR initiative, the ports in Liaoning have achieved rapid development and have also made great efforts in ports construction. To speed up China's ports construction and development and to broaden the investment and financing channels, it is particularly important to diversify the investment and financing modes. PPP is suitable and feasible as an innovative investment and financing mode for ports construction projects.

190. Secondly, promotion of interactive business between port industrial clusters. According to the International Bureau of Information, there is a large port in China about every 500 km, which also applies in Liaoning province. There are currently two large ports with similar capacity in the port groups in Liaoning—Dalian Port and Yingkou Port. Problems such as price wars and redundant construction of infrastructure will occur without coordination and proper division of labor between those ports. In this round of NEA Revitalization, the port logistics industry must seize the opportunity, burn the bridges and take the initiative to integrate into the OBOR initiative. The industrial transformation and upgrading must be integrated with the coordinated development of regional economy so as to revitalize Liaoning and break the bottleneck of development.

B. Innovating Institutional Mechanism to Improve Operating Efficiency of Ports in Liaoning

191. Shifting from "management-oriented" to "service-oriented" method, priority should be given to efficiency and service innovation to promote economic transformation and upgrading in the port areas and serve the new economy.

192. Institutional innovation. First, it is proposed to establish the Liaoning Port Development Authority to comprehensively push forward the development of ports business in Liaoning. Priority must be given to consolidate administrative resources in the port areas. Second, it is suggested to establish Liaoning Ports Group to build a network of port service platform. Internal coordination mechanism must be established to unify the service standards, service charges,

as well as supervision actions. The third is to establish integrated development mechanism between Liaoning Port Group and industrial zones surrounding the ports and build Liaoning Port-Surrounding Industrial Investment Group. It is also advised to establish a linkage mechanism between provinces and cities by consolidating such factors as capital and land. The relations between ports and cities must be properly handled and terminals for public use must be constructed. In addition, Liaoning province need to further develop the expressway and special harbor-highway to provide access to ports area and make efforts to alleviate the disturb caused by cargo loading and unloading to the cities. It is also important to speed up the construction of major port-bound railways, in particular the special railway in the downstream of Mengdong Coal, major port-bound railways in new port area and proper expansion of existing port railway marshalling stations.

193. Model innovation. The first is to vigorously promote the construction of an international shipping center based on the development and fixation of block train and linear shipping routes. The second is to build a network of port and shipping service platform. The third is to push forward technological application of Internet of things to achieve innovation in integrated online and offline service. Coastal ports are the nodes of comprehensive transportation network and also important hubs for international and domestic exchanges. As the transit point of sea and land transport and a key node of modern logistics, the port links the surrounding integrated transportation system as a platform and gives full play to various modes of transportation. To fully improve the competitive edge of the ports areas, effective linkages must be established between various modes of transport such as roads, railways, aviation and pipelines. It is suggested to establish a scientific and rational comprehensive transportation planning and management system to ensure that all modes of transportation carry out their own planning in an integrated and coordinated way; besides, scale effect is encouraged to improve operating efficiency.

194. Service innovation. First, innovation is encouraged in the whole chain of port logistics services. Second, it is advised to develop an integrated port logistics service and management platform. Third, new technologies should be applied to enhance the efficiency of port logistics services. A set of unified transport service

standards should also be formulated. The division between various industries results in different standards. Therefore industry associations must be involved to help achieve seamless transit in the cargo shipping process by creating favorable conditions for the coordinated development of various modes of transport such as forming a unified transportation management system, and balancing the interests of all parties including railway companies, cargo owners, port companies and shipping companies, etc. In short, we must carry out reforms of the current port management system and unified planning of port groups. In exploring the new model of port development and management, we should fully learn from the experience and lessons of old port areas, set up the main function of ports according to their own advantages, and encourage all ports to reallocate resources so as to achieve positive interaction and optimize the division of labor between ports. On the one hand, municipal governments should establish an institutional partnership with port groups to avoid excessive government interference. On the other hand, local governments need to make investment to support port development, but such support must be based on measurable performance indicators of ports development with specified criteria for failure and termination clause.

195. With the acceleration of economic globalization, the port development has demonstrated a trend of "information-based management, deep construction, more logistics businesses, port privatization and diversification of business operations". Privatization of ports has a crucial impact on its future development. Port enterprises should strengthen the control and decision-making power of private capital in port operations in Liaoning province through such forms as leasing, contracting and joint ventures. It will make the port industry more market-oriented and expand its business scope. Meanwhile, we should optimize the capital structure of port enterprises by improving the investment mechanism and mixed financing so as to reduce investment risks. Diversified operation is an important measure to improve the performance and handling capacity of port enterprises. Enterprises need to build large-scale and specialized logistics center, port logistics infrastructure to attract more ships. On condition of a thorough understanding of its own business and capacity, those enterprises may also consider acquiring promising new business from outside to expand its existing business scope, enhance operational efficiency and achieve better development.

C. Optimizing the allocation of port resources to increase scale and technical efficiency

196. Liaoning should set up a leading group at provincial-level for port resources consolidation, headed by provincial government leaders and consisting of government leaders of port cities and division heads from related provincial authorities including the Department of Transportation, SASAC, Department of Marine and Fishery, Department of Finance, and the Financial Service Office. From the strategic and planning level, the main functions, development direction and key construction projects of all ports in the province should be clearly defined and relevant policies should be formulated so as to provide general ideas and frameworks for the consolidation of port resources and mergers and acquisitions.

197. In recent years, China attaches great importance to consolidating superior industrial resources in its top-level design. On the one hand, it aims to give full play to resources and technological advantages by "joining forces" and make the industry bigger and stronger and adapt to the trend of globalization. On the other hand, supply side reforms are carried out to reduce the heavy burden caused by overcapacity and to gradually eliminate backward production capacities. In fact, as early as in 2014, the Ministry of Transport issued the *Guiding Opinions on Promoting the Transformation and Upgrading of Ports*. The intent is to give play to the market economic mechanism, encourage the port logistics enterprises to consolidate resources via multiple channels and across broad fields, and develop industrial clusters with economies of scale as well as regional industry leaders. Ports in coastal cities in Liaoning Province exhibit uneven development level of the logistics industry as well as supporting services and infrastructure facilities. Disordered competition and homogeneous construction of berths within the port groups are all serious problems. The ports clusters in Liaoning are still at a disadvantage against other top port groups in China in terms of infrastructure construction and handling capacity. Therefore, all ports should be properly positioned and, priority should be given to improve the competiveness of the smaller port groups without undermining the overall development. For example, the development of Jinzhou Port helps drive the development of Huludao Port into a special export port of mineral resources. Yingkou Port and Panjin Port can co-develop the new port area in Panjin in the form of joint venture. Meanwhile,

Dalian Port may inject capital into Dandong Port to help it grow stronger. When the scale effect of major port groups have been achieved to some extent, focus should be given to developing Dalian into the "International Shipping Center in Northeast Asia ". The momentum of joint development of ports in Liaoning should be maintained to reduce disordered competition and internal friction, and to compete with other regions as a team. In addition, cooperation mechanism must be formed between the port groups in the east of Liaoning and the port groups in the west of Liaoning. All ports need to further cooperate in the capital market, port logistics development and construction and eventually form the most competitive port group in Liaoning. It is suggested to stick to the development pattern with Dalian and Yingkou port as the cores, Dandong Port and Jinzhou Port as the inland supporting ports, and Panjin Port, Huludao Port and Suizhong Port as sub line supporting ports.

198. Optimizing the allocation of port resources and speeding up the consolidation of high-quality port resources in Dalian Port, Yingkou Port and Jinzhou Port will help join the advantageous resources of many enterprises and enhance their core competitiveness so as to give full play to their advantages and complement each other in such fields as natural resources, financial capital, technological innovation and scientific management, forming a concerted effort to accelerate the regional integration of port logistics resources.

D. Learning from Advanced Experiences abroad to Improve Service Efficiency of Ports

199. In recent years, the international growth rate has slowed down. However, many foreign ports are still able to operate in an orderly manner with high economic benefits. This is closely linked to their stable operation modes and high-quality services. We study the experience of well-known foreign ports such as New York Harbour, the Port of Rotterdam, the Port of Hamburg and the Port of Singapore Port and come to the following conclusions: first of all, all these well-known ports are committed to infrastructure construction, which is the guarantee for port logistics. It is also an important sign of professionalization; second, the coordinated development of supporting industries facilitates the industrial restructuring and upgrading of the port logistics industry; thirdly, the city where the port is located does not develop the logistics industry alone. Instead, it forms

an interactive and interdependent relationship with the port. As a result, it not only becomes the port center, but also the regional political, economic and cultural center. New York Harbor and the port of Singapore are both typical representatives of regional coordinated development. In addition, we should pay attention to the construction of the information service system, which has become a trend of modern logistics industry. Based on the experience above, Liaoning Province should improve its port infrastructure, focus on the coordinated development of port logistics and other industries, and form an interactive relationship between the city and the port. It should also pay attention to the construction of the information service system in order to realize industrial transformation and upgrading, as well as rapid economic development in Liaoning. Against the backdrop of increasing economic downward pressure in Northeast China, industrial transformation and upgrading has become increasingly pressing in the development of Liaoning. As for professional shipping services, we must introduce more ship management companies and shipping agencies such as ship-owner agents, protection proxies, and charterers' agents. Regarding shipping-related financial services, we need to accelerate the concentration of the relevant institutions, with priority given to introduce financial institutions such as shipping insurance providers. The public financial service platform for the shipping industry should be developed to provide financing, clearing, leasing, insurance and other innovative financial services to relevant shipping companies.

E. Accelerating the Industrial Upgrading of Port Enterprises and Improving the IT Application

200. IT Application is the main trend of modern port development. Port enterprises in Liaoning Province should get rid of the extensive development mode of relying solely on handling capacity and snatching cargo supply to hinterland as soon as possible. Instead, it needs to cultivate new economic growth points in an all-round way, and greatly enhance the port financial and information service level. It is also necessary to gradually develop modern shipping services in various fields including ship freight forwarding, crew services, ship management, shipping consulting and education, maritime insurance and arbitration, and build a whole industrial chain in the port area. At the same time, it is necessary to develop the

port economy based on the sea and promote various forms of cooperation between the port enterprises and the petrochemical, metallurgical, power and shipping enterprises, so as to extend the port service industrial chain and achieve win-win result in both port and industrial growth. Relevant departments of Liaoning Provincial Government may encourage port enterprises in their region to participate in the construction of a comprehensive information network and improve the level of information exchange and sharing among all ports. In promoting the construction of the information network, we must not only form a systematic and standard structure, but also enforce unified standards in the process of information tracking, exchange and processing. The Liaoning Provincial Government needs to integrate the information of all government departments, logistics enterprises, shipping companies, financial institutions and legal service agencies into one information platform and integrate the standard database into the port information. Meanwhile, standardized and modular software products must be developed to ensure timely and effective information sharing and communication within the whole industry. In addition, the port groups should adopt an innovation-driven attitude, and follow closely the progress of latest information technology. They should also pay attention to applying new information technology to ensure the technological leadership of information projects. In the process of IT Application, technical breakthroughs must be made the in key steps including network transmission, data mining, and intelligent processing. Application and innovation of Internet of Things, mass storage and cloud computing must be strengthened to comprehensively improve the level of IT Application in the port areas.

VI. Conclusions

A. Research Summary

201. As the only coastal province in northeast China, Liaoning is an important gateway to the sea for the three northeastern provinces and east Inner Mongolia including Chifeng, Tongliao, Hulunbeier and Hinggan League. Liaoning is also an important hub for water and land transport with rich port resources. Through literature analysis, interview and survey, this paper points out existing problems in resources management and port development in Liaoning such as unscientific port layout and institutional mechanism, unreasonable port orientation, structural overcapacity, inadequate internal management and weak supporting capacity of port industry. This paper adopts the quantitative evaluation method, niche theory and comparative advantage theory to analyze the operating efficiency, pure technical efficiency and scale efficiency of various ports in Liaoning Province. The comparative analysis of operational efficiency between port of Liaoning Province and other leading domestic ports is made to find out improvement direction for resource management in port areas. By analyzing both the above-mentioned areas and the characteristics of ports in Liaoning, this paper proposes the following suggestions to enhance resources management in ports of Liaoning.

202. Firstly, innovating the institutional mechanism to promote port privatization and diversification of port operations. Port enterprises should expand the control and decision-making power of private capital in port operations in Liaoning Province through leasing, contracting and joint ventures to make the port industry more market-oriented. Meanwhile, those enterprises may also acquire promising new business from outside to expand its existing business scope and achieve better development.

203. Secondly, optimizing the allocation of port resources to achieve differentiated cooperation between different ports. Such measures as optimizing the resources allocation and formulating rational port development plans should be taken, and the principles of encouraging integrated planning, complementary advantages and overall development must be followed. In this way, differential competition and supplementary development among different ports can be realized and problems such as low-level redundant construction and over-development can be

avoided. It also helps to create a consolidated port area with clear division of labor, orderly coordination and prominent cores, and to comprehensively enhance the core competitiveness of port groups in Liaoning Province.

204. Thirdly, promoting industrial upgrading and shifting to the intensive development mode. It is suggested to plan and build industrial parks in the port areas. It is also advised to consider the actual conditions of various ports and booster their own port industry through overall layout, scale operation and reasonable industrial positioning.

205. Fourthly, developing port alliance with core elements between ports in the coastal area of Liaoning. Cooperation mechanism must be formed between the port groups in the east of Liaoning and the port groups in the west of Liaoning. All ports need to further cooperate in the capital market, port logistics development and construction and eventually form the most competitive port group in Liaoning. It is suggested to stick to the development pattern with Dalian and Yingkou port as the cores, Dandong Port and Jinzhou Port as the inland supporting ports, and Panjin Port, Huludao Port and Suizhong Port as sub line supporting ports.

206. Fifthly, encouraging the port shipping and related industries to concentrate to speed up the economic development in the port areas. It is suggested to complete the road, rail, waterway network by optimizing the road transport, fostering the rail transport market and strengthening the waterway transport. Meanwhile, it is advised to further accelerate the concentration of key industries that provide ports and shipping services, and build a port and shipping service system based on shipping trade, driven by professional shipping services and guaranteed by shipping-related financial insurance so as to raise the level of industrial development in the concentration area.

207. Sixthly, accelerating the construction of a comprehensive transportation network. Effective linkages must be established between various modes of transport such as roads, railways, aviation and pipelines. In addition, Liaoning province need to further develop the expressway and special harbor-highway to provide access to ports area and make efforts to alleviate the disturb caused by cargo loading and unloading to the cities. It is also important to speed up the

construction of major port-bound railways, in particular the special railway in the downstream of Mengdong Coal and major port-bound railways in new port area.

208. Finally, improving the level of IT Application and talents team building. Port enterprises should strengthen the application and innovation of Internet of Things, mass storage and cloud computing in order to improve the level of IT Application. Meanwhile, the organizational department should play a leading role in building the talents team. It should adjust the organizational structure, improve the incentive mechanism and innovate management mechanism so that talent management can play a greater role in the process of creating value for the enterprises.

B. Research Summary

209. By the end of 2017, both Dalian Port (601880) and Yingkou Port (600313) announced a change of the actual controller of the company. According to the announcement, the 100% equity of Dalian Port Group and Yingkou Port Group were gratuitously transferred to Liaoning North East Asia Gang Hang Development Co., Ltd. (hereinafter referred to as Gang Hang Development), which is a SOE established by Liaoning SASAC. After this equity transfer, the controlling shareholder remains unchanged, while the actual controller changes from local SASAC to Liaoning SASAC. Jinzhou Port (600190) indirectly holds 19.08% of the total equity of Jinzhou Port Holding Company through Dalian Port Investment Holding Company. The biggest shareholder remains Dalian Port Investment Holding Company. This equity transfer represents a major progress in resource integration of the ports in Liaoning.

210. The listed companies of the three ports have all been suspended on a temporary basis in mid-June, 2017 when Liaoning provincial government signed up port cooperation framework with China Merchants Group Shenyang. Both parties agree to jointly set up one management platform for all Liaoning ports that will be based on the Dalian Port Group and Yinkou Port Group, and run a marketized Liaoning Port Group to integrate all coastal port operators into one. Meanwhile, both parties set up the target to complete the establishment of Liaoning Port Group and the reform of mixed ownership by the end of 2017 and

the integration of all operators by end of 2018. The plan for Liaoning Port Group has been officially unveiled.

211. According to the agreement, under the premises that the Merchant Group will be the investor and shareholder of Liaoning Port Group, it will lead the management operations of all entities under the Group's umbrella, and fully utilize advantages and resources in business designs, re-organizations and capital operations to re-structure its business and optimize framework, enhance well-coordinated development and strengthen the Group's international competitiveness. By positioning Liaoning Port Group as the core, the Merchant Group will promote the development of shipment center and relevant industries, and expand investment in building industrial parks, financial services, highways, healthcare, which is destined to drive the reform of supply side and speed up the construction of a shipment center for NEA.

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VIII. Appendix

Index Data of Dalian Port from 2007 to 2016 (in ten thousand RMB)

	Total Assets	Operating Costs	EPS	Net Profits	Main Operating Income
2007	991852	83255	0.2	60528	157014
2008	1055374	86140	0.25	77233	158651
2009	1143565	87451	0.2	57883	168286
2010	2269082	188827	0.22	84682	333695
2011	2717385	248775	0.15	75746	395539
2012	2782878	305669	0.14	68476	464456
2013	2722611	539440	0.15	78197	698198
2014	2784405	656756	0.12	60567	794246
2015	2912989	743166	0.11	56914	888617
2016	3190206	1142706	0.04	61268	1281448

Index Data of Jinzhou Port from 2007 to 2016 (in ten thousand RMB)

	Total Assets	Operating Costs	EPS	Net Profits	Main Operating Income
2007	393476	24808	0.06	6386	52633
2008	430931	36287	0.16	16759	79224
2009	520810	32333	0.11	16615	73886
2010	659158	41199	0.14	22137	86392
2011	784697	63215	0.16	25404	11880

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2012	1025321	75400	0.08	13906	116869
2013	1119838	132341	0.1	16905	184463
2014	1219501	160815	0.11	23192	212699
2015	1200416	136744	0.06	12947	180555
2016	1223845	226974	0.03	5010	255267

Index Data of Yingkou Port from 2007 to 2016 (in ten thousand RMB)

	Total Assets	Operating Costs	EPS	Net Profits	Main Operating Income
2007	323777	72519	0.57	18462	108162
2008	895072	130173	0.55	30554	195080
2009	905612	123107	0.18	19974	187582
2010	1019950	155417	0.2	22669	234318
2011	1133244	201560	0.21	27479	291415
2012	1604713	217187	0.23	52301	344164
2013	1614543	24052	0.24	53540	36871

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2014	1722295	269305	0.08	56306	391049
2015	1632973	256171	0.08	52448	378776
2016	1652761	247162	0.08	36122	366559