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Status and Development Trends of China's Coastal Port Construction (Post-print)

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Abstract

The development of China's coastal ports has undergone three distinct phases—recovery development, rapid development, and high-speed development—establishing the country as a major global port nation. Amidst the global economic downturn and China's transition to a new normal of medium-high speed growth, its coastal ports have entered a stage of stable development. Taking into account China's economic conditions and environmental constraints, this paper analyzes the future development trends and challenges confronting China's coastal ports. National strategies such as the “Belt and Road” initiative present new opportunities for the transformation, upgrading, and integrated development of China's ports. Green ports and smart ports will constitute the primary directions for future construction and development, and accordingly, relevant countermeasures and recommendations are proposed.

Full Text

Topic: Coastal Science and Sustainable Development

Construction State and Development Trend of Coastal Ports in China*

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Abstract

The development of China's coastal ports has experienced three typical periods: recovery, rapid development, and high-speed development, establishing China as a major port country worldwide. With the global economic downturn and China's economy entering a new normal of medium-high growth, the country's coastal ports have also entered a stage of steady development. Considering China's economic situation and environmental constraints, this paper analyzes

the development trends and challenges facing coastal ports in the coming period. National strategies such as the “One Belt One Road” initiative present new opportunities for the transformation, upgrading, and integrated development of China’s ports. Green ports and smart ports will be the main directions for future construction and development, and corresponding countermeasures and recommendations are proposed accordingly.

Keywords: coastal port, berth, throughput, navigation channel, One Belt One Road

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Maritime transport has always been the primary mode of global trade due to its advantages of large capacity and low cost. More than two-thirds of total international trade volume is carried by sea, with ports serving as the critical nodes connecting maritime transport. Currently, over 90% of China’s foreign trade import and export goods are handled through ports. Every 1 million tons of port throughput creates more than 100 million yuan in GDP, and the combined GDP of 62 coastal cities at or above the prefecture level accounts for approximately 42% of the national total. Ports occupy an extremely important position in China’s national economic development.

1.1 Development History of Coastal Port Construction

Since the founding of the People’s Republic of China, the development of China’s coastal ports can be broadly divided into four stages.

(1) Recovery and Development Period (1949-1979)

This period is further divided into two phases. The first phase spanned from the founding of New China to the late 1960s, during which port construction focused primarily on expanding and renovating old wharves. The second phase was the 1970s. Following China’s restoration of its lawful seat in the United Nations, foreign trade expanded year by year, and China’s port construction experienced its first construction boom, building several deep-water crude oil terminals and expanding or constructing a number of berths above 10,000 tons for bulk cargo and passenger transport. During this period, port construction was basically based on original port sites.

(2) Rapid Development Period (1980-1999)

With the implementation of China’s reform and opening-up policy, foreign trade and energy/raw material transportation grew rapidly. Consequently, the state increased investment in coastal port construction, ushering in another boom in port development. During this period, numerous new port areas were first developed in 14 coastal open cities, such as Dalian Dayao Bay, Yingkou Bayuquan, Qingdao Qianwan, Shanghai Waigaoqiao, and Ningbo Beilun deep-water port areas. New ports including Jinzhou, Tangshan, Huanghua, Rizhao, and Qinzhou

were also developed. To highlight development priorities and concentrate resources on solving critical issues related to energy and foreign trade, the Ministry of Transportation proposed a layout plan for major coastal hub ports, guiding the construction of a number of specialized terminals. For instance, specialized coal loading terminals were built at ports such as Qinhuangdao, Qingdao, Rizhao, and Lianyungang; specialized container terminals were constructed at Tianjin, Dalian, Qingdao, Shanghai, Ningbo, Xiamen, and Shenzhen; 100,000-ton-plus iron ore terminals were built at Ningbo, Dalian, and Qingdao; and ocean-going vessel port areas were developed at ports along the lower Yangtze River such as Nantong, Zhangjiagang, and Nanjing. Simultaneously, a number of small and medium-sized ports serving local economic development were also built, initially forming a coastal port layout combining large, medium, and small ports.

(3) High-speed and High-grade Development Period (2000-2010)

Following China's accession to the WTO, which promoted rapid economic development and the rise of port-adjacent industries, coastal port construction entered a phase of high-speed development. The construction of high-grade terminals and navigation channels accelerated significantly, with both port throughput and the number of deep-water berths increasing rapidly (Figure 1 [Figure 1: see original paper]). The average annual growth rate of coastal port throughput reached 16.25%, rising to 5.48 billion tons by 2010, while the number of berths above 10,000 tons increased to 1,343. To better guide port construction, the Ministry of Transportation and the National Development and Reform Commission jointly organized the compilation of the *National Coastal Port Layout Plan* (2006), and local provincial and municipal port authorities subsequently formulated regional port plans, laying a foundation for the scientific layout and orderly construction of national ports. Under the guidance of these plans, and to adapt to the trends of large-scale and specialized international maritime transport, a number of specialized terminals were built, including 300,000-ton crude oil and iron ore terminals, coal loading terminals above 70,000 tons, 100,000-ton container terminals, and deep-water channel projects, which were subsequently completed and put into operation, providing support for throughput growth and basically meeting China's maritime transport demands. During this period, relying on technological innovation, China's port construction technology improved significantly, with technologies for deep-water channels in complex environments and offshore deep-water port construction reaching world advanced levels.

(4) Steady Development Period (since 2011)

Affected by macroeconomic downturn, the coastal port construction boom has slowed during this period, with both the number of berths and throughput growth rates declining significantly. The port throughput growth rate dropped from 12.5% in 2011 to 5.69% in 2014, and is expected to be only

about 1.9% in 2015 (Figure 2 [Figure 2: see original paper]). In the coming period, coastal ports will face dual pressures of declining profitability and resource/environmental constraints. The previous double-digit growth rates will be difficult to achieve. Meanwhile, as the global economy recovers moderately and China's economy enters a new normal, the effects of port quality improvement, efficiency enhancement, and transformation and upgrading will become apparent, and the downward trend in throughput will be curbed. Coastal ports will enter a stage of steady growth and development.

1.2 Current Development Status of Coastal Ports

As of 2014, China had 2,110 berths above 10,000 tons nationwide (Table 1), of which 1,704 were at coastal ports, accounting for 80.8%. China's port cargo and container throughput has ranked first in the world for 13 consecutive years. According to 2013 and 2014 statistics, mainland China accounted for 6 of the world's top 10 billion-ton ports and top 10 container ports (Table 2 and Table 3), maintaining China's position as a world port giant.

Currently, China's coastal ports have formed five port clusters: the Bohai Rim, Yangtze River Delta, Southeast Coast, Pearl River Delta, and Southwest Coast (Figure 3 [Figure 3: see original paper]), and have established eight major specialized port transportation systems for coal, petroleum, iron ore, containers, grain, commercial vehicles, island roll-on/roll-off, and passenger transport. After decades of port construction, China's port scale has continuously expanded, with 23 coastal ports exceeding 100 million tons in throughput.

2 Development Trends and Challenges for Coastal Port Construction

Entering the "13th Five-Year Plan" period, the impact and profound effects of the international financial crisis persist. China's economy has entered a critical stage of building a moderately prosperous society in all respects, adapting to the new normal of economic development. Coastal port construction will enter a new stage of steady development. The "13th Five-Year Plan" establishes the development concepts of innovation, coordination, green development, openness, and sharing, which bring new opportunities for the transformation, upgrading, and integrated development of China's ports. Green ports and smart ports will be the main directions for future construction and development of China's coastal ports.

2.2 Impact of "One Belt One Road" and Other National Strategies

The implementation of national strategies such as "One Belt One Road" will have a significant impact on port development. The Ministry of Transport has formulated the *Implementation Plan for the One Belt One Road Strategic Plan* and introduced a series of measures to accelerate transportation infrastructure connectivity, facilitate international transport, and promote the "going global" of

transportation enterprises. Domestic ports will actively “go global” on one hand, expanding foreign trade and participating in the construction and operation of foreign ports; on the other hand, they will extend their hinterlands westward and accelerate the construction of international and domestic “dry ports.”

Currently, from north to south, China has formed the Northeast dry port cluster with Dalian Port and Yingkou Port as sea outlets, the North China and Northwest dry port cluster with Tianjin Port as the sea outlet, the dry port cluster with Qingdao Port and Rizhao Port on the Shandong Peninsula as sea outlets, and the dry port cluster with Ningbo, Xiamen, and Shenzhen ports on the southeast coast radiating inland. The rational planning and layout of “dry ports” and the planning and construction of east-west railway-sea intermodal transport corridors have become increasingly important.

The Yangtze River Economic Belt national development strategy is another major strategic deployment made by the central government, providing development opportunities not only for inland river ports but also for coastal ports along the lower Yangtze River and its periphery. According to the *Yangtze River Economic Belt Comprehensive Three-Dimensional Transportation Corridor Plan*, by 2020, a comprehensive three-dimensional transportation corridor will be built that runs east-west, connects north-south, links rivers and seas, and is convenient and efficient. The rational planning of the Yangtze River Delta port cluster and the construction of river-sea intermodal transport channels will adapt to the requirements of the Yangtze River golden waterway. The extension of the 12.5 m deep-water channel to Nanjing before the end of 2016 will boost the development of ports along the lower Yangtze River and the Yangtze River Delta.

2.3 Increasingly Prominent Port Regional Integration Development

Under economic downturn and resource/environmental pressures, ports within coastal port clusters will focus on division of labor and collaboration, complementing each other’s advantages to avoid overlapping hinterlands, redundant construction, and homogeneous competition. For example, with the help of the Beijing-Tianjin-Hebei integration strategy, ports in Hebei and Tianjin are seeking win-win cooperation. Hebei Port Group and Tianjin Port Group have jointly established the Bohai Tianjin-Hebei Port Investment Development Co., Ltd., and both parties will focus on building a belt-shaped port cluster with clear positioning, rational layout, clear division of labor, complementary advantages, and orderly competition.

Fujian Province proposes to fully build “two container, two bulk, and two liquid” core port areas, which means breaking administrative regional restrictions, highlighting cores, and driving the development of other port areas. Zhejiang, Guangdong and other provinces have also made beneficial attempts in port regional economic integration. However, it should be recognized that since relevant policies and measures have not yet been fully implemented, cooperation

methods and experience still need to be studied and summarized, and there is still a long way to go for port regional economic integration development.

2.4 Green Ports as the Main Development Theme

Ports are the engines driving regional economic development, but they are also typically high-impact areas for resource consumption and environmental pollution. Port construction and operation occupy shorelines and tidal flats, consume fresh water, coal, oil and other resources, and generate sewage, solid waste, noise, dust, and exhaust gases. Taking PM_{2.5} emissions as an example, a container ship (8,000 TEU) berthed at a terminal emits PM_{2.5} from its diesel engine equivalent to 1,000 motor vehicles per hour, plus exhaust emissions from various equipment during loading and unloading operations, which has a very significant impact on air quality. Developed countries have made building green ports their development goal. A “green port” is a sustainable development port that saves resources, meets environmental and ecological requirements, and achieves good economic benefits. Its core objective is to achieve harmonious development among ports, society, and the environment.

China currently also attaches great importance to green port construction, advocating the building of “resource-saving and environment-friendly” ports. The Ministry of Transport has successively issued relevant standards and specifications such as the *Green Port Grade Evaluation Standard*, *Technical Specification for Shore Power Facilities for Terminal Vessels*, *Energy-saving Design Code for Water Transport Engineering*, and *Design Code for Dust Control at Coal and Ore Terminals*, making green port construction gradually scientific, standardized, and standardized. Relying on technological progress, China’s ports have done a great deal of work in resource recycling and environmental protection, such as comprehensively implementing “oil-to-electricity” conversion for gantry cranes at container yards, promoting the use of shore power for vessels and LNG clean energy for mobile equipment, and widely using technologies such as ground-source heat pumps, dust control, dredged soil utilization, and sewage treatment and recycling, achieving good results. China’s green port grade evaluation work has also been launched. However, it should be recognized that there is still a large gap between China’s green port development and international advanced levels in design, construction, and operation, mainly reflected in gaps in concepts, management, and technology. In the long run, under the environment of resource shortages and limited environmental carrying capacity, China’s ports can only achieve sustainable development by pursuing the path of green ports. Green ports will become the main theme of future development.

2.5 Addressing the Challenges of Vessel Upsizing

Shipping companies have long been driving the process of vessel upsizing to reduce transportation costs. The design ship types in China’s water transport industry technical codes are also constantly updated. Table 4 shows the maximum ship tonnage for major cargo types in different versions of the codes. As

can be seen from Table 4, the upsizing trend is obvious for bulk carriers and container ships.

On July 4, 2015, the 400,000-ton ore carrier *Yuanzhuo Hai* berthed at Qingdao Port, marking China's coastal ports' entry into the era of 400,000-ton-class dry bulk operations. As of September 2014, a total of 30 Valemax-class 400,000-ton bulk carriers have been put into operation or are under construction globally. Currently, Dalian Port, Qingdao Port, Caofeidian Port Area, and Ningbo Port in China can accommodate Valemax vessels, and other ports are also actively responding.

Container ships are the fastest-growing vessel type in terms of upsizing. In 2013, the first 3E-class container ship with a capacity of 18,000 TEU made its maiden voyage to China. China's coastal ports actively responded by renovating terminals and deepening port basins and channels to become calling ports. On July 19, the *Mærsk Mc-Kinney Møller* made its maiden voyage and berthed at Shanghai Yangshan Port Area, and since then, Dalian, Tianjin, Qingdao, Ningbo, Xiamen, Shenzhen, and Guangzhou ports have all berthed such vessels. Currently, 3E-class container ships have been extensively deployed on routes, and even larger container ships with a capacity of 21,000 TEU are under construction. The global transportation of ultra-large container ships will reduce the number of calling ports and may even affect the layout of hub ports, which will have far-reaching impacts on the development of China's coastal ports.

To address the trend of vessel upsizing, first, the national coastal port layout needs to be forward-looking and scientific; second, port enterprises need to prepare accordingly based on their own positioning and conditions, such as having terminals of corresponding grades, sufficiently scaled port basins and channels, matching loading and unloading equipment, fast and smooth collection and distribution channels, and efficient management.

2.6 Ports Transforming Toward Intelligence

World ports have experienced the development stages of the first-generation loading and unloading transit centers, second-generation loading/unloading and processing service centers, and third-generation comprehensive logistics centers, and have now begun to transform and develop toward fourth-generation supply chain centers based on networks. As the core hub in the logistics supply chain, coastal ports gather enormous logistics, information flow, and capital flow. Compared with the past, the functions of modern ports have undergone tremendous changes. Competition among modern ports is evolving into comprehensive competition among supply chains in which ports participate. The Internet, cross-border e-commerce, and modern logistics have become means for ports to transform, upgrade, and enhance competitiveness.

In the future, with the continuous innovative application of new-generation information technologies such as cloud computing, big data, and the Internet of Things, building smart ports relying on modern information technology will

become the strategic choice for major coastal ports to seize the commanding heights of a new round of port development.

Considering rising labor costs, energy conservation and emission reduction, and the need to improve safety and reliability, the pace of automation and intelligence in coastal port operations has accelerated. In particular, smart technology applications in container and bulk cargo specialized terminal operations have achieved many results. Xiamen Port' s Haicang Port Area automated container terminal was put into trial operation in 2015, while Qingdao Port' s Qianwan Port Area automated container terminal, Tianjin Port' s Dongjiang Port Area automated container terminal, and Shanghai International Shipping Center' s Yangshan Deep-water Port Area automated container terminal project are also in the implementation stage.

To adapt to China' s economic development new normal, industrial structure adjustment, and the new changes brought by the trend of vessel upsizing, and to meet the new requirements for implementing national strategies such as "One Belt One Road" and "Yangtze River Economic Belt" , it is necessary to accelerate the adjustment and improvement of China' s coastal port layout planning, formulate inland dry port layout planning, improve the layout of multimodal transport main channels, and establish a large port transportation network with rational layout, clear positioning, distinct levels, division of labor and collaboration, and interconnectivity among port clusters, ports within clusters, dry ports, and between coastal ports and dry ports, to avoid disorderly competition, redundant construction, and resource waste.

To connect with the Yangtze River Economic Belt comprehensive three-dimensional transportation corridor, optimize and improve the layout planning of the Yangtze River Delta port cluster. Make full use of the blank shoreline and tidal flat resources in northern Jiangsu, and accelerate the scientific layout and development of ports based on scientific research to open up sea channels and drive regional economic development with ports as the engine. Leverage the Yangtze River golden waterway to vigorously develop river-sea intermodal transport and reduce logistics costs. Strengthen the layout of ports on the north wing of the Shanghai International Shipping Center.

With economic integration and vessel upsizing, on one hand, it is necessary to strengthen the construction of shipping centers and hub ports; on the other hand, regional ports and feeder ports should be strengthened, with appropriate construction scale and avoiding excessive ambition. Port infrastructure requires large investment and has a long payback period. It is necessary to actively explore port development financing methods, improve the investment and financing mechanism combining state investment, local fundraising, social financing, and foreign investment utilization, and formulate policies and measures to encourage social capital, including private capital, to invest in port infrastructure construction.

The development concept of resource conservation, environmental protection,

and building green ports needs to run through the entire process of port design, construction, and management and operation. On the basis of green port grade evaluation, summarize experience, accumulate data, and promptly formulate relevant port clean production standards based on the *Cleaner Production Promotion Law* to reduce pollution at the source, improve resource utilization efficiency, and lay a foundation for sustainable port development.

Give full play to the advantages of ports as core logistics hubs, supported by “Internet+”, establish a whole-industry-chain logistics e-commerce platform centered on ports to reduce logistics costs. Achieve port information interconnectivity and resource sharing. Improve the intelligent operation mode of specialized terminals, and study the transformation from informatization to intelligence for non-specialized terminals. Use cloud computing and big data to promote intelligent port management.

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Note: Figure translations are in progress. See original paper for figures.

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