Research on the Construction and Development Mode of High-Quality Inland "Smart Port" in China

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Abstract: In order to promote the digital and smart transformation, to improve the developing level and synthetical competitiveness of the inland ports comprehensively, to promote the construction of port-type national logistical hub and to serve and support the regional economic and social development better, the current situation of the construction and development of inland ports in China is analyzed and evaluated, the situation and requirements faced by inland ports is analyzed from the aspects of national strategy, regional economy, scientific and technological development, etc., and the overall framework for the construction of high-quality inland "smart port" is studied and proposed. The port "smart brain" is built, its functional modules such as port intelligent operation monitoring, intelligent production scheduling, intelligent decision support and digital cockpit are established. And the constructing ideas and functional composition of six smart port application platforms which includes the comprehensive management platform, production and operation platform, logistics collaborative application platform, commercial and trade financial service platform, intelligent safety and environment management platform and customer integrated service platform are put forward. Through scientific and technological empowerment and innovation drive, the high-quality inland "smart port" will be constructed to create the first-class facilities, technology, management and service. The green and safe inland smart port development system will be formatted to promote regional economic and social development effectively.

1 INTRODUCTION

As a comprehensive transportation hub, port is strategic resource and important support for economic and social development, and plays an important role in regional economic development (Li, Wang, & Liu, 2020a). Based on modern infrastructure and equipment, the "smart port" is a new modern port operational format with distinctive characteristics such as production intelligence, management wisdom, service flexibility and strong guarantee (Yin, 2019). The construction of smart port will promote the transformation of port business model and concept innovation, improve the productive and operational efficiency, operation level and service quality comprehensively (Gu, 2020) and reconstruct multi-boundary port ecosystem through the deep integration of new generation of information technologies such as cloud computing, big data, Internet of things, mobile Internet, artificial intelligence and blockchain with port business, so as to realize the optimal allocation of port resources,

meet the needs of multi-level, agile and high-quality port transportation services at a higher level.

There are many rivers and lakes in the inland of China with more than 160 large and small water systems. By 2019, the navigation mileage of national inland has reached 127,300 kilometers, of which 27 provinces, autonomous regions and municipalities hold the graded navigation channels of 66,700 kilometers and the navigation channels of class III or above for 13,800 kilometers. The Yangtze River system, Pearl River system, Heilongjiang River system, Huaihe River system and inland ports on the Beijing-Hangzhou Canal are the main inland ports of China. China has more than 1,200 inland ports of which 28 are the main inland ports, including Nanjing Port, Wuhan Port, Chongqing Port, Suzhou Port, Wuhu Port, Yichang Port and Luzhou Port. The inland ports are the important parts of Chinese modern comprehensive transportation system, and they are also the important hubs for personnel exchanges and goods circulation of inland navigation areas (Liu, 2020).

2 ANALYSIS AND EVALUATION OF THE CURRENT SITUATION OF INLAND PORTS

The inland ports of China are the important infrastructure for the development of modern logistics system in inland areas, and also the important factor for the promotion to the economic and social development of cities and regions along rivers. The spatial distribution and construction scale of inland ports are quite different in the three regions due to the different navigation conditions and environment of rivers in eastern, central and western China. There are a large number of inland ports in the eastern region which are developing rapidly. However, the inland ports in the central and western regions are developing relatively slowly.

Specifically, the section from Nanjing to the Yangtze River Estuary can meet the all-weather navigation of 30000 ton seagoing ships and the tide passage of 50000 ton seagoing ships. At present, the 12.5m deep-water channel of the Yangtze River Estuary has been extended to Nanjing. The ports from Nanjing to the Yangtze River Estuary has high-grade construction, complete facilities and advanced equipment, which can be comparable to the coastal ports, and the ports are in a high position in the regional economic development. For most other inland ports, due to the limitation of navigation conditions, the level of wharf construction is low, the construction funds are tight, the construction speed is slow, and most port facilities and loading and unloading technology are backward. Besides, the ship types of inland river are messy, the average tonnage is small, the safety performance is poor, the energy consumption is high, the pollution is relatively large, and the inland ports do not have a high position in the local economic development and do not get enough attention. The main problems of inland ports are as the followings:

2.1 The Development Is Relatively Backward and Unbalanced

In addition to some economically developed regions, such as the Yangtze River Delta and the Pearl River Delta, most inland ports in China lag behind the development of roads and railways and other transportation facilities. They are faced with problems such as insufficient funds, small scale and lack of experience, and they are not given enough attention in the local economic development. At the same time, there are problems such as unbalanced development among regions, between seasons and of transport capacity.

2.2 Infrastructure Level Is Low

Many old inland ports, especially small and medium-sized ports, have outdated equipment due to years of operation, which not only has low work efficiency, but also the degree of informatization is not high, which making them not able to meet the requirements of modern logistics management. If the local government and port enterprises do not pay attention, the funds for upgrading facilities will not be supplemented, and the low logistics efficiency will lead to less cargo flow, so that the operation and management of the port will be more and more difficult.

2.3 The Efficiency of the Collection and Distribution System Is not High

In the process of transportation from the ports to other land logistics nodes or the other way around, most inland ports rely on road transportation for distribution, and a perfect rail-water intermodal transportation system has not been formed. Taking a port in northern China as an example, 67% of the goods rely on road transportation for distribution, while the volume of goods transported by railway accounts for only 2%. The average traffic volume of highway transportation is smaller than that of railway, and the unit cost is also higher.

2.4 The Logistics Industry Develops Slowly and Lacks Modern Ideas

Modern logistics is a new socialized mode of mass production which combines trade in goods and services. It is a technology intensive service mode with wide coverage and high informatization, and it's developing into the field of transportation rapidly. However, at present, most inland ports lack the concept of modern logistics industry.

2.5 The Comprehensive Service Capacity Is not High and the Function Is Simple

After the continuous development, the modern port can become a comprehensive logistical center with various logistical, commercial and auxiliary functions. However, the logistics service of the inland ports in China has not been developed and improved,

and there are few ports with such comprehensive logistics service capacity.

2.6 Some Policy Plans Are Unreasonable and Lack Stability

The pertinence of some policies is not strong and does not meet the requirements of the long-term development of local inland ports. For example, after several years of use, the freight yards of some inland ports became too small, which led to replanning. The imperfect policies will also lead to the unsmooth organization and coordination between the ports and the supervision departments, business departments and other relevant units.

3 SITUATION AND REQUIREMENTS

The situation and requirements of inland ports are as the followings:

3.1 The Transformation of Demand Structure and Developing Mode of Inland High-Quality Smart Port Requires the Expansion of the Scope and Enrichment of the Content on the Construction

The Chinese government points out that it is necessary to promote high-quality development by adhering to the supply side structural reform as the main line, grasping the position of "pioneer" for transportation, and promoting the transformation of transportation development from pursuing speed and scale to quality and efficiency, from various independent development to integrated development, and from relying on traditional factors to paying more attention to innovation. With the high-quality development of China's economy, the demand structure and developing mode of inland ports have also changed. In terms of port transport demand, it will show the characteristics of "high base, medium and low growth speed", which will slow down the building of new port terminals, increase the upgrading of old terminals, and adjust the cargo structure gradually. With the deep adjustment of industrial structure along the river and the transformation of urban strategy, the developing mode of the ports will change from traditional loading, unloading and transshipment to modern logistics, multimodal transportation and port-

industry-city integration, etc. Based on this, the construction and development of China's inland high-quality smart port, comparing with the traditional port construction mode oriented by the scale of cargo throughput, will expand the scope of construction significantly, and the construction content will be more diversified, with distinct characteristics in the stage of high-quality development.

3.2 The Establishment of the Land Spatial Planning System Requires that the Construction of High-Quality Inland Smart Port Pay More Attention to Multi-Party Coordination and Integration, and Support Space Protection and Development Better

China has established its own land spatial planning system. Land spatial planning is the guide for national spatial development, the spatial blueprint for sustainable development, and the basic basis for various development, protection and construction activities. Land space planning is the superior planning of port planning and construction. Therefore, the planning, construction and development of inland high-quality smart port should pay attention to coordinating the relationship between ports, cities and industries, formulate the functional position and developing direction reasonably, and optimize the strategic space for the coordinated development of ports, industries and cities. According to the transportation and functional requirements of the port under the new situation, the inland high-quality smart port should build and configure port operation areas, logistics parks, collection and distribution facilities and supporting facilities scientifically, strengthen the linkage with the ecological red line, basic farmland and other relevant industries and build an efficient and collaborative high-quality smart port ecosystem inside and outside the industry, so as to strengthen the sustainability and operability of port construction and development.

3.3 The Deep Integration and Application of New Generation of Information Technologies Provide New Driving Force for the Development of Inland Ports

The vigorous development of smart port provides new drive for the construction of high-quality inland

"smart port", which promotes to realize the overall and efficient utilization of resources, reducing transportation costs and becoming more economical. And the high-quality inland "smart port" can also make the port infrastructure and operation network more reliable, and the integrated and intelligent transportation service more efficient. It can achieve a higher level of port safety supervision and emergency rescue, and make the innovative and high value-added transportation service more agile. Finally, the high quality inland "smart port" can realize the sustainable and harmonious development of energy conservation and environmental protection, making the port greener.

4 OVERALL FRAMEWORK

Considering the constructing condition and developing requirements, the overall framework of high-quality inland "smart port" can be summarized as "1 pivot, 6 platforms, 1 center and 1 baseplate".

1 pivot, namely the port "smart brain". Through the deep integration of new generation of information technologies with port business (Cai, Cai, & Zheng, 2020), the "smart brain" is built for promoting the intelligent production, scheduling, decision-making and service, and realizing the online equipment and facilities, the integration of terminal management and control, the intellectualization of yard management and the automation of terminal operation, improving the level of process and standardization of port business management.

6 platforms, namely the smart port application platforms. Relying on the modern infrastructure and the supporting system of the port, the port production and operation platform, comprehensive management and control platform, logistics coordination platform, commercial finance platform, smart security platform and customer service platform are built to realize the high automation, integration and intellectualization of the management and wharf operation of the port. Meanwhile, the whole industrial chain will be highly interconnected, integrated, collaborative, digital and intelligent.

1 center, namely the smart port big data center. Through network interconnection and data sharing, as well as cross-industry data exchange with the custom, railway and other industries, and the big data center including ship dynamics, logistics dynamics, port production, multimodal transportation, port supervision and other information is established to realize data collection, storage and management, providing users with comprehensive data services

through calculation and processing according to unified standards and caliber.

1 baseplate, namely the smart port digital baseplate. Supporting the perception network, hardware equipment and communication network of the smart port, the digital baseplate is mainly based on cloud computing, big data, AI, internet of things, CCTV and other technologies to provide solid digital, intelligent and networking environment for the efficient operation and value-added services in the whole scene.

5 "SMART BRAIN" OF THE PORT

"Smart brain" is the "nerve center" of the smart port. Through the comprehensive application of big data, cloud computing, BIM, virtual reality, AI, GIS and other technologies, the intelligent operation digital command center is built to realize the interactive visual presentation of port logistics supply chain and digital command and dispatching management (Fang, 2020). Through the deep integration of information, technology and business, the "smart brain" will drive the intelligent management and gather massive data efficiently. The value of data aggregation and integration will be shown through the "nerve center" by integrating the separated data and capabilities of different industries, so as the role of cross-department coordination (Huang, 2020).

The main functions of the "smart brain" include port intelligent operation monitoring, intelligent production scheduling, intelligent decision support and digital cockpit.

5.1 Intelligent Operation Monitoring

With the full use of advanced technical means, the port production and operation will be monitored in real time through IOT perception, video perception and data analysis. At the same time, the data models and algorithms will be used to analyze the current situation, study the trend, find out the law and form the basis for decision-making.

5.2 Intelligent Production Scheduling

Based on the BIM platform, the intelligent production scheduling platform integrating ship scheduling, ship tracking, production monitoring, production scheduling, port collection and distribution scheduling and safety supervision is built, so as to

realize interactive visual presentation and scheduling management of port operation, as well as automatic cruise, scene reproduction and dynamic display of the whole process.

5.3 Intelligent Decision Support

By integrating and analyzing the data resources of relevant business systems, based on the digital baseplate, the "smart brain" focuses on building a data-driven intelligent decision-making system from the aspects of production control, financial control, project engineering control, business intelligence analysis, etc. to provide support for managers and decision makers at all levels of the port in terms of various management and control functions, decision analysis and suggestions, helping realizing digital and intelligent production and operation.

5.4 Digital Cockpit

Relying on big data, digital twin, AIS, GIS, 3D and other technologies, a multi-level digital cockpit is established to optimize the presentation of various digital indicators, establish a complete personal and institutional data account, and create a unified port logistics data system with full integration. Based on the overall integration of data resources and capabilities of all parties in the port and shipping logistics supply chain, a smart port big data central platform is established to help construct the port big data system, and form data fusion and intelligent application capabilities across regions, industries, domains and systems.

6 SMART PORT APPLICATION PLATFORMS

Adhere to the combination of goal and demand orientation, making full use of "digital +" and "intelligent +" innovation empowerment, the production and operation platform, comprehensive management and control platform, logistics coordination platform, commercial and financial platform, smart security platform and comprehensive customer service platform will be built based on modern port infrastructure and equipment, so as to achieve a high degree of automation, integration, intelligence and unmanned inland port management and wharf operation and realize the highly interconnected, integrated, collaborative, digital and intelligent development of the whole port industry chain.

6.1 Port Comprehensive Management Platform

In order to realize the intensive, digital and collaborative internal management, promote the integration of internal management system and information resources and improve the collaborative application of internal businesses of inland ports (Ren, 2019), the port comprehensive management platform integrating office automation, operation management, financial management, project contract management, equipment management, human resource management, customer relationship management and material management will be established, so as to realize the digitization and intellectualization of the whole process of production operation, operation management and decision-making. This platform can also improve the digital and intelligent level of daily operation management, production statistics and decision-making analysis of inland ports.

6.2 Port Production and Operation Platform

Based on the developing concept of "promoting innovation with service", applying big data intelligent analysis technology, mobile internet, cloud computing, automatic control technology and other means comprehensively (Yuan & Sui, 2022), and adopting automatic operation equipment, intelligent mechanical equipment and supporting management and control software, the full coverage production and operation platform will be built to realize the automation and intellectualization of the whole process of port dispatching, gate operation, plane transportation and yard operation, and improve the operating efficiency and productivity of inland ports comprehensively.

The port production and operation platform mainly include bulk cargo terminal production management system and container terminal production management system. Among them, the bulk cargo terminal production management system mainly includes ship management, production resource management, remote measurement and other functions. The container terminal production management system mainly includes ship planning, intelligent gate, custom supervision and business intelligence analysis etc...

6.3 Port Logistics Collaborative Application Platform

Facing the needs of port logistics supply chain customers, the inland port logistics collaborative application platform should be built through the integration of new information technology and port logistics business. The platform can promote the application of park management, multimodal transport and paperless port documents, to realize the automatic perception, intelligent operation, business coordination and service innovation of logistics business, and provide customers with accurate, efficient, customized and visual service experience.

Port logistics collaborative application platform mainly includes logistics park management system, regional logistics business linkage system, port supervision support system and multimodal transport integrated service system. Among them, the logistics park management system mainly includes freight management, train loading and unloading plan management and other functions (Wu, 2021). The regional logistics business linkage system mainly includes logistics coordination and business linkage, logistics resource integration and scheduling and other functions. The port supervision support system mainly includes comprehensive declaration of ships, customs supervision support for wharf operation, joint declaration of dangerous goods etc... Multimodal transport integrated service system mainly includes freight plan declaration, railway plan approval query and other functions.

6.4 Port Commercial and Financial Service Platform

Based on the business needs of trade facilitation, value chain integration and ecological economy of domestic inland ports, focusing on the smart trading, bulk materials, financial services and big data services and other online trading and supporting services (Li, Wang, & Liu, 2020b), the port commercial and financial service platform will be established to promote the efficient operation of logistical, informational and capital flow in the inland port commercial and financial ecosystem. The platform will be oriented to individual and enterprise users, and realize the business model innovation, business process reengineering and service collaborative operation of inland ports.

The port commercial and financial service platform mainly includes bulk cargo trading system, supply chain financial system and financial insurance service system. Among them, the bulk cargo trading

system mainly includes industry information release, comprehensive information query and other functions. Supply chain financial system mainly includes plan management, process control and other functions. The financial insurance service system mainly includes information query and other functions.

6.5 Port Smart Safety and Environment Management Platform

Focusing on achieving the objectives of prevention, control and emergency response with minimum civil defense investment, perfect physical defense facilities and efficient and accurate technical defense means (Wang & Wang, 2021), a unified and shared port smart safety and environment management platform should be built to establish a three-dimensional and intelligent control system linking all port areas. This platform can improve the management responsibilities and standard system by highlighting key points, hierarchical control and division of responsibilities, so as to provide technical support for the construction of safe and green inland ports.

Port smart safety and environment management platform mainly consists of port production safety monitoring system, green port control system and port equipment intelligent monitoring system. Among them, the port production safety monitoring system mainly includes safety production visualization, major hazard source monitoring and early warning and other functions. The green port management and control system mainly includes basic data parameter configuration, real-time monitoring of energy consumption and other functions. Port equipment intelligent monitoring system mainly includes equipment management, remote monitoring of equipment safety status and other functions.

6.6 Port Integrated Customer Service Platform

The competition between ports is mainly the competition of economic hinterland and supply, that is, the competition of customer resources. With the construction and development of inland ports in China and the deepening of marketization, the competition and cooperation situation between inland ports has become more prominent. Inland ports should regard customer resources as important strategic resources, attach great importance to the service experience of terminal shippers and logistics

participants, and create first-class customer service to strengthen cooperation with many stakeholders through the construction of integrated customer service platform. With the building of the platform, it can also promote service agility and trade facilitation, and provide all-weather and all-round interactive services to ensure convenient and reliable services.

Port integrated customer service platform mainly consists of port and shipping customer integrated service system, customer call service system and mobile application service system. Among them, the port and shipping customer integrated service system mainly includes business acceptance, online business operation and other functions. Customer call service system mainly includes one key call service, online message service and other functions. Internet mobile application system mainly realizes the extension of customer comprehensive service to mobile terminal.

7 CONCLUSION

Through the construction in the next 10-20 years, China's inland ports will realize the deep integration of the new generation of information technologies and port production and operation processes, so that the port production, management and services can fully realize informatization, digitization and intellectualization. The port production and operation segments such as ship berthing and departure, cargo loading and unloading, passenger arrival and departure are highly coordinated (Hou, Zhuang, Shi, & Wan, 2020), the port production efficiency, safety and environmental protection level will be significantly improved, and the operating cost will be reasonably reduced. The smart port construction will fully realize the comprehensive perception of elements, sharing of information, intelligence of production and high-quality services (Wang, 2020), and promote the fundamental transformation of inland port production and operation from business process type to accurate digital type and then to agile smart type.

At the same time, the construction of China's inland high-quality smart port will breed more modern inland ports with extensive network coverage and high flexibility (Peng, 2020), guided by knowledge and intelligence, based on advanced information and intelligent technologies, and form a high-quality "smart port" developing pattern of "global perception of information, comprehensive intelligence of production, full analysis of decision-making, transparency of service and full-time

interconnection", supporting regional economic and social development efficiently.

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