

Research on Countermeasures and System Optimization of Cargo Distribution and Transportation Management in Ningbo-Zhoushan Port

Chen Su*

Ningbo University of Finance & Economics
Ningbo, China
552080565@qq.com

Abstract—The Ningbo-Zhoushan Port has weaknesses in terms of cargo distributing and transportation system. To improve the competitiveness and promote the fast and healthy development of Ningbo-Zhoushan Port, management of the cargo distribution and transportation should be optimized while appropriate solving countermeasures should be found as well. To that end, this study points out its existing problems, analyzes relevant issues about cargo distribution and transportation management, and put forward corresponding countermeasures. From the perspectives of coordination and optimization, this paper conducts scientific forecasting on Ningbo-Zhoushan Port's cargo throughput, in order to construct a reasonable optimization model of cargo distribution and transportation system in the ports. The analysis results show that by optimizing the management of the cargo distributing and transportation system, the transportation efficiency can be increased, and the overall competitiveness of Ningbo-Zhoushan Port can be improved.

Keywords—Ningbo-Zhoushan Port; Cargo Distribution and Transportation System; Management Countermeasure; Optimization Model

I. INTRODUCTION

In recent years, the marine economy has been holding an increasingly higher status in China's national development strategy. Under the background of "the Belt and Road" in China, it is necessary to accelerate the development mode of "relying on the ocean leads to prosperity" and restructure and optimize the industrial structure to achieve the goal of improving the quality and efficiency of port logistics. The infrastructure of port logistics in China mainly focuses on meeting the requirements of conventional transportation operation, with insufficient strength in integrating transportation modes such as the railways, roads and inland waters. There are also many problems existing in the development of modern port logistics. For instance, road transportation accounts for a significant proportion despite the low-grade roads and a relatively small number of channels; railway transportation accounts for a relatively small proportion [1], and the development of multimodal transport is slow. These problems have been restricting the effectiveness

and efficiency of the cargo distribution and transportation system in the ports, which has a direct influence on the efficiency of port operation and plays a crucial role in the development of modern ports.

At present, with the rapid development of international trade, smooth and convenient cargo distribution and transportation system can not only facilitate the rapid development of port cargo throughput but also have great significance for speeding up cargo handling, ensuring timely delivery of goods and reducing transportation time of goods. Ningbo-Zhoushan Port is an artery port in mainland China, which also serves as an important storage place for crude oil, ore and other materials as well as a transit and storage site for most of the bulk cargoes in East China [2]. However, the development of cargo distribution and transportation system in Ningbo-Zhoushan Port lacks long-term and far-reaching planning, not to mention the negative competition environment. Some problems existing in the development process of cargo distribution and transportation system are also viewed as obstacles for the logistics development of Ningbo-Zhoushan Port.

Through analysis of the current situation of the cargo distribution and transportation system in Ningbo-Zhoushan Port, this paper analyzed problems existing in cargo distribution and transportation management and put forward countermeasures for improvement. Moreover, from the perspective of coordination and optimization, this paper utilized the grey forecasting method to conduct scientific forecasting on Ningbo-Zhoushan Port's cargo throughput in order to construct a reasonable optimization model of cargo distribution and transportation system in the ports. At the same time, specific to existing problems of the status quo of the cargo distribution and transportation system in Ningbo-Zhoushan Port, countermeasures and suggestions were put forward.

II. IMPORTANCE OF THE CARGO DISTRIBUTION AND TRANSPORTATION SYSTEM TO PORT DEVELOPMENT

Nowadays, global trade is closely connected and rapidly developing with a sharp increase in imports and exports. In

such an environment, as an important node of the international logistics network with the effects of aggregation and diffusion, port logistics has been developing rapidly. The whole process of port logistics includes three parts, namely, marine transportation, port handling and inland transportation (distribution and transportation), in which, the port and the various modes of inland transportation cooperate and connect with each other to form the cargo distribution and transportation system in the ports.

As the world's largest power in trading, China has a huge volume of cargoes for distribution and transportation in coastal ports which are important hubs for connecting China's hinterland with the outside [3]. Therefore, the cargo distribution and transportation system at coastal ports are essential in the connection, handling and transportation of cargoes.

A. Reducing Transportation Cost and Time of Cargoes

Waterways, railways and roads are commonly used in cargo transport. In the cargo distribution and transportation process, reasonably allocating different transportation modes and facilities and scientifically and effectively arranging cargo transportation can not only reduce the time for handling over the goods but also cut down the transportation cost.

B. Improving Cargo Transportation Efficiency

Reasonable and practical plans for cargo distribution and transportation management at coastal ports should be formulated. For instance, unnecessary steps can be reduced in the process of transportation, collection and distribution; the cargoes can be classified during handling, so that they can quickly and orderly be loaded and unloaded; and each process can be closely connected by actively coordinating different departments [4], thus effectively reducing the ship's duration of stay in the port and relieving the pressure from the handling process. Hence, scientific and efficient cargo distribution and transportation system in a port not only improves the operation and organization capacity of the port, but also greatly raises the efficiency of cargo transportation.

C. Improving the Economic Benefits of Goods in Transportation

Port is the transfer station in the process of cargo transportation. Reasonable and effective allocation of different cargo distribution and transportation ways during the transportation can ensure the quick, effective and safe delivery of goods to the destination, accordingly reducing costs of transportation and maximizing the economic benefits to a certain extent.

D. Expanding Economy Hinterland of Ports

The cargo distribution and transportation system acts as the bridge connecting the ports and the inland hinterland, and the connection of the economic development of the inland hinterland and the ports is interdependent and indispensable [5]. Therefore, promoting continuous improvement of the cargo distribution and transportation network system at coastal ports

is conducive to attracting more sources of goods and accelerating the overall development and progress of the ports.

III. THE STATUS QUO AND PROBLEMS OF THE CARGO DISTRIBUTION AND TRANSPORTATION SYSTEM IN NINGBO-ZHOUSHAN PORT

A. Analysis of the Status Quo

The cargo distribution and transportation system in Ningbo-Zhoushan Port includes two parts: the marine transportation system which consists of oceangoing main lines and near-sea branch lines, and the rear-area cargo distribution and transportation network composed of various transportation modes such as roads, railways, waterways and pipelines, the latter of which would mainly be investigated in this paper.

Transportation modes of the rear-area cargo distribution and transportation system in Ningbo-Zhoushan Port include roads, railways, waterways, pipelines and other ways represented by belt conveyors. The proportion of cargo distribution and transportation of each mode in 2018 is shown in Table I.

TABLE I. THE PROPORTION OF VARIOUS MODES OF THE CARGO DISTRIBUTION AND TRANSPORTATION SYSTEM IN NINGBO-ZHOUSHAN PORT

Mode of Transportation	Road	Waterway	Railway and others
Ratio of cargo distribution and transportation (%)	≥80	15	3-5

B. Development Trend

According to the present situation, the development trend of the cargo distribution and transportation system in Ningbo-Zhoushan Port can be concluded into three aspects. First, it is about coordinating the proportion of the three cargo distribution and transportation modes, namely, waterways, roads and railways, according to the actual situation of each port.

Second, focus on developing railway transportation and strengthening marine-railway combined transportation and marine-river combined transportation.

Third, the green development of the cargo distribution and transportation system in ports is considered the future direction. For this, road transportation that is a pollutant to the environment will be gradually replaced by environmental friendly transportation methods such as railways and waterways.

C. Existing Problems

Generally speaking, the current cargo distribution and transportation system in Ningbo-Zhoushan Port takes the port as the core and partial roads as the skeletons with the allocation of four modes of transportation: roads, railways, waterways and air transport. It gradually forms an integration of highways, port roads and general roads. However, there are still many weak points in the construction of the cargo distribution and transportation system in Ningbo-Zhoushan Port, mainly embodied in the following aspects: the structure of cargo

distribution and transportation in the port is unreasonable; the road transportation is inefficient and has prominent contradictions; the advantages of railway distribution and transportation in the port is not obvious; the infrastructure level for cargo distribution and transportation is low in the port; and the corresponding management of cargo distribution and transportation is disordered.

1) Management and Systematic Problems of Cargo Distribution and Transportation Infrastructure

The enhancement of ports' cargo distribution and transportation capacities needs to be realized through the continuous improvement of port infrastructure. Cargo distribution and transportation facilities in ports mainly include nodes and accesses [6]. The bottleneck of Ningbo-Zhoushan Port lies in the inconsistent development of infrastructure and economy, including the following points: *a)* the supply of infrastructure is not efficiently connected with the needs of ports' modernized development; *b)* the construction of infrastructure fails to be adapted to the growth rate of port throughput; *c)* the construction of infrastructure cannot guarantee the environmental protection needs to be raised by improvement of people's quality of life and *d)* the development of infrastructure construction cannot guarantee the maximum benefit from the cost of supply.

2) Lack of Supply Chain Management Targeting Port Logistics

It is observed from the current management of port function development that port management is increasingly inclined to the management method of supply chains. According to Gu Junbo (2014), Ningbo Port and Zhoushan Port were originally under the jurisdiction of Ningbo and Zhoushan [7]. Although the idea of "unified planning, unified branding, unified construction and unified management" of these two ports was put forward in accordance with the integration strategy, the port administration of Ningbo and Zhoushan was still performed according to the principle of territoriality, which has not yet achieved the goal of unified planning, rational division of work and advantage complementation. Integration of the Ningbo-Zhoushan Port progressed slowly from 2003 till now, and the current management situation which has not yet been unified makes the operation management of the logistics supply chain of the Ningbo-Zhoushan Port more complicated.

3) Insufficient Port Management and Service Capabilities

According to the overall management system, Ningbo-Zhoushan Port, like other coastal ports in Zhejiang province, faces the segmentation of management system. The various transportation modes involved in the port are highly independent. Each of them has established a separate management system and development plan, which lacks systematic and coordinated management, optimized integration and mutual cooperation across systems, thus resulting in a great waste of transportation resources. The lack of systematic coordinated management will inevitably become hidden trouble for its future development. Li Xiaogang (2012) found that, from the current situation of Ningbo-Zhoushan Port operation, various operators of the port logistics supply chain still regard market regulation as their main resource allocation method [8]. As a result, the competition between Ningbo Port

and Zhoushan Port did not change substantially, making the port in lack of coordination and unification. As a consequence, the operation efficiency of logistics services is relatively low, and it is difficult to provide integrated port logistics services for customers.

4) Insufficient Information Management of the Port

In the era of the new economy, ports are not only the intermediate link of cargo circulation, but also the intermediate link of information circulation. Therefore, it is an inevitable trend to build a unified e-data exchange information platform based on the multimodal transport information system, together with trade-related enterprises, social service organizations and relevant government departments, so as to lay a foundation for the sustainable development of shipping centers.

At present, there are problems such as tedious and slow information transmission and a small volume of information sharing and e-data exchange, existing in actual business operation and management by port authorities in China, which is difficult to meet the needs of port development. And because of the development degree of Zhoushan Port lags behind that of Ningbo Port, there are certain differences in informationization level and utilization rate of information. In the context of constructing integration, Ningbo-Zhoushan Port needs an information platform for collaborative operation.

IV. OPTIMIZATION MODEL MANAGEMENT

COUNTERMEASURE ANALYSIS OF THE CARGO DISTRIBUTION AND TRANSPORTATION SYSTEM IN NINGBO-ZHOUSHAN PORT

Forecast of port's cargo throughput is the key to strategic research of port development as well as an important basis for guiding the construction of the cargo distribution and transportation system and an important indicator for allocating the freight volume of cargo distribution and transportation. Therefore, the optimized model of the cargo distribution and transportation in Ningbo-Zhoushan Port must be built on the basis of the forecast of port cargo throughput, so as to optimize the arrangement of freight stations or transfer stations according to reasonable forecasts and construct an effective optimization model.

A. Optimization Model of the Cargo Distribution and Transportation System in Ningbo-Zhoushan Port

This paper focuses on the limitation of ports and freight stations in the cargo distribution and transportation system. By studying the flow assignment of the distribution and transportation lines, the operative and managing capabilities of each node are optimized and improved, so as to improve the accessibility of the cargo distribution and transportation system.

1) Determining the assumptions. *a.* analyze freight stations, transfer stations and transportation routes to determine relevant selection and use; *b.* leave out the location of freight stations; *c.* there are three main methods of transportation: roads, railways and short-distance waterways, and all transportation modes are in good condition; *d.* the cargo distribution and transportation volume of both railways and roads are within a bearable range.

2) Formulating a linear planning model. According to the relationship among the port, freight stations and the cargo

distribution and transportation network, take the actual situation into account and formulate a linear planning model with the goal of minimizing the capital investment of the freight stations, the transfer stations and the total transportation cost of cargoes.

The objective function is defined as a 0 ~ 1 integer planning model, and the decision variable is that if cargoes are transported from the place of production to the destination port p through the freight station (or transit station, branch port) j , then $=1$, otherwise $=0$.

3) Use the genetic algorithm to calculate x_{ip}^j that minimizes $Z(x)$ and the optimal operation volume of the freight station, that is, all freight stations, transfer stations or branch ports meeting $x_{ip}^j \neq 0$ are the optimal nodes in the cargo distribution and transportation system. In addition, because of the different transportation modes and routes, the unit transportation cost also differs. Therefore, the optimal arrangement of the transportation routes can be obtained, and the best development mode of the cargo distribution and transportation system for port logistics can also be obtained.

B. Countermeasures for Further Solving Problems of the Cargo Distribution and Transportation Management in Ningbo-Zhoushan Port

To improve the competitiveness of multimodal transport, Ningbo-Zhoushan Port should comprehensively establish and improve the railway transportation system and reform the structure of its cargo distribution and transportation system. Sound infrastructure should be established to increase port cargo throughput and meet transportation needs, thereby attracting more cargo resources. At the same time, it is necessary to promote railway construction near the port and expand the transportation capacity of the railway, so as to ensure unblocked port channels and enable cargoes to be transported fast and efficiently.

1) Optimizing the Cargo Distribution and Transportation Structure

a) Optimizing the Cargo Distribution and Transportation Structure in the Port

By promoting the development of multimodal transport, it is expected to integrate the development of railways, roads and inland waterways to form a cargo distribution and transportation pattern of multimodal transport of roads, waterways, and railways. (1) The marine-railway combined transportation should be strengthened by actively exploring the marine-railway combined transportation and building a marine-railway combined logistics channel, so that the service hinterland of Ningbo-Zhoushan Port can be expanded and the radiation range of the port can be enlarged to better serve the export-oriented economic development in the central and western regions. (2) Strengthening river-marine combined transportation is conducive to boosting resource integration, promoting the development of river-marine combined transportation and improving the transportation efficiency of the golden waterway of Yangtze River, which is of great significance for driving the development of the Yangtze River economic zone.

b) Improving the Railway-centered Cargo Distribution and Transportation Network

By constructing freight routes of the Ningbo-Zhoushan Railway, the Ningbo-Yiwu Railway, and the coastal railways, it is to increase the proportion of railway freight transportation and strengthen the bond with major sources of supply. As proposed by Fang Yudong (2013), to build the main channel of Ningbo-Zhoushan Port, the function of the Ningbo-Zhoushan expressway can further be exerted with the formation of the main channel of the expressway for cargo distribution in the port [9]. To improve the convenience of cargo distribution in the port via the special channels in the port area, the main channel consisting of Hangzhou-Ningbo expressway and Xiangshanwan expressway has been constructed. To actively promote the process of the Shanghai-Zhoushan-Ningbo large-channel project and prompt the transfer of Zhoushan from the end of transportation to a transportation hub, while strengthening the northern port distribution capacity and mutual cooperation with Shanghai Port, it aims to promote the regional economic development.

2) Enhancing Port Supply Chain Management Capabilities and Standard of Service

The integrated logistics services of modern ports should satisfy the needs of the entire supply chain. Under the background of Zhejiang Economic Demonstration Zone, Zhejiang Zhoushan Islands New District, and the construction of the "Three-in-One" port and shipping logistics system, the supply chain management of Ningbo-Zhoushan Port should be optimized by taking the business philosophy, integrated operation, service quality and information level into account.

a) Reinforcing Integrated Operation

The unified planning and rational labor arrangement between the port areas should be strengthened, so as to exploit the regional advantages to the full. Port departments and related enterprises should be coordinated with each other and the cross-system and cross-department cooperation between transport companies should be strengthened to ensure an unimpeded transportation process of cargoes, thereby improving the efficiency of logistics operation [10]. At the same time, the integrated operation of cargoes in storage, transportation and sales ought to be accelerated to form a manageable and cost-controllable supply chain.

b) Strengthening Informatization Management of Port Logistics

To accelerate the integration of Ningbo-Zhoushan Port, members of the supply chain in or used to center in Zhoushan Port area should rapidly improve the level of informationization, accelerate the construction of enterprise information, and actively participate in the construction of the public information platform, so as to achieve the goal of effective collaboration [11]. Meanwhile, in order to adapt to the rapid development of the information era, Ningbo Port must also provide corresponding information services. The first is to establish an authoritative public information platform for the cargo distribution and transportation system that provides unified external services, which can be achieved by combining the "Ningbo e-Port", "Ningbo Port EDI Center", "Dongfang

Port Import and Export Logistics Information” and “Ningbo Traffic Information”.

The second is to complete the port information platform. On the one hand, in order to realize interconnection and data sharing of information, support from relevant government departments are still needed to ensure that the relevant information of the vertical managing department can continue to operate on a platform of the port; On the other hand, it is necessary to establish a system which can unify data and identity authentication between various enterprise departments related to the port, between government authorities and enterprises, and between key ports, so as to strengthen the information of cargo distribution and transportation in the port and better serve and contribute to the cargo distribution and transportation system of Ningbo Port.

V. CONCLUSION

The formation of ports is highly relative to the level of cargo distribution and transportation systems. The change of cargo distribution and transportation ability would also affect port development. The cargo distribution and transportation ability have a huge influence on the cargo distribution and transportation system in the ports, which will greatly affect the whole cargo distribution and transportation system of the ports. Therefore, in order to improve the overall condition of cargo distribution and transportation system in the ports, it is important to learn about other ports' arrangement characteristics and combine them with their own characteristics, while focusing on the improvement on cargo distribution and transportation ability of roads, railways and waterways. The optimization of cargo distribution and transportation system in the ports can improve the turnover speed of loading and unloading, which makes cargo deliver on time and reduces the cargo circulation time. Oriented by the development requirements of Ningbo-Zhoushan Port, study on the construction of cargo distribution and transportation system in Ningbo-Zhoushan Port with the consideration of various transportation means can help to achieve organic coordination between the cargo distribution and transportation system and urban traffic and promote the infrastructure construction of the cargo distribution and transportation system in the port, while

paying more attention to transportation market management and actively constructing the digital information platform. Meanwhile, the management mode of the cargo distribution and transportation system in Ningbo-Zhoushan Port can be improved to promote the fast and healthy logistics development of Ningbo-Zhoushan Port.

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