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Research on double-stack container transport organization in international multimodal transport

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Declaration

I certify that all the material in this research paper that is not my own work has been identified, and that no materials are included for which a degree has previously been conferred on me. The contents of this research paper reflect my own personal views, and are not necessarily endorsed by the University.

Supervised by

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Abstract

Research on Double-stack Container Transport Organization in International Multimodal Transport

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The development and application of double-stack container transportation is a huge revolution in the history of container transportation development. This paper will first analyze the status of international multimodal transport and point out the trend and problems facing by China. Secondly, the paper analyzed the development status of the development of double-stack container transportation in foreign countries and gives an introduction to advanced technology. Then analyzing the situation existing in the double-stack container transport of sea-rail transportation in China and indicating the problem. Finally, by using SWOT-PEST Analysis to analyze the example of Ningbo Zhoushan-Shaoxing double-stack container sea-rail transportation which was opened in December 2018, this paper gives some suggestions to the development of double-stack container transportation in China and make a conclusion.

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Keywords: International Multimodal Transport; Double-stack Container; Sea-rail Transportation; SWOT-PEST

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List of Abbreviations

B&R	the Belt and Road
CRE	China Railway Express
NVOCC	Non-vessel Operating Common Carrier
LCL	Less Than Container Load
FCL	Full Container Load
SP	South Pacific Railway Company
SL	Sea-Land Group
APL	American President Shipping Company
CN	Canadian National Railway Corporation
ARTC	Australian Railway Track Corporation
CNY	China Yuan

Chapter 1 Introduction

1.1 Research Background and Significance

1.1.1 Research Background

Container transportation is an efficient and advanced mode of transportation. It has deepened the development of various modes of transportation by sea, rail and highway through international multimodal transport. Its emergence has also made it possible for the generation of multimodal transport, and realizes the modernization of logistics for China is very important. Since its appearance, containers have been greatly developed with their advantages of high efficiency, high safety factor and small environmental impact. China's containers also entered a period of rapid development in the 1990s. In the following ten years, the level of economic and trade openness has been continuously increased, and container throughput has increased year by year. According to the media of the classification society, there are 24 ports in the top 100 ports of world container throughput in 2017. Among the top ten ports, China has seven.

The promotion of containers in China is constantly deepening. The development of ‘Belt and Road’ has promoted economic and cultural ties between China and Central Asia, North and West Asia, the Indian Ocean, and the Mediterranean countries. The interconnection and mutual benefit have become a trend, and the trade volume between countries has also increased. In 2017, the opening of the China Railway Express accelerated the development of container multimodal transport, building the Belt and Road and adding to the economic and trade exchanges between the countries and regions along the route. All kinds of environments have put forward a higher demand for the development of China's container transportation. In order to absorb the growing demand for container transportation and adapt to the acceleration of economic development, the development of railway container transportation will also follow the trend.

The double-stack container transportation is the result of the development of container transportation, which can further improve transportation efficiency, greatly increase the number of one-way transportation goods, and save a lot of costs. It can be defined as a major revolution in the development of the container transportation. The double-stack container sea-rail intermodal transport has been widely used abroad. The development of double-stack container transportation in China did not have the first double-stack container trial operation train of the Beijing-Shanghai Railway until 2001. In December 2018, China's first double-stack container sea-rail intermodal train, which was officially opened to traffic from Shaoxing to Beilun port in Zhoushan Ningbo, brought hope to China's double-stack container sea-rail combined transport.

1.1.2Research Significance

Since the beginning of the 21st century, the development of the international container transportation market has made significant progress. Based on the analysis of the development of double-stack container transportation in international multimodal transport, this paper compares the current status of China's sea-rail intermodal transportation and points out the gap between China and foreign countries in the development of double-stack container transportation. From the advanced achievements in the development of double-stack containers abroad, we are looking for the experience of the double-container sea-rail combined transport Chineseization.

Besides, through the analysis of the newly-opened sea-rail intermodal trains, this double-stack container class will be analyzed for problems that have been or may be encountered during the construction and operation. The problems faced by Chinese double-stack containers transportation will be analyzed from special to general and personal suggestions will be given for these issues.

In summary, the significance of this paper is mainly to provide some suggestions for the double-stack container in the field of China's sea-rail intermodal transport, as well as some solutions to the problems encountered in its development process.

1.2 Methodology

1.2.1Research Contents

(1) Comparative analysis of the development status of international multimodal transport in China and China

(2) Comparative analysis of the development status of double-stack container transportation in the world and China

(3) Proposing and analyzing the double-stack container transportation problem in China

(4) Based on the analysis of SWOT-PEST from Ningbo Zhoushan Port to Shaoxing double-stack container sea-rail intermodal train, from special to general, we can find out the problems existing in China's current double-stack container transportation, and double-stack for sea-rail combined transport in other parts of China. The reference significance of the development of container transportation.

(5) From the development of double-stack container transportation in the international and Chinese, to find a solution to the problems in the development of China's double-stack container.

1.2.2 Research Method

The research method of this paper is to first analyze the development of global multimodal transport, and then analyze the problems and challenges encountered in China's double-deck container transportation, and from Beilun Line to Xiaoyu Railway in Ningbo Zhoushan Beilun Station to Shaoxingyu Railway Station. China's first double-deck container sea-rail combined transport class was included in the SWOT-PEST analysis to find out the common problems for the double-deck container sea-rail combined transport in other parts of China and the places worth learning. Finally, through the analysis of the development of foreign double-deck container sea-rail combined transport, the author puts forward personal views and suggestions on the development of China-sea rail transport double-deck container transportation.

Chapter 2 Literature Review

The origin and rapid development of containers are all abroad, and the double-deck container transportation technology has also appeared abroad. At present, foreign-related research has been quite rich and mature, and it has been widely applied and practiced. The research on infrastructure construction, service level, related technical and safety has also developed rapidly in foreign countries. After reviewing the information, I found that research on double-deck container transportation focused on the research of related transport loading technologies:

Umang Nitish, Morganti Gianluca, Frejinger Emma imposes weight and center of gravity limitations on the loading of double-deck multimodal transport, loading stacking and technical load limitations associated with specific bins or content. An integer linear programming (ILP) formula was proposed to select the best container stacking method and the best way to load them onto the outbound train in order to minimize the resulting loading costs. AUpadhyay, WGu, NBolia optimizes the loading of double-deck container trains by developing a multi-objective optimization model that maximizes profit and minimizes the delay. The model considers different types, weights and heights of containers, and their feasible loading combinations on trucks that meet actual operational constraints. After leveraging problem-specific attributes, CPLEX can best solve the model. Decision support systems based on this optimization model have been deployed by major train operators in India.

'Double-stack containers: changing the image of intermodalism' is an article published in 1992. The author extends from the development of multimodal transport to the development of double-deck container technology. Finally, combined with the specific situation of double-deck container development in the United States, the advantages and disadvantages of double-deck container transportation are analyzed from the perspective of economics. The article has done a good job in the development of double-deck container technology, but due to the age, many technical things have been updated and not applicable to the research of container development in China.

Compared with foreign countries, the development of double-deck container transportation is relatively lagging behind in China. The level of double-stack container application in the country and the construction of related infrastructure are relatively limited. There are relatively few related studies on double-deck container transportation. The research of most experts and scholars mainly focuses on the loading and unloading scheme of double-stack containers and the construction of transport corridors for double-stack containers. Technical study on the transport carrier of the double-stack container. Yao Fengjin, Zhao Peng, Yang Hao's article "Assessing Algorithm for Double-deck Container Transport Vehicles" is related to the calculation analysis, structure selection and packing mode of the double-stack container flat car. The analysis and improvement of the other aspects have reached the final research and development goal, and the theoretical optimization of the transportation carrier of the double-deck container. Zhang Jian and Li Jiang Jian Wenliang of Tongji University analyzed the box structure and box weight statistical characteristics of the newly opened sea-rail combined transport double-deck container train in the article “Study on the double-deck container loading plan of Shaoxing-Ningbo Zhoushan Port". Based on the requirements of the regulations, the limit requirements of different box type stacking forms are calculated, and the various types of stacking schemes that meet the requirements of the center of gravity of the heavy truck are discussed. The feasibility of each loading scheme is analyzed in combination with market demand characteristics. And selected the best plan from it, and proposed the preparations needed for the development of double-deck container transportation in the future.

Mei Zhixing, a major in transportation planning and management of Lanzhou Jiaotong University, analyzed the characteristics of the current double-stack container transportation channel construction in his master's thesis "Research on the Economic Evaluation Method of Railway Double-deck Container Transport Channel Construction Project", and analyzed and pointed out the current The problems existing in the economic evaluation method of railway construction projects, combined with the three evaluation methods of railway transportation demand forecasting, financial evaluation method and national economic evaluation method, established the economic evaluation method system of double-deck container transportation channel construction project.

Chapter 3 International Logistics and Multimodal Transport

3.1Overview of International Logistics and Multimodal Transport

International logistics refers to the flow of goods between different countries. The essence is to realize the optimal allocation of global resources among different countries based on the principle of division of labor and cooperation and promote the rapid development of a regional economy. The overall goal of international logistics is to deliver goods to different regions with minimal risk incidence and lowest cost. Due to the high transportation requirements of international logistics and long transportation distance, it is necessary to select appropriate transportation modes and transportation routes in the international logistics process to minimize logistics costs, reduce cargo transportation time and shorten transportation distance. There are three main forms of international logistics transportation: international Multimodal Transport, International Intermodal Transport, and Segmented Transport. In China, segmented transport is used for more than 90% during the international logistics, but segmented transport is often difficult to achieve large-scale transportation. It is a typical "small play" decentralized operation model, which seriously affected the competitiveness of Chinese international logistics companies in the global market. However, international multimodal transport can be a good way to make up for these problems. International multimodal transport has a series of obvious features such as "safety", "flexibility" and "convenience", which can effectively integrate multiple modes of transport. It can improve the efficiency of cargo transportation, and can effectively increase the quality of cargo transportation. It can also meet the individualized needs of different customers for cargo transportation, and can also achieve the door-to-door service, which is why this form of transportation has received wide attention from all walks of life. It is worth noting that international multimodal transport is basically container transport and has become an essential component of the international trading process.

3.2 Advantages of international multimodal transport

3.2.1 Simple procedures and clear responsibilities.

As is known to all, international logistics often require multiple transshipments and transportation routes are extremely remote. The logistics procedure is more cumbersome. Once the goods are lost, it is difficult to clarify the responsibilities of the relevant responsible persons. International multimodal transport effectively integrates various modes of transportation. The customer only needs to go through one procedure, pay one fee, and sign one contract and then the entire responsibility of the goods during the transportation process would be taken by the multimodal carrier.

3.2.2 Saving goods and time loss

International multimodal transport has strong flexibility, which greatly reduces the intermediate links involved in the transportation process and effectively improves the quality of transportation. The international multimodal transport is basically based on container transportation and the containers will be packed with lead seals before shipment. There will be no unpacking during transportation, and will not be opened until the consignee signs the receipt, which greatly save the loss of goods and time.

3.2.3 Saving transportation costs

The international logistics costs will be collected by the multimodal transport carrier at one time. The customer can use the intermodal bill of lading to settle the goods after the goods are placed on the first-pass transport or after the goods are packed. It is beneficial to reduce the loss of interest, but also facilitates the settlement of foreign exchange time in advance, and also helps to shorten the capital turnover time of the shipper, thereby effectively saving transportation costs.

3.3 Development trend of international multimodal transport and international logistics

3.3.1 The importance of international liner companies in international multimodal transport is increasing evidently

The earliest international multimodal transport operators are NVOCCs, who will play an intermediate role between shippers and carriers. The actual carrier of international multimodal transport is usually an international liner company. Following the increasing competitive pressure in the market, international liner companies will no longer only be satisfied with only obtaining transportation profits. They will directly undertake trade, transportation, cargo collection services by setting up offices in various ports and they will also spend huge sums of money to increase air transportation, port transportation and warehousing. With the increasing amount of international logistics throughput, international liner companies have become the central role of international multimodal transport with their strong monopoly transportation strength.

3.3.2 The obvious trend of integration between enterprise business and international multimodal transportation

Today, the pace of life is accelerating, which requires the international logistics companies to respond to customer’s needs in the shortest possible time and to minimize the transit time and transportation costs of goods. which is also the international multimodal transport. With the high requirements of international logistics, more and more enterprises are inclined to require international multimodal transport operators to provide integrated services. There are even some companies require the international multimodal transport operators to infiltrate their business into the sales, production, and distribution of their products. For example, Nike requires a full range of services (distribution, packaging, delivery, financial services, etc.) for international multimodal transport operators who have only provided logistics services. This shows the influence of international multimodal transport in enterprise supply chain solutions continues to grow.

3.3.3 Internationalized Network Becomes the Core Resource of International Multimodal Transport Competition

Most customers hope that international multimodal transport can provide “door-to-door” services, which requires international multimodal transport operators to set up intermodal outlets or branches offices in major cities. The establishment of branch offices or intermodal outlets is not only supported by economic but also the stability and scale of the supply. Once an international multimodal transport network is formed, it will become the core resource which will enable the company to have the credit guarantee and service capability to achieve sustainable development in market competition.

1.3.4 The proportion of LCL cargo is increasing

The most profitable business in the international multimodal transport process is often the international container multimodal transport, which can be further subdivided into LCL and FCL, of which LCL is the main transport. From the current point of view, as the demand of the vast number of consumers presents the characteristics of "diversity" and "individualization", the types of goods are increasing, but the volume of goods is decreasing. To satisfy the demand for diversity of goods in container transportation, the requirement of LCL will keep increasing. The transportation cost of LCL is lower, but the requirements for LCL experience and technology are relatively high, which brings development opportunities and challenges for international multimodal transport operators.

3.4 Status of China's international multimodal transport development

China's international container transportation began in the 1970s. In 1997, the Chinese government promulgated the "International Container Multimodal Transport Management Rules", which is the signal that Chinese container multimodal transport had entered a period of comprehensive development. At the end of 2018, China's container throughput has exceeded 250 million TEUs and China has 7 of the world’s top 10 ports. After nearly 50 years of development, China's international multimodal transport has achieved a series of achievements, especially the infrastructure level has been greatly improved, and the standardization construction has been in line with international standards.

China's multimodal operation industry is in the development stage, and its characteristics are mainly reflected in the following aspects:

3.4.1 The rapid expansion of multimodal transport

Year	Freight Volume Ratio/%			Freight Turnover Ratio/%			Average Transport Distance/km		
	rail	road	sea	rail	road	sea	rail	road	sea
1995	13.44	77.1	8.03	54.44	19.59	23.42	786.2	49.93	573.21
2000	13.14	77.77	7.44	50.54	22.5	24.45	771.11	59	669.86
2005	14.46	73.99	9.43	49.7	20.84	26.66	769.64	64.79	649.93
2010	11.24	76.89	10.08	28.84	45.27	23.4	758.89	177.24	698.94
2015	8.05	75.52	14.72	13.41	32.67	51.49	707.39	183.98	1487.7
2017	7.7	76.75	13.89	13.75	34	49.69	730.68	181.28	1463.2

Table 1:Proportion of freight volume and ton-km freight of railway transport, road/highway transport and sea/waterway transport from 1995 to 2017

Table 1 shows the changes in the freight volume and freight turnover of the three modes of transportation of railways, highways and waterways in China from 1995 to 2017, which accounted for the proportion of the national comprehensive transportation market.It is not difficult to see that the railway freight volume and freight turnover accounted for a continuous decline. Road, waterway freight volume and freight turnover have increased in different degrees.Research shows that the railway cost is about 1/3 of the highway, the energy consumption is about 1/7 of the highway, and the discharge is 1/13 of the highway. The railway freight turnover in China only accounts for 13.75% of the comprehensive transportation market, and the road transportation reaches 34.00. %, water transport has reached 49.69%.This is in stark contrast to the 33.23% share of the US rail freight turnover in the integrated transportation market (39.01% for road transport and 9.34% for water transport).It can be considered that the role of railways in China's comprehensive transportation system has not been fully utilized.

Although there is no specific multimodal transport statistics, the total amount of multimodal transport in China shows a rapid growth from the multimodal transport data of individual ports. In 2006, the combined volume of rivers and seas reached 2 million TEUs, accounting for 9.2% of the port container throughput. The sea-rail intermodal transport volume was 84,000 TEUs, accounting for 0.4% of the port container throughput. Although the proportion of multimodal transport volume to container throughput is not very high, from the trend in recent years, the average annual growth rate of sea-rail intermodal transport volume is as high as 30%, and the growth rate of river-sea combined transport volume is also over 20%. Despite the financial crisis in 2008, the container throughput of China's ports still reached 130 million TEUs, and the rapid development of foreign trade created conditions for the development of multimodal transport. As China's freight demand continues to grow, China's freight forwarding industry and international intermodal routes have also developed rapidly. In 2008, the number of Chinese freight forwarding enterprises reached 13,500. 80% of China's import and export trade cargo transportation and transit business, and 90% of international air cargo transportation business were completed by international freight forwarding companies. At the same time, China's 135 water transport ports, 66 land ports, and 57 airports have opened intermodal lines that mainly include the Mainland to Japan, the United States, the African, the Western European and the Australian.

3.4.2. China's multimodal transport is based on collaborative e intermodal transport

According to the organization of multimodal transport, it can be divided into collaborative and link type. Collaborative multimodal transport refers to the transport of two or more modes of transport, following uniform regulations or agreed agreements, to transport goods from the location where the goods are taken to the place where the goods are delivered. Link type multimodal transport refers to a transport enterprise that combines two or more modes of transport by a multimodal transport operator to transport goods from the location where the goods are taken to the place where the goods are delivered. At present, China's multimodal transport business is also based on collaboration. In this form, each carrier completes the actual transportation of its section and the related freight transport organization work, and then bears the risks and distributes the interests according to relevant contracts or agreements. In the form of link type multimodal transport, the multimodal transport operator is the entire carrier, signing the contract with the shipper and taking the carrier's responsibility. In comparison, link type multimodal transport is more in line with the definition of multimodal transport. It achieves the separation of transport organization and transport products, which not only facilitates the cargo owner and the actual carrier but also facilitates the transport connection work. From this point of view, the form of China's multimodal transport organization has yet to be further optimized.

3.4.3. The road-sea transport is the main mode of transport for multimodal transport in China

According to the combination of different modes of transportation, multimodal transport can be divided into different modes of transport such as rail-to-rail transport, sea-rail intermodal transport, and road-sea joint transport. Judging from the actual operation of China, road-sea transport is still the main mode of transport for multimodal transport in China. Limited by the railway management system and capacity, China's railway-related intermodal forms are showing signs of shrinking. Especially the huge potential of sea-rail intermodal transport is difficult to play. It can only rely on highways to transport large quantities of containers in the port to inland areas. The efficiency is unsatisfactory. The proportion of sea-rail intermodal transport in developed countries accounts for 20% to 40% of port container throughput, while in 2007 this figure was only about 1.5% in China. Railway-Rail transport plays an important role in the land port, but it is also subject to the railway container transport management system. Some other intermodal transport modes (such as air and rail transport, air and water transport) have also achieved some development in recent years, but the overall scale is small.

3.4.4. Continental Bridge Transportation Becomes a Feature of China's International Multimodal Transport

In international multimodal transport, Land Bridge Service is a special form of transportation. Strictly speaking, land-bridge transportation is also a form of land-sea transportation. IIt uses container-specific trains or trucks to use transcontinental railways or highways as intermediate “bridges”, linking container shipping routes at both ends of the continent to dedicated trains or trucks. China has a natural advantage in carrying out Continental Bridge transportation. The three Continental Bridge transportation lines are connected to Russia, Mongolia, and European countries via the three continental road ports of Manzhouli, Erlianhot, and Alashankou respectively. The transportation volume is maintained at around 10,000 TEU per year. The shortening of the transportation distance and the acceleration of the transportation speed not only shorten the transportation time but also save the transportation cost by 20%~30%. The huge advantage makes the throughput of China's land ports increase greatly. However, due to the need for land-bridge transportation to be transited through customs in several countries, and the inconsistency between European and Asian rail standards, the advantages of land-bridge transportation have been greatly weakened.

3.4.5. The infrastructure has been greatly improved, the hardware standards have been basically in line with the international reform.

Since the economic reform and open up, the status of China's transportation infrastructure has been greatly improved, which the standard of equipment has been internationalized and the convergence of hardware has greatly eased the "bottleneck" effect of multimodal transport development. China's "three horizontal and four vertical" railway network system has begun to play an important role and meanwhile, the "five vertical and seven horizontal" way national highway trunk line has also been completed at the end of 2007. The port is equipped with modern mechanical facilities, improving the efficiency of loading and unloading.1 tons, 5 tons and 10 tons containers have been eliminated and replaced with internationally available 20-inch and 40-inch standard containers. At the same time, some new transshipment technologies and information technologies have also begun to be applied to intermodal operations, such as double-stack container trains, piggyback trailers, and electronic customs clearance.

3.5 Problems in the development of China's international multimodal transport

International container transportation has entered the era of multimodal transport, but China's container multimodal transport still adopts a segmented transport mode, and international multimodal transport is still in its infancy. There are many reasons for hindering the development of China's international multimodal transport. The following will conduct simple analysis.

3.5.1. The failure of the management system directly affects the efficiency of international multimodal transport

Multimodal transport involves the connection and integration of various modes of transport. Only by designing the management system from the whole, can the advantages of multimodal transport be realized. However, China's current management system still implements a block management model, and there is a lack of coordination and cooperation among the departments.There is not enough coordination between infrastructures. There is no reasonable division of labor in various modes of transportation in operation, and there is blind competition in similar sources of supply. The information resources cannot be shared, which directly leads to the complicated multimodal transport process, complicated procedures and low efficiency. As far as the railway system is concerned, a shipment of 20-foot containers, if using a freight waybill, is as many as 39. If using intermodal documents, there are as many as 44, including more than 22 transit box documents. The tax rate standard set by the taxation department does not conform to the reality of multimodal transport, artificially splitting the single rate of multimodal transport into a split rate, and the lack of multimodal transport management has caused this situation to be effectively resolved.

3.5.2. Insufficient railway capacity has become the key to restricting the development of sea-rail intermodal transport

The total rate of trains requested by trains is only about 35% per day. The number of wagons applied to the railway department every day has reached 280,000 to 290,000, but the largest loading capacity of the railway department is only about 100,000 per day. The lack of railway capacity has seriously hindered the development of sea-rail combined transport. With the continuous improvement of China's socialist market economic system, the planned management system of railway administration and the government is even more unable to meet the requirements of the rapid response of multimodal transport. Taking the continental bridge transportation as an example, the railway department stipulates that the train cannot be parked for more than 24 hours. At the same time, the Customs requires the international intermodal transport enterprise to provide the wagon number of the cargo train to declare, and the wagon number can only be obtained after the cargo is loaded onto the train. Under this circumstance, the multimodal transport operator can only get the wagon number to declare the goods after loading, but the customs clearance time usually exceeds 24 hours, and the loading wagon must be issued within the specified time, otherwise, it will be accused of smuggling. Therefore, it is difficult for us to complete the intermodal business under the normal process. It can be seen that the lack of coordination between the functional departments has caused great difficulties for the actual operation of the intermodal enterprises.

3.5.3. China's freight forwarding international intermodal capacity is limited, it is difficult to undertake international multimodal transport business

Although there are tens of thousands of freight forwarding enterprises in China, there are not enough enterprises that are capable of shouldering the responsibility of international multimodal transport operators. After the opening of China's freight industry in 1994, due to the lack of necessary qualification review mechanism, many enterprises with poor credit levels began to engage in freight forwarding business, resulting in the current mixed cargo market in China. it has formed a situation in which the Chinese market is divided, the division between sectors is fragmented, and there is a lack of competitiveness abroad. Engaged in international multimodal transport business requires enterprises to have strong strength, not only to have an international intermodal network, but also to be able to negotiate with large liner companies to ensure the provision of "door to door" services. At present, the scale of China's intermodal transport enterprises is generally small, and the mode of operation is generally to deliver the goods to a powerful international intermodal enterprise after the goods are collected. This layered agent and multiple subcontracting model will inevitably increase the information asymmetry between the principal agents, which inevitably increases the obstacles and risks in the process of multimodal transport.

Chapter4 Development of double-stack container transportation in foreign railways

4.1 Overview of the development of double-stack container in foreign railway

Railway double-stack container transportation is the product of fierce competition in the transportation market. It is a new freight product with fast transportation speed and low transportation cost. It can reduce unit transportation cost by 25%-40% while increasing transportation capacity by more than 30%. The creation of railway double-stack container transportation is a revolution in the history of container transportation. Since the advent of the railway double-stack container transportation in the United States in the late 1970s, it has been highly praised by the transportation industry. It has been widely used in the United States, Canada, and Australia, and has become an important way and direction for the development of railway container transportation. The experience of railways transportation in western countries shows that double-stack container transportation can take advantages of railways, make full use of railway capacity, reduce transportation costs, and improve transportation efficiency and make transportation enterprises competitive in market competition.

4.1.1 Development of double-stack container transportation in the US

The concept of double-stack container transportation was first proposed by Donald C. Orris, the intermodal business manager of the Denver-Grand Western Railway Company, who later served as president of the US President's Domestic Transportation Company. He proposed to transport "put a container on top of another container" on a railway vehicle to increase the vehicle's load capacity. In 1977, the South Pacific Railway Company (SP) believed that the transportation method could be applied to land-bridge transportation across the continental United States. The US vehicle manufacturer piloted a single-section double-stack box drop hole prototype car for the SP company and organized a test in a container train serves for the Sea-Land Group(SL). Subsequently, SP and SL jointly developed a five-link articulated vehicle capable of shipping 10 40GP. In 1981, 42 vehicles of this type were put into use and started to be used in railway transportation between Los Angeles and Houston. In 1984, the United States began fixed double-stack train transportation based on successful development and trials. In April, it began to transport a double-stack container train from LongBeach to Chicago every week.

In 1985, the American President Shipping Company (APL) formed the American President Inter (API) to operate double-stack train. In the same year, APL developed a 48-foot domestic standard container. APL's initial double-stack container trains consisted of 20 units with a total length of 1609m and a total of 200 40GP. From Los Angeles, Seattle to Chicago, the whole journey is about 3540km, running 53.5 hours, and the maximum speed of train running is 113km/h. In April 1993, the number of double-stack container trains from the main ports on the west coast of the United States to the eastern cities reached 241 per week. Subsequently, the north-south double-stack container train route was opened.

SL's huge economic benefits in double-stack container transportation have led the railway companies to participate in this new transportation field. They have invested in the formation of the double-stack transport team, strengthened infrastructure construction, and improved transportation network systems, which led to the rapid development of US rail double-stack container transportation.

Nowadays, the double-stack container traffic has accounted for more than 70% of the railway container traffic, which has become the main way for containers to be transported from the port to the inland. The main transport routes are New York-Chicago, Chicago-New Orleans, Chicago-Dallas 1500km, San Francisco - Chicago, Los Angeles - Chicago 3600km, Seattle - New York, San Francisco - New York, Los Angeles - New York 5000km, created a huge domestic network with the total size about 10100km.

Except for the international standard box, the 53-foot large domestic container is also transported by double-stack container train. APL introduced a 53-foot domestic container in 1988 and from the end of 1993, it used a railway line from two other railway companies to open a 53-foot large-box double-stack container train from New York to Atlanta.

TTX is a railway truck leasing company jointly owned by various railway companies in North America. It is also the main double-stack container truck provider in the market, with more than 230,000 trucks, including 116,000 double-stack container trucks. The proportion of containers in the US multimodal transport increased from 62% in 1998 to 91% in 2016. The proportion of 53-foot container transport in 48-foot and above has increased from 25% in 2001 to 79%. To adapt to market demand and improve transportation efficiency, TTX invested 930 million US dollars in propelling a 53-foot double-stack car. Within just 3 years (2010.12~2013.12), the capacity of double-stack container trains increased by 46%. During the 10 years from 2004 to 2013, TTX added 78,900 double-stack container trucks, 80% of which were for 53-foot facilities and 20% for 20-foot facilities with a total investment of $2.2 billion.

4.1.2 Development of double-stack container transportation in Canadian

In the mid-1980s, under the influence of the US double-stack container train, the Canadian National Railways Corporation (CN) and the Pacific Railway Company (CP) began to invest large amounts of money to transform the east-west double-stack container transport line and the north-south transport line. At the end of 1985, CN started using double-stack container trains in running the inland transport for the containers arrived at the Atlantic coast ports. Large container yards have been developed, and inland railway container yards in Vancouver, Montreal, Toronto and Calgary are the starting points for double-stack container trains.

4.1.3 Development of double-stack container transportation in Australian

In 1980, the Australian Railways introduced a “one-and-a-half” container transportation mode, that is, the lower half is a half-height box, and the upper level is a standard box. In 1989, the Australian National Railway used a concave flat car on the Adelaide-Whyalla route to pilot a two-story standard container stack of containers, marking the beginning of double-stack container transportation. After the double-stack container transportation is generally operating on the western railway, the total train loading amount has been increased by 20% to 30%.

The Australian Rail Track Corporation (ARTC) is responsible for 80% of east-west rail freight transportation. In 2007, ARTC invested 4.8 million US dollars in order to rebuild the main railway according to the conditions of double-stack transportation. On June 25, 2008, the reconstruction of the double-stack container transport route between Parkes and Perth was completed, with a double-stack container train of 115km/h and a maximum axle loading weight of 21 tons. Before July 2022, a double-stack container train will be opened between Parkes and Brisbane， and before July 2024, a double-stack container train will be opened between Yelarbon and Brisbane.

The double-stack container transport in Australia is mainly in the upper 2896mm (9ft6in) high container, and the lower part is designed as a concave bottom. The overall height limit is 6.5m. The north-south transportation channel can only pass through a single high container. If the 3200mm (10ft6in) ultra-high container is transported, the low-type well type vehicle must be used; the middle transport channel has the condition of the double-layer container. In the future, the line limit will reach 7.1m, which will create better conditions for the double-stack container.

In June 2015, China's export-oriented Australian double-stack container flat car was mainly used to ship 20-foot and 40-foot international standard containers. The vehicle has a load capacity of 78t, a weight of 21.9t, a shaft weight of 25t and a length of 21650mm. The loading method is shown in the table.

NO.	Method of Loading
1	Two 20GP loading on each of the upper and lower floors, with a total weight of 78 ton.
2	Two 20GP on the lower floors, and the upper deck is loaded with a 40~53GP with a total weight of 78 ton.
3	One 40GP on the lower floors, and the upper layer is loaded with a 40~53GP with a total weight of 69.6 ton.

Table 1: Loading method of export Australia's concave bottom double-stack container flat car

4.1.4 Indian double-stack transportation

With the rapid growth of the country's import and export cargo business, Indian port container shipping services are often delayed. Indian Railway Technology and Economic Services (RITES) estimates that the daily number of container trains between Mumbai and northern India will surge in the next 15 years. In September 2005, a detailed survey of container transportation services was carried out. According to the length of the meeting line and the length of the container train, the train length was limited to 45 trucks, equivalent to 180 TEU. The maximum speed of container trains is 75km/h. This made the double-stack container transport service became an important part of the Indian Railways' large-capacity freight corridor plan.

From the Gujarat Ports of Gendra, Mondara, and Pipavav to Gurgaon, the survey revealed that the infrastructure needed for the double-stack container transport needs to be rebuilt include: 20 road bridges, 31 pedestrian bridges, 1 railway bridge, 22 high-voltage transmission lines, 24 low-voltage transmission lines, 83 telegraph lines, and 66 signal towers. However, it needs to build another 7 road bridges and transform some railway bridges and the total reconstruction cost is over 650 million rupees. The height of the container allowed by the railway line is limited to 2591mm (8ft6in) which 76% of the container in India adopts this size. After the transformation, it can run 2896mm (9ft6in) high box.

To open double-stack containers before the completion of the dedicated freight corridor, the Indian Railways (IR) has opened a non-electrified line between the ports of Gujarat and the hinterland of northern India for double-stack container freight. This line is 200km shorter than the Delhi-Mumbai electrification line, saving about $40/TEU shipping. An analysis of the shipments between the ports of Pipavav and the four cargo terminals of Gneigpur, Tughlakabad, Dudley and Dhandarikalan indicated that 86% of the containers came from this four cargo terminal and 52% of them are 40ft containers. An analysis of the weight of the containers on the line shows that 93% of imported containers and 99% of export containers can be double-stacked and do not exceed the axle weight limit.

Container type	Truck height	Container height	Joint height	Safety gap	Total height
2×8.6ft	1009	5182	20	225	6436
2×9.6ft	1009	5792	20	225	7046
1×8.6ft+1×9.6ft	1009	5486	20	225	6740

Table 2: Height of double-deck transportation in Indian railway (unit: mm)

The Indian container truck has a gauge of 1676mm and is 1009mm from the floor surface of the rail. If two 2591mm (8ft6in) containers are loaded on the existing flat car or two 2896mm are mounted on the modified flat bottom car with a height of 407mm (9ft6in) container, double-layer height is 6089mm and 6199mm respectively. On this basis, if the infrastructure is not modified, it is theoretically feasible to use a flat car to load only 2,591 mm (8 ft 6 in) high containers for restrictive double-stack container transportation, but all based on static dimensions. Considering the movement within the gauge limit, a vertical clearance of 229 mm is required, so that the height of the rail to the overhead facility is increased to 6426 mm, taking into account changes in rail height (caused by ballasting and surface smoothing). Therefore, the gap height is set to be 6553 mm to 6705 mm. The Research Design and Standards Organization (RDSO) stipulates that two 91/2-foot container channels are 7300 mm high and 4360 mm wide; two 81/2-foot container channels are transported 6500 mm high and 4360 mm wide.

4.1.5 German double-layer box research

The German railway research department has studied the feasibility of double-stack train operation between the ports of Hamburg & Bremen and the inland container handling stations, focusing on two aspects, the boundary conditions of railway line and the container vehicle technology. The axle loading limit in Europe is 22.5t. If the bottom load is two 20 feet or one 40 feet (the new vehicle bottom can be loaded 48 feet), the upper floor is loaded with 40 feet and above, plus the flat car weight of 16 tons. The axle weight of the intermediate bogie will reach 47 tons. If the average weight of the container is calculated, the axle weight will reach 33 tons, and it needs to be carefully calculated before loading so that each vehicle is not overloaded.

If the axle weight is increased to 25 tons, it may be possible on certain lines and the bridge will be reinforced. However, it is such a heavy-duty line that does not provide sufficient capacity because the double-stack train cannot be based on the average weight of the container. Therefore, European double-stack container transportation can only be used for vehicles with two single-axle bogies.

The axle load is 18 tons based on the average weight of the container, and the axle weight is 25 tons based on the maximum weight. At this time, the vehicle must be designed to be a drop-type bearing between the two bodies. The result is a vehicle with a length of 19.5 m and a 40-foot container on each side. The existing container vehicle is loaded with three 20-foot containers at 20m. Therefore, within the maximum train length (750m in most European countries), the ability to increase is limited.

Double-stack transportation also requires extensive renovation of the line facilities: heightening the power line suspension; expanding the existing limit to a height of 5.8 m above the rail surface. The corresponding loading scheme is a layer of 81/2 ft (2591 mm) and a layer of 9 1/2 ft (2896 mm). If both floors are 9 1/2 ft. containers, it will be extended to 6.1 m. In addition, the line reconstruction needs to be reconstructed or demolished, and the length of the line varies from 11.5 to 117km. The investment required for the five lines that need to be retrofitted ranges from 350,000 to 1.3 million euros per kilometer, with an average of 800,000 euros per kilometer (1990 price). Considering the construction cost and the transformation of the container double-stack transportation channel of the 5,000km trunk railway in Europe, a total investment of 6 billion euros is required.

On the other hand, considering the limitation of the European axle load, the benefits obtained from the double-stack container transportation are small, and the circuit transformation will interfere with the daily traffic. Taking into account the technical and economic limitations, it is unrealistic to implement a double-stack rail transport line in Europe by modifying the existing trunk lines.

4.1.6 British double-stack research

The limitation of the British railway system is the smallest among European countries. Therefore, one of the problems with the double-stack container transport of the British Railways is the limit. The size of the limit cannot pass through the trains carrying cars and large-size containers. To load the flat car, the height of the limit is 5.83m. The line limit height designed by Central Railway is suitable for transporting double-layer "ultra-high containers". This requires the rail surface to reach a height of 6.55 m at the upper limit, including the suspended power line. Although the current container traffic and foreseeable future traffic in the UK do not require double-stack containers, it is unwise to design a rail freight line with a very small margin as in the past. The height and width of the line to be designed by central railway are shown in the figure (the limit height reaches 6.67m). The width is slightly larger than the UK's limit criteria and allows European trains to enter the British railways through the Channel Tunnel.

4.2 Summary

To sum up, the countries that operate the double-stack container transport of the railway are basically countries with vast land areas. These countries develop double-stack containers with the following favorable conditions:

(1) Railway transportation has the characteristics of large line limit and long transportation distance. The axle weight of locomotives is high. Some countries can use triplex and quadruple vehicles to effectively shorten train length.

(2) Most of the containerized goods are industrially manufactured goods, daily necessities, household appliances, etc., and are mostly loaded by pallet loading units. The gaps inside the containers are large, and the average net load of the containers is low. For the

intermediate bogies of joint vehicles, the bearing weight is 2 containers.

(3) Taking the United States as an example, the railway trunk line is drawn by diesel locomotives, and the tunnels, bridges, etc. on the line do not need to increase the height of the power line and are easy to be rebuilt.

(4) The double-stack trains are mostly originated and finally arrive at the port, which not only ensures sufficient supply but also plays a role of quick loading and unloading, which are unreachable by road transport.

4.3 US double-stack railway container technology introduction

4.3.1 Grouping method

The double-stack container trains in the United States mainly use an articulated structure that is suitable for loading light goods. The double-stack container trains generally have a length of 2 to 3 kilometers and a group of 100 to 220 vehicles. The flatbed truck group consists of a single car, a triple car or a five-car. The commonly used grouping method is 20 units per train. Each unit consists of 5 articulated concave flat cars, which are towed by 4 locomotives. The total weight of the train is nearly 10,000 tons, which realizes heavy-duty transportation of double-stack containers. The five-car unit is shown below:

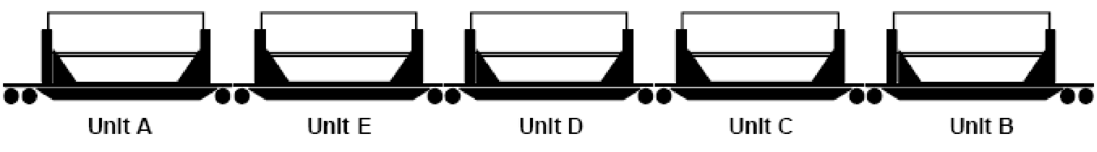

Figure 1: 5-section articulated double-stack container train unit with wall

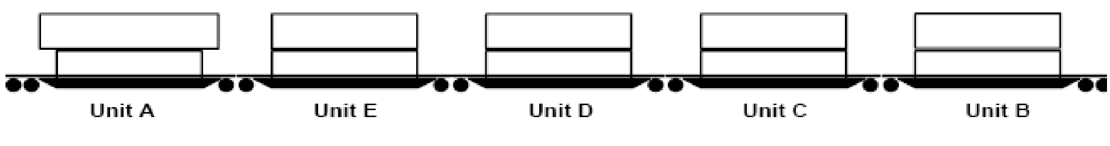

Figure 2: 5-section articulated double-stack container train unit without wall

TYPE	UP					BOTTOM				
	A	E	D	C	B	A	E	D	C	B
Bulkhead 100-Ton	2-20 1-40	2-20 1-40	2-20 1-40	2-20 1-40	2-20 1-40	1-40 1-48	1-40 1-48	1-40 1-48	1-40 1-48	1-40 1-48
IBC 125-Ton	2-20	2-20	2-20	2-20	2-20	1-40	1-40	1-40	1-40	1-40
	1-40	1-40	1-40	1-40	1-40	1-45	1-45	1-45	1-45	1-45
	1-45	1-45	1-45	1-45	1-45	1-48	1-48	1-48	1-48	1-48
	1-48	1-48	1-48	1-48	1-48	1-53	1-53	1-53	1-53	1-53

Table 3: 5-section double-stack container train loading form

4.3.2 Line Limit Requirements

Depending on the container being transported, the double-stack container transport rail line limits in height in the United States is various. Most railroads now have double-stack high containers (9 feet 6 inches) as unrestricted transport lanes. The bottom of the bottom box that is typically loaded by the vehicle after the drop is about 1 foot from the top of the rail.

Height of Double-stack Container/m	Height of Tunnel/m
5.792(2*40HQ)	6.68
5.182(2*40GP)	6.1
5.487(40HQ+40GP)	6.25
The New Built Line Limit	7.01

Table 4: Height Limit of Tunnels on Double-stack Container Channels in the United States

4.3.3 Advantages of the United States in developing railway double-stack container transportation

(1) The conditions of the US railway line are good, and the axle weight of the vehicle is up to 35.7 tons. Therefore, it is possible to shorten the length of the vehicle by using the triple-unit car or the five-unit car, and it is possible to load more containers within a certain length of the train.

(2) The US railroad trunks are drawn by diesel locomotives. The tunnels, bridges, and boundaries on the lines are relatively easy to rebuild. The double-stack container has a boundary of 6124mm, which is high enough to adapt the condition of two 2896mm high double-stack containers. Some tunnels only need to cut the top arc to fit the double container transport requirements.

(3) American railways use long locomotives to cross the road. The locomotives can be towed from the originating point to the end point, using multi-machine traction (generally

3 to 5 reconnections), and the traction weight is large. A typical double-stack container train can ship 200 to 440 40ft containers with only 2 trainmen.

(4) The weight condition is perfect. US containers are generally lighter, and the total number of containers in the station is large, which is conducive to the selection of counterweights.

Chapter 5 analysis of China's double-stack container sea-rail intermodal transport

5.1 China's container sea-rail intermodal transport situation

The development of China's container transportation began in the 1950s, it started late but developed rapidly. In 1955, the Ministry of Railways began to handle small container transportation and after several attempts, in 1973, sea international container transportation began. After the end of the '12th Five-Year Plan' period, China's railway reform has made great achievements, and it has made considerable progress in terms of infrastructure, transportation capacity, service level, and technological innovation. The railway has become an important part of the “the Silk Road Economic Belt and the 21st-Century Maritime Silk Road”(B&R). Recently, in the government’s "13th Five-Year Plan for Railways", Railway construction is designated as an infrastructure construction project that determines the level of the national economy. The '13th Five-Year Plan' specifically mentioned the need to expand the railway freight market, accelerate the speed of the railway container transportation development, develop new types of railway container transportation, promote the development of multimodal transport from the aspects of improving technical standards and optimizing information flow management, and actively explore new type of transportation methods such as double-stack containers transportation.

In addition, the “China Railway Express(CRE) Brand Construction Plan" is also being implemented continuously. CRE's infrastructure construction, the inland main source of goods, major railway hubs, important coastal ports, and evolving land ports have set up a number of hubs to strengthen supply support and transportation organization, and reduce the cost of transportation logistics. By promoting the facilitation of large customs clearance, CRE has created a logistics brand with stable, convenient, efficient and safe.

The construction of the CRE trains provides a convenient transportation channel for economic and trade exchanges between countries on the B&R. As China's trade with countries along the B&R route becomes closer and the volume of freight is increasing, an idea be proposed to apply double-stack container transportation to China-European train transportation, thereby further improving the transportation efficiency of the China-Europe class.

At present, most of the Chinese main ports' sea-rail intermodal transport has been developing rapidly and has achieved great success. The construction speed of coastal ports such as Shanghai Port, Ningbo Zhoushan Port, and Guangzhou Port has been accelerated. From 2009 to 2018, the Sea-railway transportation container throughput of Zhoushan Port has continued to grow steadily as shown in Figure 3.

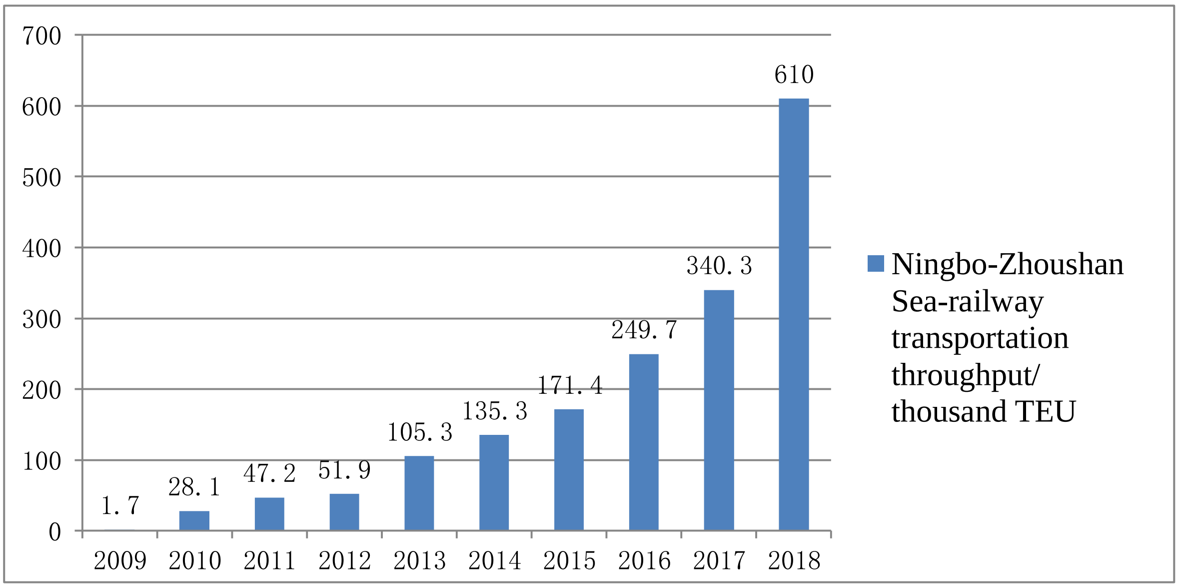

Figure 3: Histogram of sea-railway transportation throughput of Zhoushan port in Ningbo from 2009-2018

In terms of port throughput, according to the statistical report of China's ports, as shown in Figure 3: From 2009 to 2018, the container throughput of the port increased rapidly. It can be seen that the transportation demand for containers in China is increasing.

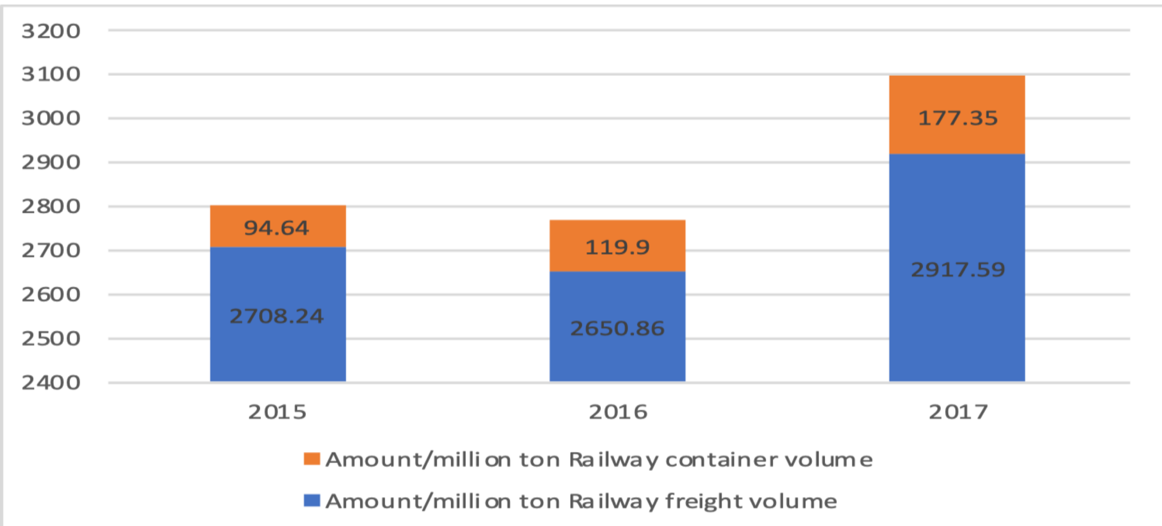

Figure 4: Bar chart of the railway freight &container volume

At the same time, as shown in Figure 4 and Table 5, the proportion of container freight volume to total freight volume is also increasing year by year. From 2015 to 2017, the proportion increased from 3.49% to 6.07%.

Year	Amount/million ton		The proportion of container volume
	Railway freight volume	Railway container volume	
2015	2708.24	94.64	3.49%
2016	2650.86	119.9	4.50%
2017	2917.59	177.35	6.07%

Table 5: The railway freight &container volume and its proportion

In terms of railway supply, in 2017, China's railway fixed assets investment reached 801 billion CNY, railway operating mileage reached 127,000 kilometers. 208 first- and second-class railway logistics bases continued to be constructed, of which 21 first-class logistics bases and 85 second-class bases had been completed. 13 of them are put into operation. The number of railway container central stations is 30% of the total volume of railway containers, which plays an important role in railway container transportation. The proportion of trucks with a load over 70 tons reaches 50% and the total container holding capacity reached 403,000, with a growth rate of 22.1%. The number of handling stations showed a rapid growth trend, with the number of railway container handling stations reaching 1,827, covered 50% of railway freight shipping stations. It can be seen from all the figures above that the Chinese government has invested heavily in the construction of container transportation infrastructure.

From the experience of port construction in China's sea-rail intermodal transport, Tianjin Port completed the construction of a circular railway network in the main port terminal, enabling the railway trains to be loaded and unloaded in the port. In addition, Tianjin Port actively builds a transit and distribution hub in the inland, and builds 25 dry ports(land port) in Beijing and some cities in Hebei, which improves the ability of source organization and the utilization efficiency of transportation resources. In addition, Tianjin Port established marketing and logistics center basing in Beijing, Jin, Anhui, Shandong and Henan. At the same time, Tianjin Port has carried out long-term cooperation with a number of major shipping companies such as COSCO and Maersk to achieve business coverage of many major ports around the world, and had built a sea-land double-side logistics network.

Yingkou Port has built the east-west and north-south transportation corridors with the port as the center, and has docked the 'Silk Road Economic Belt' (part of the B&R) and the Russian 'Eurasian Economic Union’. At the same time, Yingkou Port was transformed from the original terminal station to the transit station through the transfer mode between the Liaoning and Shenyang.

5.2 Development status of China's container and double-stack container

5.2.1 Development status of containers

China's container development is relatively late. The early container models were designed only for rail transportation. The container size is small, the load capacity is limited and the early container possession is also no large enough, which made it difficult to exert its advantages. After the 1990s, China began to develop special containers under international standards. By the end of 2017, the railway line had 326,000 railway containers, including 241,000 20ft general purposes and 27,000 40ft dry freight container. Although the number of containers has been increasing in recent years, it is still difficult to solve the problems encountered in the current cargo transportation. These problems are also faced in double-stack container transportation.

First of all, there is a shortage of container types. At present, China's railway transportation is mainly based on containers of 20 ft and 40 ft ISO standards, and it has been difficult to adapt to the diversified demand for loading and transportation of different types of goods that are currently in flux.

Secondly, the matching equipment for container loading and unloading has a low matching degree with international standards. For example, the current problem of compatibility between China's loading pallets and ISO standard containers. At present, the outer width of ISO standard containers is 2438mm, while the specifications of China's main pallets are 1200mm×1200mm, 1100×1100mm, and 1200×800mm.

5.2.2 Development of China's double-stack container railway transportation

China's double-stack container rail transport is also relatively late. In April 2004, China owned the first double-stack container train from Beijing to Shanghai (Beijing-Shanghai double-stack container train). This railway line serves to connect the two economic zones of Beijing-Tianjin-Hebei and the Yangtze River Delta. At the beginning of the operation, the double-stack container train used a flat-car container with a "concave bottom" structure, consisting of 38 dedicated flat cars, taking a 48-foot large container on the upper floor and two 20-foot standard containers on the lower floor. Compared to traditional single-layer container trains, it can increase the load quality by 30% while increasing the load of TEU by 50%. After reasonable loading and packing, the transportation cost per unit standard box can be reduced by a quarter. However, the restrictive factors of the double-stack container class at that time were quite obvious.

First of all, in the transportation organization, the low load flat car is difficult to match the planned box load. At that time, the maximum load capacity was 78t, and the entire car could carry 67t, which was far from meeting the planned load. In addition, due to the high center of gravity of the vehicle, the difficulty of loading is further increased: the double-container flatcar has a center of gravity of 2.2 meters, but it needs to be strictly loaded to prevent the film from being high while controlling the center of gravity. The main transportation goods of the Beijing-Shanghai line are mineral building materials, raw materials for the production of chemicals, and consumer goods such as food and tobacco products.

Secondly, due to the infrastructure construction and technical conditions at that time, coupled with the lack of a complete double-stack container transportation network and corresponding supporting information system, it is impossible to realize real-time management and tracing of container transportation. The actual operational results have not reached the theoretical level. At the expected level, transportation was once frustrated. Later, affected by the economic crisis in 2008, domestic trade transportation was seriously affected. The trains that were scheduled to be scheduled at the same time could not complete the transportation plan on time. Many sources of supply are borne by relatively efficient road transport. Later, in order to solve the problem of transportation organization and improve the efficiency of freight organization, the operation contractor began to increase gradually from the original one. Some freight forwarders and cargo owners began to become contractors, which greatly expanded the stable supply.

In 2006, China's second double-stack container rail transport train (Zhengzhou to Qingdao) was also put into operation. This transport train station means that China has the first sea-rail intermodal transport double-stack container transport class that can be quickly exported. Column. At the beginning of the shift, the single-layer transportation was adopted. Because of its regular fixed-point route, it was favored by the supply of Zhengzhou and quickly achieved some economic benefits. In 2006, the container traffic volume of Zhengzhou to the railway increased by 69.2%, and in 2007 it increased by 50.5%. In terms of box type, the ratio of 40-foot containers to 20-foot containers from 2005 to 2007 was a declining trend from 29.9% in 2005 to 20.7% in 2006 and 16.1% in 2007. As shown in Figure 5:

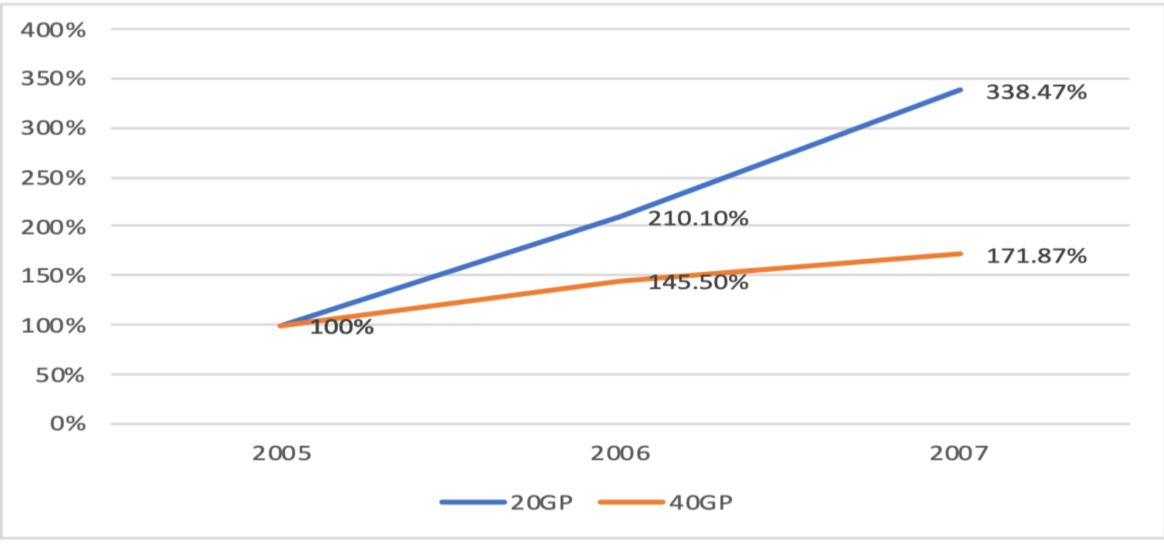

Figure 5: The growth rate of the 20GP & 40GP

In addition, in the formulation of its freight rate, the operating cost is composed of freight added to the station operating fee. Compared with road transportation, the advantage of railway transportation is not obvious, because the price of returning goods for automobile transportation is much lower than the price of iron transportation. Add the following figure four comparison:

It can be seen that in the container transportation process from Zhengzhou to Qingdao, the 20-foot container still has certain advantages, but the price advantage of the open road compared to the automobile road transportation is lost. It is even more difficult to compare the price of a 40-foot box. Moreover, the timeliness flexibility of roads tends to be better than that of rail transport. As a result, railways are difficult to compete with road transport.

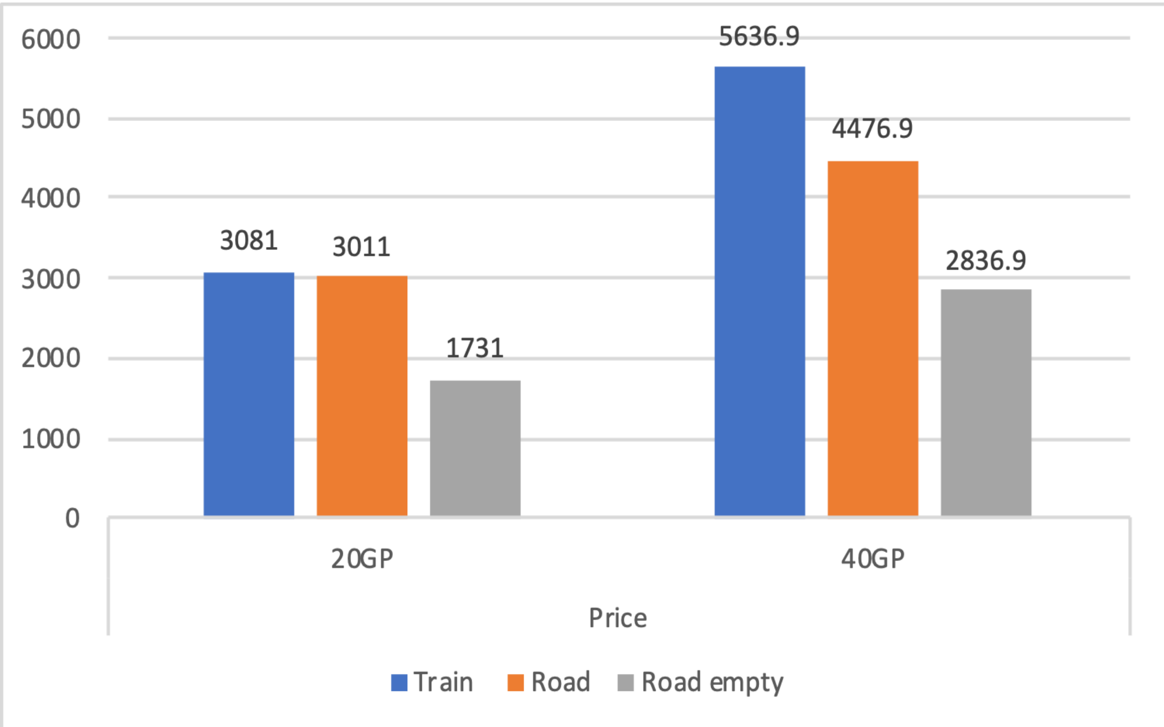

Figure 6: Price of different method of transportation for 20GP & 40GP

This view is similar to the problems encountered in the Beijing-Shanghai double-stack container transport class. The problem of the supply structure, freight rate, and container volume management failed to fully exploit the advantages of the double-stack container. These problems are also a huge obstacle to double-stack container transportation.

5.2.3 Technical level of equipment construction equipment for double-stack container transportation

The development of railway container transportation is inseparable from the construction of corresponding supporting technical equipment infrastructure. This includes handling equipment, transportation carriers, yard construction, information management, number of containers, and line networks. These hardware conditions are directly related to the development of railway container trains.

The existing container handling stations in China are mainly built based on the original general freight yards. The technical level is relatively backward and the equipment is relatively insufficient. The lack of professional handling equipment reduces handling efficiency and is often prone to damage. Many of the gantry cranes in the container handling station are still old products of the 1980s and 1990s, and it is difficult to meet the modern loading and unloading requirements.

In addition, in the construction of double-stack container transportation passages, according to the “Administrative Measures for Railway Double-stack Container Transportation”, the construction boundary of the double-stack container transportation passage must meet the minimum height requirement in the “Technical Regulations for Railway Technology”. This brings huge cost pressure to the promotion of double-stack containers. In order to operate a double-stack container train, it is necessary to expand the actual limit of the existing line. And the current expansion is only the lowest cost of two 20-foot containers in the lower 40-foot container, which is the most important form of stacked transport.

China's current use is mainly X2K-type flat cars and X2H-type flat cars to complete the double-stack container loading and transportation tasks. To ensure the safe transportation of these two flat cars, the overall center of gravity of the container cargo should not exceed 2400 mm. There is also a hard requirement for the weight of the loaded goods. Due to the limitation of the weight of the existing model and the limitation of the center of gravity, the choice of the type of the loaded cargo will have great limitations. In order to avoid the center of gravity being too high, in the actual transportation process, the type of cargo loaded in the upper container is limited, and the container of the upper container loaded with heavy goods cannot be fully utilized.

5.2.4 Resistance of China's double-stack container transportation development

(1) Double-stack container trains are slow and cannot complete door-to-door transportation which is not faster or more flexible than road transportations.

(2) Double-stack container trains are often delayed. In the case of seriousness, two or three days later happened and it will cause a demurrage fee. This has seriously affected the quality of double-stack container trains.

(3) The volume of transportation is not balanced. The types of goods transported between the two stations are very different. Many goods are not suitable for transportation by containers which makes the waste of the capacity of the containers.

(4) The double-stack container handling stations are backward with limited space for storage. The stations do not have the capacity to loading and unloading the entire trucks, resulting in low container loading and unloading efficiency and low transportation efficiency, which increases the overall transportation time.

(5) The interconnection information management system for double-stack container transportation has not been established yet, and the related information transmission is inconvenient which makes the container cannot be effectively monitory.

(6) The current double-stack container transportation routes are very little and the complete double-stack container railway transportation network has not been funded.

Chapter 6 analysis of Ningbo Zhoushan Port double-stack container transportation

On December 18, 2018, the domestic first-class container sea-rail combined transport double-deck container transport line was dispatched from Beilun Port Station of Ningbo Zhoushan Port to Shaoxing Station.

The following article uses the SWOT-PEST analysis method to analyze the newly-opened double-deck container sea-rail intermodal trains in China.

Figure 7: Picture of the Ningbo-Shaoxing double-stack container train

6.1 SWOT-PEST analysis of Ningbo Zhoushan Port to Shaoxing double-stack container sea-rail intermodal transport class

6.1.1 S-PEST Advantages of Ningbo Zhoushan Port to Shaoxing double-stack container sea-rail intermodal transport train

(1) Geographical advantage

The Ningbo Zhoushan-Shaoxing double-stack container sea-rail intermodal train is currently operating on the original Xiaoshan-Ningbo Railway and Beilun Line. Started from Zhoushan Beilun Port in the east to the Gaobu station in the west.

The station is located in the middle of Xiaoshan-Ningbo Railway, connecting to the south and southwest, north, northeast and central China through the Zhejiang-Jiangxi railway, Shanghai-Nanjing Railway and the Shangqiu-Hangzhou Railway. The advantage of the transportation hub is becoming more and more obvious. Ningbo North Railway Station is one of the most advanced railway freight yards in China and is also an important cargo distribution hub which serves as a link between the mainland and Ningbo Port. It can quickly reach Ningbo Lishe International Airport through highways which makes it achieve the connection of the three modes of transportation.

(2) Advantages of port resources

Beilun Station in the east end is directly connected to Zhoushan Port which is one of the few ports that can serve ships of 10,000-ton or above, and it is one of the ports with the largest cargo throughput in the world. From 2009 to 2018, the container throughput of Zhoushan Port has continued to grow steadily as shown in Figure 6. Providing a rich source of supply for inland double-stack container transportation.

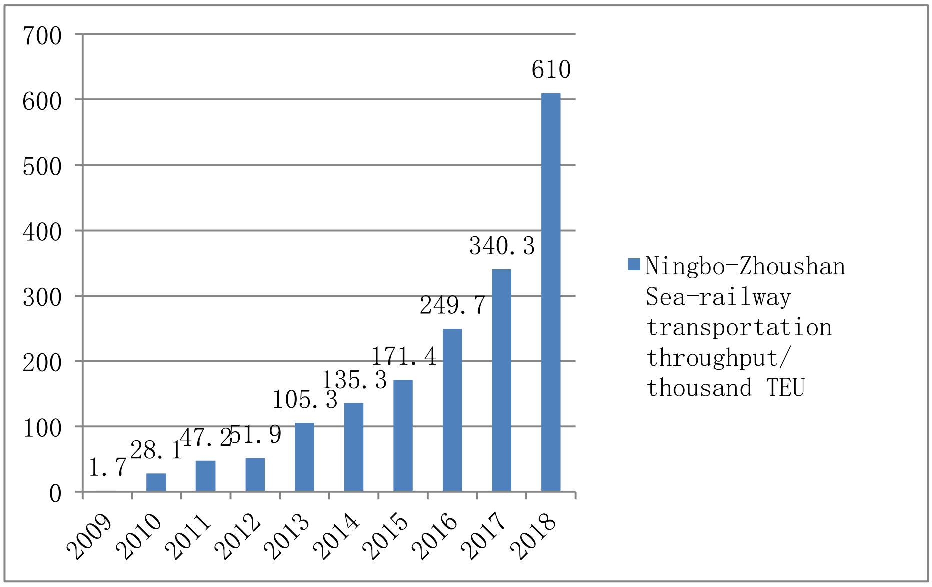

Figure 8: Histogram of container cargo throughput of Zhoushan port in Ningbo from 2009-2018

(3) Government policy support

Ningbo Zhoushan Port has been at the forefront of China's sea-rail intermodal transport, playing a model for the development of China's sea-rail intermodal transport. The Ningbo government has always provided subsidy support for its development. The construction of the double-stack container transportation channel is the result of the consultation between Ningbo Zhoushan Port and the Shanghai Railway Bureau and the local government.

6.1.2 W-PEST disadvantages of Ningbo Zhoushan Port to Shaoxing double-stack container sea-rail intermodal train

(1) Freight rate mechanism

The freight rate of railway containers needs to be adjusted. Since 2012, China has raised the price of container railway transportation for several times which has brought more difficulties to the relevant transportation enterprises in bargaining. This series of raise in price is not conducive to the completion of the signing of long-term contracts, affecting the maintenance of stable traffic on the line, and further weakening the advantages of railway transportation. In addition, the double-stack container will take more time during the loading and unloading process, greatly extending its overall transportation time, which may result in a further increase in costs beyond the free-use period.

(2) A single type of problem

At present, the main container type of Ningbo Zhoushan Port to Shaoxing is 40ft GP and 20ft GP. The single type of container results in the fact that while facing the increasing number of goods with various loading requirements, the two types of containers are obviously not fully satisfied, thus would lose more freight.

(3) Information network construction issues

At present, China's container sea-rail intermodal Internet of Things is still under construction, and information on container transportation cannot be smoothly exchanged and shared among various departments in each part of the transportation chain. The lack of information greatly hinders the quality of its services and the efficiency of transportation.

(4) China's double-stack container transportation network has not yet formed

There are still relatively few traffic lines for double-stack container transportation in China. In the process of transshipment of double-stack containers and ordinary single-story containers, station exchanges are also required, which reduces the overall transportation effect. The transportation of the double-stack container will alleviate the transportation pressure of the current line, but it will bring about the problem of tight transportation capacity for the ordinary container railway transportation line that is connected.

(5) The distance between Ningbo Zhoushan Port and Shaoxing double-stack container sea-rail intermodal transport is short, and the competition with road transport is serious because the price advantage is not obvious enough.

6.1.3 O-PEST Ningbo Zhoushan Port to Shaoxing double-stack container sea-rail intermodal transport development opportunities

(1) The national strategy.

The double-stack container can save energy and reduce emissions, promote environmental protection, and meet the requirements of the current national "Railway 13th Five-Year Plan" to develop a green and low-carbon economy. In addition, the China government is currently building the B&R, which the construction of the China-Europe Railway provides policy support for joint transportation at sea and on land. The successful and efficient operation of the double-stack container will be gradually promoted in the future, and the transformation and docking of other suitable railway routes in China will be carried out. In addition, the railway 13th Five-Year Plan will take the railway freight train network construction as an important task, and will actively guide the sea-rail intermodal transport and other forms of multimodal transport. At the same time, it will actively explore transportation methods such as double-stack container transport and humpback transport.

(2) Double-stack container transportation lines are also being gradually promoted.

At present, the construction of new double-stack container roads in China is accelerating. After the smooth operation and promotion of the current double-stack container and transportation trains, the networked double-stack container transportation system is just around the corner.

(3) The construction of an intelligent and modern railway container transportation information management system has been put into the railway “13th Five-Year Plan”. In the future, the BeiDou Navigation Satellite System(BDS) will be promoted in the railway transportation field. After the platform is built, it will realize the interconnection and interconnection of various departments and system information, and realize the intelligent management of traffic operations, dispatch management, transportation planning and other services.

6.1.4 T-PEST Ningbo Zhoushan Port to Shaoxing double-stack container sea-rail intermodal transport development threat

(1) The competition from Shanghai Port has intensified, and the Beijing-Shanghai double-stack container railway in the same direction has a shorter distance.

(2) Competition from other modes of transportation has increased. Ningbo Port is located at the mouth of the Yangtze River and can reach to the ocean from both north to south direction which affects sea-rail intermodal transport. In addition, the opening of the Ningbo oil pipeline has also caused a small impact on its railway transportation sector. According to the above aspects, the following SWOT-PEST analysis matrix is listed:

SWOT-PEST	Politics	Economy	Society	Technology

Internal Factors	Strengths	Supported by national policies, the Railway 13th Five-Year Plan incorporates two-tier container transportation into important strategic planning. The CEIBS of the “Belt and Road” provides a good platform for double-stack container transportation.	1. The cargo throughput of Ningbo Port has increased year by year in recent years. This provides an adequate source of supply for two-tier container transport. 2. Double-stack container transportation can save energy, reduce emissions and reduce transportation costs, which can meet the requirements of green economy development.	1. The geographical position is superior, and the distribution hubs of multiple stations along the line are getting stronger and stronger. 2. There are many stations along with the main transportation mode, which is conducive to the development of multimodal transport.	The level of the manufacturing industry in China is constantly improving, which provides a strong guarantee for the innovation of container manufacturing and the optimization and improvement of double-stack container transport flat cars.

	Weaknesses	1. Compared with foreign countries, relevant management level and institutional system in China are still insufficient and not easy enough. 2. The degree of standardization in transportation management is insufficient.	Due to the long construction period of the double-stack container transportation channel, the transformation cost of the channel construction in some areas is relatively high.	There are fewer routes that have been opened, and the distance is short, which is difficult to achieve in the near future. Due to the short distance, the actual transportation effect is greatly reduced.	1. The current technical level in China is still relatively backward, the equipment is relatively old and the supporting facilities are not perfect. 2. Logistics management information technology is still in the process of research and development, so cargo container information is still difficult to communicate in various departments.

Externa l Factors	Opportun ities	With the promotion of "the Belt and Road" Initiative in the international arena, all countries have a positive attitude towards China's friendly opening up, so in the future, more supply will be provided for double-stack container transportation in the international logistics.	Double-stack container transportation can achieve energy saving and emission reduction, and at the same time reduce costs and gain competitive advantage.	The enthusiasm for the investment in double-stack container transportation has increased year by year and the railway section connecting with the double-stack container transportation channel has also been constructed.	At present, it is closely related to foreign exchanges, so it is technically possible to introduce advanced solutions from foreign countries.
	Threats	At present, the international situation is still unstable and trade disputes are continuing to escalate, which will have a great impact on trade and transport.	Due to the inflexibility of the transportation route, the timeliness is poor. Comparing with road transportation, the advantage is not obvious.	The throughput of containers in Ningbo Port will be subject to competition from Shanghai Port.	Research funding for containers is currently limited.

6.2 Suggestion

Ningbo Zhoushan Port to Shaoxing Double-stack Container Sea-rail Intermodal Train Development Strategy For the above advantages and disadvantages and based on threat analysis, I have developed the following strategies:

	Strengths	Weaknesses
Opportunities	Growth strategy: 1. Make good use of the current national planning and policy advantages in the exploration of sea-rail intermodal transport and double-stack container transportation, and take advantage of the “ the Belt and Road ” Initiative to actively expand the market. 2. Accelerate the construction of double-stack container railway facilities and accelerate the construction of the passage along the connecting railways to gradually promote the opening. At the same time, it will accumulate the experience and lessons of the current railways and provide a reference for double-stack container railway transportation in other regions.	Tort type strategy: 1. Actively respond to the “13th Five-Year Plan for Railways” and increase the research and development of railway freight information systems. 2. Strive to further reduce costs through double-stack container transportation, thus creating more room for the price reduction. 3. Actively develop special containers suitable for railway transportation to meet the transportation needs of more types of goods.

Treats	Business strategy: 1. Make full use of the geographical advantages, the excellent conditions of deepwater Port to have cooperation with Shanghai Port to actively develop the double-stack container transportation route of Zhejiang-Jiangxi Railway. 2. Consolidate and ban small and dense container handling stations. Extend the double-stack container transportation channel as much as possible to extend the transportation distance and enhance the competitive advantage.	Defensive strategy: 1. Avoid competition with the advantages of other ports in the hinterland. 2. Stabilize the current time of sea-rail intermodal transportation of bulk cargo and try to win the market hinterland.

Chapter 7 Summary

By comparing the development status of international and China's double-deck container sea-rail combined transport and the development status of the newly-opened double-deck container sea-rail combined transport train, the following suggestions are proposed for the development of China's double-deck container sea-rail combined transport:

(1) Further speed up the construction of double-deck container trains, extend the operation length of double-deck container trains, further enhance the competitive advantage of long-distance transportation on land, and form a complete double-deck container train operation network at an early date to reduce the reloading of different trains. time.

(3) Accelerate the layout management of container handling stations, reduce the size of the station, and distribute the intensive processing stations, and merge the lines and stations of the double-deck container handling station. Innovate the old low-efficiency equipment, expand the capacity of the entire line of loading and unloading vehicles, reduce the loading and unloading time and reduce the overall transportation time, thus increasing the class rate.

(4) On the basis of reducing the cost and ensuring the quality of transportation, stabilize and moderately reduce the freight rate and attract the supply. Long-term planning should be carried out on the route planning to avoid excess capacity caused by the same route.

(5) Actively respond to the "13th Five-Year Plan for Railways" and increase the research and development of railway freight information systems. Establish a complete container transportation management information system as soon as possible, realize the interconnection and interoperability of various departments of various systems as soon as possible, improve work efficiency and strengthen real-time supervision of the container transportation process.

At this stage, the level of container transportation in China and China is far different from that in countries with developed container transportation, whether in the management system, transportation network construction, equipment technology, or information management system construction. But this also means that China's container sea-rail combined transport has a lot of room for development and development potential. At present, China is paying more and more attention to the development of sea-rail combined transport and double-deck containers. Considering the policy environment, like the "One Belt, One Road" strategy, the opening of the China-European class will provide more sources of supply for the double-deck container sea-rail combined transport. In addition, the country's overall comprehensive national strength is enhanced, the manufacturing capacity level is continuously improved, and more advanced container transportation carriers, loading and unloading equipment will soon be gradually installed in various collection and distribution hubs. It is foreseeable that double-deck container transportation will be promoted in China and China. It will add to the modernization of China's transportation level.

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