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The study on the vessel size of container transport in the Yangtze River

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The Study on the Vessel Size of Container Transport in the Yangtze River

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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 material is 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.

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ABSTRACT

Title of Dissertation: **The Study on the Vessel Size of Container Transport in the Yangtze River**

Degree: **Master of Science in International Transport and Logistics**

With technological progress, economical globalization, and the development of electronic commerce, China's container shipping industry developed rapidly. As the demand of foreign trade and internal trade grew at a high speed, the container transportation in Yangtze River starting quite recently but is full of vitality. The container throughput has a fast development in recent years. Along with this developed tendency, the vessel size and the infrastructure condition are facing the challenges. It needs to optimize the vessel size to display the economical development. Therefore analysis of the vessel size is extremely important. It is generally agreed that, the large scale ships is possibly a good choice. The main goal of this dissertation is to analyze the factor which influenced the vessel size including tendency of the cargoes volume and the infrastructure conditions, and obtain the optimal container vessel size in the Yangtze River.

Through the analysis of the cargo volume tendency, the restrictive condition including ports and navigation, the conclusion is that regarding the container transport in the Yangtze River, the container cargoes will grow continuously; the decision about optimal size depends on the shipping market situation.

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1. INTRODUCTION

1.1 Research Background

With technological progress, economical globalization, and the development of electronic commerce, China's container shipping industry developed rapidly. As the demand of foreign trade and internal trade grew at a high speed, the container transportation in Yangtze River starting quite recently but is full of vitality. The Yangtze River containers transportation network architectures gradually coming into being. The economy of the reaches of Yangtze River grew at a very rapid rate, and Yangtze Delta economic circle which centers on Shanghai, Nanjing, Wuhan, Chongqing appeared. This attracted lots of notable multinational investments, and took the business opportunities to the containers transportation industry in Yangtze River.

The volume of Cargo transported by the Yangtze River grows continually. During the 10th Five-year-plan, the cargo volume of 13 cities in the Yangtze River reaches climbed year by year, the annual increase of that is more than 10 percent. In 2005, cargo volume transported by the Yangtze River skeleton-line achieved 795,000,000 tons, was 1.65 times of that in 2000. The proportion that water transportation in the basin synthesis transportation system rises, the freight transportation volume of the circular flow has accounted for about 30 percent of the transportation total quantity. Major ports in the Yangtze River handled 0.65 billion tons of cargo, up to 2.9 times of that in 2000, and the annual increase was 23.5 percent. They handled 78,000,000 tons of merchandise for foreign trade, up to 2.7 times of that in 2000, and annual increase was 22 percent. The container throughput of major ports was 2,600,000 tons,

up to 3.8 times of that in 2000, and the annual increase was 30.4 percent.

Uncoordinated with the fast development container throughput, There are few standardized container ships in the Yangtze River. In the Yangtze River container ships, the container ships which are transformed by the bulk freighter still hold the perspective. The age of the ships get older, the performance is bad, the speed is slow, the box position is few, technical level is relatively backward. The vessel form does not adapt obviously. It is difficult to realize its docking with the increased cargoes,

Next, From the ports aspect, except Nanjing, Wuhan, Chongqing these ports are relatively big ports, in the other Yangtze River ports specially the ports in the middle and upper reaches, the standard container berth infrastructure construction is bad, the specialized wharf are few, technical equipment relatively backward, the loading and unloading efficiency is low, partial ports container handling capacity is insufficient, which lead the ships to stop in the harbor. In upstream harbors, influenced by the hydrology condition, there are many links in the container loading and unloading technical process, and the cost is high.

Finally, The infrastructure condition is bad, at present, upstream Yangtze River above Chongqing the majority of navigation are at the natural state basically, which limited the Yangtze River container transportation extend upwardly; Navigation of middle reaches is not improved systematically, the ability resisting the change of hydrology condition is poor. In dry season the ships must reduce the load to navigate.

After studying above background information, the author realized that along with this developed tendency, the vessel size and the infrastructure condition are facing the challenges. What extend the scale-developing trend of container ships reach to in Yangtze River? It needs to optimize the vessel size to display the economical

development. Therefore analysis of the vessel size is extremely important. It is generally agreed that, the large scale ships is possibly a good choice. Therefore, this study takes the situation of cargo flows tendency and the infrastructures condition into account and construct model to analyze the cargo tendency and determine the optimal container vessel size in the Yangtze River.

1.2 Research Purpose and Methodology

Previous studies on the container transportation in the Yangtze River were focused largely on policies and marketing analysis. These studies indicate the volume of Cargo transported by the Yangtze River grows continually. They use the liner previous data of container throughput to predict the developed tendency of container throughput in the future years. In previous years, the throughput's change approximates to a straight line. Therefore, many studies directly take the linear regression model to predict the container cargo volume. This calculated method has more error. Different from previous studies, the study considers that the dada of recent years, and observed the change of the throughput in recent years is close to the non-linear regression model.

The study also considers that there are certain relationships among the cargo flow, the vessel size, and the condition of shipping infrastructures. After predicting the cargo flow tendency, the vessel size also needs to be optimized. Considered the positive and negative factors which influence the Large-scale tendency of vessels, the optimized vessel size will be obtained.

1.3 The Logical Link and Skeleton of Thesis

Chapter 1 gives a brief introduction of the research background, study purpose and

research methodology as well as the logical link of each chapter.

Chapter 2 is literature review, which the author intends to bring up his appreciation to those experts who are well-known in the research on container transportation in the Yangtze River and briefly introduce their accomplishment to assist the thesis.

Chapter 3 detailed introduces the situation of container transportation in the Yangtze River and analyzes the tendency of cargo flow in the Yangtze River. In this part a tendency extrapolation model is set up for predicting the developed tendency of container cargo volume.

The author in Chapter 4 would like to analyze the large-scale tendency of vessel in the Yangtze River. After introducing the major underlying forces of large-scale tendency, a optimal subjective model is set up for cost function and finally obtains the final ship size decision.

Chapter 5 introduces the situation of navigation and major ports in the Yangtze River, and the problems in development and restrictive conditions of the large-scale tendency of container vessel.

Chapter 6 makes some suggestions and a final conclusion of the thesis.

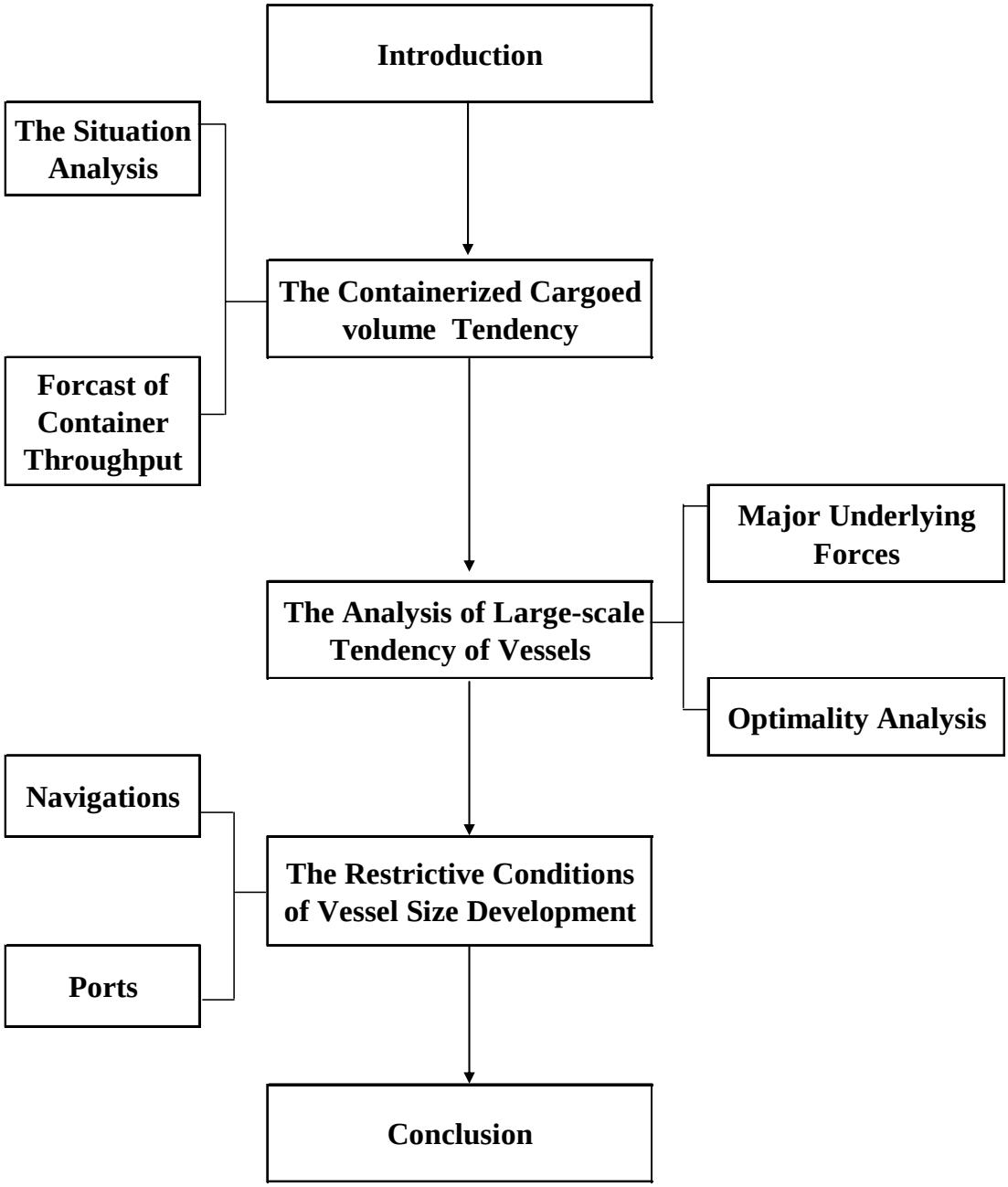

Figure 1.1 Structure of the Dissertation

2. Literature Review

2.1 Literature Review

Cai Zhengrong(2003), analyzed the ports, container shipping companies in the Yangtze River, and situation of containers volume completion. He described that Yangtze containers transportation was at the stage of self-development, the degree of specialization was not high enough, and the handling capacity of ports could not catch up with the increase of cargo volume. He mentioned the development prospect of Yangtze River is cheerful and the demand of the container transportation in the Yangtze River will continue to grow.

Zhang Yanli(2004), described that the bottlenecks of containers transportation in the Yangtze River located the hub ports in upper reaches. The roots of bottlenecks were: the high through capacity and low unit cost of Yangtze container transportation attracted a large number of cargoes, but the adjustment of ports could not keep pace with the changes of cargoes and the development of ship form.

Chen Ning, Hu Liangde, Jiang Peng,(2005) analyzed the containerized routes, cargo flows and its tendency of Yangtze River, then illustrated the condition of competition in the Yangtze river.

Gu Chang xin,(2004) analyzed the development of container transport in the Yangtze River, using the container throughput data of 1990-2003 and linear regression model to forecast the cargo flow tendency, and indicated the existing problems in the container shipping in the Yangtze river.

2.2 Forecasts the Method and the Basis

The throughput is one kind of time series forecast, it refers that arranged the object according to the time in order, constitutes a time series. According to the rule of this group of time series' past change, inference next change possibility and change tendency, change rule. The basis of time series forecast method is: In certain time, the law of development continuous nature will often cause the future change to assume very strong trendy, therefore it might extrapolate its future according to the thing historical change situation the trend. In the time series forecast process, generally speaking, the historical data's influence which develops regarding the future is not equal, influence of data to future value declines by near and far. Our country's container industry already continuously maintains high speed growth for many years. In the complex situation that the present international economy growth postpones, the macroeconomic regulation and control strengthened, and the foreign trade rate rise recedes, it is difficult to accurately judge growth prospect container throughput in the Yangtze River in 2006-2010. Therefore, according to the investigation and study, the article will use the tendency extrapolation regression model and the foreign trade container production quantity connection analysis method to carry on the forecast of the Yangtze River container throughput.

The third chapter seeks the inherent laws from Yangtze River skeleton line containers throughput in its own development, carries on the forecast using the tendency extrapolation model, and carries on the examination and the revision to the forecast value according to the relations between port throughput and the container production quantity. The tendency extrapolated method, refers that using the Yangtze River container throughput development gradation, establishes the throughput along with the time variation tendency model. Strictly speaking, the relation between the economical variables are non-linear, when the non-linear degree is low, may use the linear regression model to obtain a more satisfactory result; When the non-linear

degree is high, it must use the non-linear regression model. The tendency extrapolated method forecasting the container throughput is suitable for the short-term forecast. The concrete model is as follows:

The linear regression model：$y(T)=a + bT$

The non-linear regression model：$y(T)= aexp(bT)$

In the formula: T is the year sequence (Table); Y is container throughput.

Table 2.1- The value of 'T" in the tendency extrapolation regression model

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
T	1	2	3	4	5	6	7	8	9	10

For the linear regression model, the value of "a" and "b" is calculated by the formula:

$$b=\frac{\sum_{i=1}^{n} T_i y_i - n\overline{T}\,\overline{y}}{\sum_{i=1}^{n} T^2{}_i - n(\overline{T})^2}$$

$$a=\overline{y} - b\overline{T}$$

For the non-linear regression model：$y(T)= aexp(bT)$, it should change this non-linear form in to the linear regression model.

For y(T)= aexp(bT)

Let y'= lny, a'=e^a

$y' = a' + bT$

According to the calculated method of the linear regression model, we calculate the value of "a'" and "b", the predicted regression model is obtained.

Then, take "T" into the predicted regression model, the predicted value can be obtained.

3. STUDY ON THE TENDENCY OF CARGOES FLOW

3.1 Situation Analysis

3.1.1 Economic environment analysis

Yangtze valley economical belt includes Jiangsu, Anhui, Jiangxi, Hubei, Hunan, Chongqing, Sichuan. The total area is 1,440,000 square kilometers, occupies the approximately 14.5 percent of nation land area, the population accounts for the 33.5 percent of national population. The Yangtze valley economical belt is our country most important and high density economical area. In 2006, its GDP occupied 33.42 percent of that of nation.

The superiorities of the Yangtze valley economy development are:

1. The Yangtze valley is one of the most economy-developed areas in China. The farming, forestry and fishery occupy the dominant position in the national economy.

2. The Yangtze valley is the area where the transportation is most advanced in China. Its routes which opened to navigation occupy the head of the national rivers. There are several railroad skeleton lines cut the Yangtze River, such as the Beijing-Shanghai railroad, the Beijing-Guangzhou railroad, the Beijing-Jiujiang railroad. In addition, the expressway system and the aviation network are advanced, and the transportation extends in all directions.

3. The Yangtze valley is the biggest urban and rural markets in our country. From the metal industrial base Panzhihua in western to East China Sea international metropolis Shanghai, Yangtze River just like “a silver wire to put on the pearl”. Not only are there cities like Shanghai, Chongqing where the population is above 10million, ,but

also there are dozens of places where are big or media-sized cities like Wuhan, Nanjing, Hefei. It has formed the biggest urban and rural markets network.

4. The Yangtze valley is the area where the economic potential is biggest in our country. The natural condition of subtropics and the temperate zone enable the agriculture in the Yangtze valley to have very big potential and the energy and the minerals to be rich. The water resources of the Yangtze River occupy 40 percent of that in the nation, 130 kinds of minerals are proving in China, and the Yangtze valley has 110 kinds. The phosphorus ore is nearly all in the Yangtze valley. The titanium, the vanadium, the mercury, and the copper accounts for above 50 percent of that in the nation.

5. The high technology and new technology industry developed rapidly. The high technology and new technology industry of Suzhou area, Nanjing, Wuhan, Chongqing city grow fast. In aspects of information engineering, bio-engineering, new material, environmental protection, integration of machinery, it forms the emerging industrial superiority, which has led readjustment of the economic structure. The Yangtze valley is becoming the most active high technology and new technology industry developed belt in China.

6. The Yangtze valley has the intelligence resources and the technological resource which cannot be underestimated. These people have high the education level. The quality of labor force is high and there are the multitudinous well-known institutes of higher education. The technology basis is solid. The modern management and operation experience is rich.

7. The political and economic situation of our country is stable at present, and the peaceful international politics environment also gives the good external condition to

the economical development of China. Joined WTO since 2001 year's end, our country's foreign economy development was faster, especially the Yangtze River delta area's economy fast developed. At present it already has surpasses the Zhujiang Delta. 2008 Beijing Olympic Games as well as in Shanghai World Expo are going to be hold. This also will bring the new power the economical development of our country. At the same time, western development and the Three Gorges Project construction, also promoted the economical development of the upstream area in the Yangtze River. In addition, the Yangtze valley has the rich natural resource, the technological resource and the management resources, therefore the Yangtze valley economy development will continue to develop fast.

3.1.2 The Superiorities of the Waterway Transportation Compared to Other Transported Modes in the Yangtze River.

The Yangtze River waterway containerized transportation competes with other transport modes including waterway bulk cargo transportation, the railway transportation and the highway transportation.

1. Waterway bulk cargo transportation

Before the container transportation entered the Yangtze River waterway market, the cargoes in the Yangtze valley mainly is delivered through the waterway bulk cargo transportation. It mainly uses the tugboat to tow the barge for carrying on the transportation. The superiority is that the freight volume is big, the transportation charges is low. It is suitable for transporting the batch big cargo specially, for instance the ore, the coal, etc. The inferiority lies in the long transportation time, damage to goods in the loading and unloading process and the transportation process quite is serious, similarly also is affected by the weather, for instance fog, the gale as

well as the navigation influence. After the containerized traffic entered the Yangtze valley, many suitable cargos changed to be transported by the containerized traffic.

2. Railway Transportation

The merits of the railway transportation is the high speed, big freight volume, continuous, being less influenced by the natural condition, guaranteeing the whole year moves, being able to transport each kind of cargo nearly. Its transportation security is high, and the accuracy of the cargoes' sending and reaching is good. The expense is higher than the waterway, but is lower than the highway transportation, generally only is as 1/5 as that of the highway transportation.The railway transportation's profitable haul is less than 500 kilometers, mainly undertakes the service of medium-distance and big-freight-volume transportation.

3. The highway transportation

The characteristic of the highway transportation is flexible. The cargo loss is few, and the speed is quick. It is able to penetrate the industrial and mining enterprises, and suits to display door-to-door transportation. Compared with the waterway, the railway transportation, its transport capacity is small, the transportation cost is high, the profitable haul in 300 kilometers, is not suitable for the long-distance transport and delivering large amount cargo. Besides the first-class highway, other state of roads is bad, and the bridge load was generally low, limiting the container vehicles passing through. In addition, as a result of the place protection, the majority highway networks is artificially divided, the transportation cost is high. The main source of goods of the highway transportation is some high value product and some to the time intensive product, also is precisely the goods which the Yangtze River waterway containerized transportation will vigorously plant in next stage. In the Yangtze River

delta area, mainly is between the Nanjing/Shanghai, because the transportation is developed, consigned for shipment the container through the container truck still occupies many market share, but the highway transportation mainly is the assistance service for the waterway, the railway transportation, to realize the door-to-door transportation.

4. The Yangtze River waterway container transportation

The superiority of the Yangtze River waterway container transportation mainly lies in its high loading and unloading efficiency, high quality of the freight transportation, low expense of cartage and packing as well as convenience of organizing many kinds of transport modes to realize the door-to-door transportation. But it easily affected by the weather such the fog, the gale as well as the navigation condition. Because it uses the self-propeller ship of which speed is quick, the transportation time is shorter than that of the bulk transportation in the Yangtze River waterway. But compared with the railroad and the highway transportation, the time is long. Simultaneously the personnel quality, management level and grade of service are relative high, the traffic security is guaranteed.

According to above analysis, it may promote the competition situation matrix (Table 3.1) of the waterway bulk transportation, the waterway container transportation, the railway transportation and the highway transportation in the Yangtze River. After the synthesis evaluation, the Yangtze River waterway container transportation is optimal.

Table 3.1- The Competition Situation Matrix s of Different Transport Modes.

	Waterway Bulk Cargo Transportation	Waterway Container Transportation	Railway Transportation	Highway Transportation
Time	4	3	2	1
Proportion	0.2	0.2	0.2	0.2
Cost	1	2	3	4
Proportion	0.3	0.3	0.3	0.3
Transport Quality	4	1	2	2
Proportion	0.2	0.2	0.2	0.2
Convenience	4	2	3	2
Proportion	0.3	0.3	0.3	0.3
Total Mark	3.1	2	2.6	2.4

Source: Gu,C.X.(2004). *Analysis of the development of container transportation in the Yangtze River*

It may foresee, the Yangtze River waterway container transportation will preserve the high growth momentum in future period of time. On the one hand, because the national economy will maintain the high rate of increment continuously, and the Yangtze River area also is the advanced area of our country economy development. The economical growth provides the broad foundation with the waterway container transportation in the Yangtze River; On the other hand in the existing low transportation charges foundation, along with the grade of service unceasing enhancement, the Yangtze River waterway containerized traffic superiority more and more will approve for the general cargo owners.

3.2 Forecast of the container cargoes flow in Yangtze River.

3.2.1 Forecast of the Yangtze River containers throughput by the tendency extrapolation model

According to the data (Table 3.2) and the changing tendency (Figure 3.1), it can be seen that in recent years containers throughput of the Yangtze River skeleton line presented the exponential growth basically.

Table3.2- Container Throughput in the Skeleton line of Yangtze River in 2000-2006

Year	Throughput/10000TEU)	The annual average growth rate /%
2000	69.04	26
2001	79.96	16
2002	106.01	33
2003	139.93	32
2004	182	28
2005	260	43
2006	380	46

Source: National Bureau of Statistics of China.

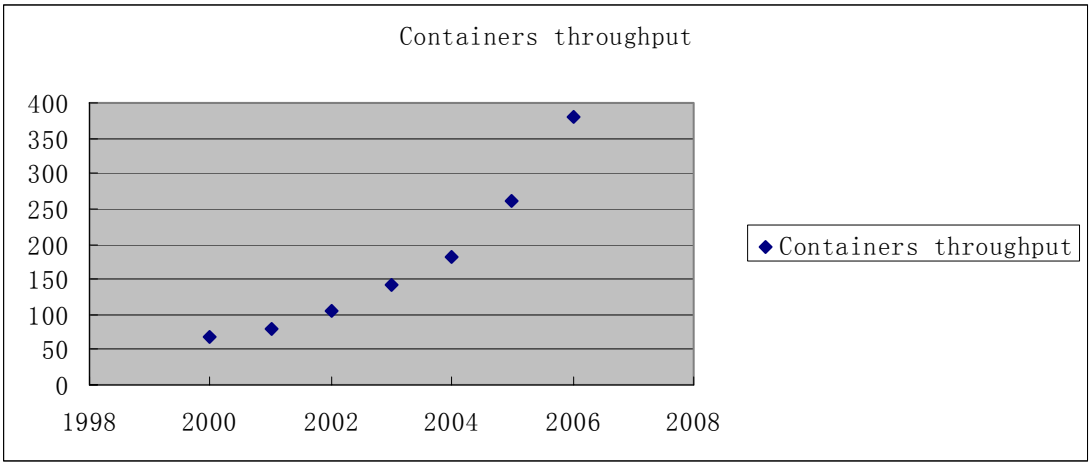

Figure3.1- Container Throughput in the Skeleton line of Yangtze River in 2000-2006

According to the formula: y(T)= aexp(bT)

It obtains: $\ln y = \ln a + bT$

Let: $y' = \ln y$, $a' = \ln a$

It obtains the linear regression model: $y' = a' + bT$

Set up the model in the Microsoft Excel program.

	A	B	C	D	E	F	G
1							
2		YEAR	T	Actual Throughput	y'	T2	Ty'
3		2000	1	69.04	4.234686047	1	4.23469
4		2001	2	79.96	4.38152651	4	8.76305
5		2002	3	106.01	4.663533429	9	13.9906
6		2003	4	142.4	4.958639999	16	19.8346
7		2004	5	182	5.204006687	25	26.02
8		2005	6	260	5.560681631	36	33.3641
9		2006	7	380	5.940171253	49	41.5812
10							
11	sum		28		34.94324556	140	147.788
12	average		4		4.991892222	20	21.1126
13							
14							
15	b=	0.28626					
16							
17	a'=	3.84686					

Figure 3.2- Calculated Process of the Variable Value.

	A	B	C	D	E	F	G
1							
2		YEAR	T	Actual Throughput	y'	T2	Ty'
3		2000	1	69.04	=LN(D3)	=C3*C3	=C3*E3
4		2001	2	79.96	=LN(D4)	=C4*C4	=C4*E4
5		2002	3	106.01	=LN(D5)	=C5*C5	=C5*E5
6		2003	4	142.4	=LN(D6)	=C6*C6	=C6*E6
7		2004	5	182	=LN(D7)	=C7*C7	=C7*E7
8		2005	6	260	=LN(D8)	=C8*C8	=C8*E8
9		2006	7	380	=LN(D9)	=C9*C9	=C9*E9
10							
11	sum		=SUM(C3:C9)		=SUM(E3:E9)	=SUM(F3:F9)	=SUM(G3:G9)
12	average		=AVERAGE(C3:C9)		=AVERAGE(E3:E9)	=AVERAGE(F3:F9)	=AVERAGE(G3:G9)
13							
14							
15	b=	=(G11-7*C12*E12)/(F11-7*C12*C12)					
16							
17	a'=	=E12-B1					

Figure 3.3- The Computational Formula of the Calculating Variable Value.

$$b=\frac{\sum_{i=1}^{n} T_i y'_i - n\overline{T}\,\overline{y'}}{\sum_{i=1}^{n} T^2{}_i - n(\overline{T})^2}=\frac{147.79-7(4)(4.99)}{140-7\times(4)^2}=0.286$$

$a'=\overline{y'}-b\overline{T}$ =21.11-0.286×4=3.847

It obtains: y'=3.847+0.286T

$\ln y$=3.847+0.286T

y= exp(3.847+0.286T)

$y=e^{3.847}\times e^{0.286T}$

After the return fitting, results in the function fitted curve like chart 2, and the model

is as follows:

$y(T)=46.85e^{0.286T}$

In the formula: y is all previous years container throughput; T is the year sequence. 2000 was base year 1, the model and the parameter examination result is remarkable.

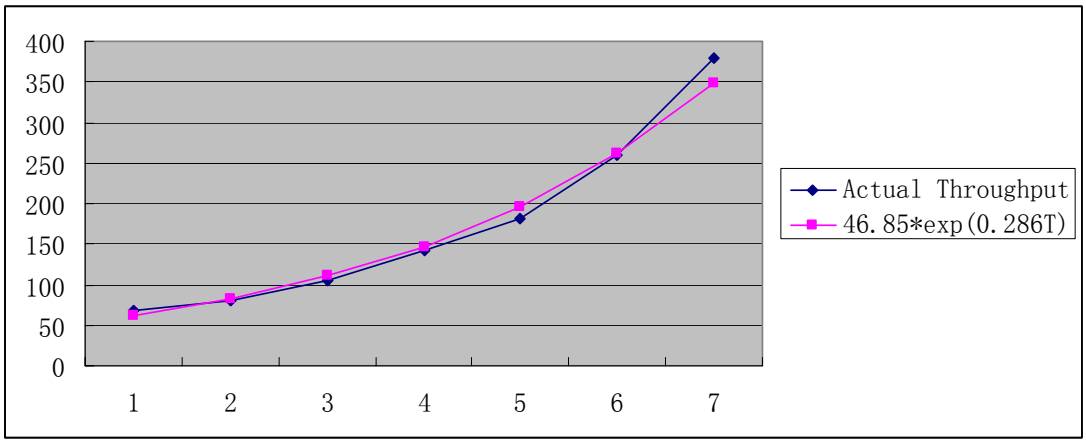

Figure 3.4- Curve fitting of the Actual Throughput and the Data in the Model

Forecast according to the model, future Yangtze River skeleton line container throughput are like table 3.3.

Likewise, according to tendency extrapolation model forecast, the concrete result of the Yangtze River container throughput forecast is shown in table 3.4.

Table 3.3- The predictive consequence of the Container Throughput in the skeleton line of the Yangtze River in 2007-2010.

Year	Throughput /10000TEU	Year	Throughput/10000TEU
2007	462.6294	2009	820.1141
2008	615.9618	2010	1091.93

Table 3.4- The predictive consequence of the container throughput in different areas in the Yangtze River waterway.

Year	The Upstream Areas	The Middle Reaches	The Downstream Areas	Total
2006(Actual data)	39.0	66.7	262.2	367.9
2008	82.6	140.1	460.7	683.4
2010	177.2	286.5	811.0	1274.7
Annual Developed Rate	46.0%	44.0%	32.6%	36%

3.2.2 Analysis of the Results of Model.

Analyzing the model forecast results, simultaneously according to the Yangtze River container production quantity in the forecast result, it needs to explain following several points:

(1) According to the rule of ports containers throughput, it forecasts that the container throughput grows obviously lower than the growth of predicted container quantity. It is mainly because the container industry in the Yangtze River is on started stage in 1990s; the water transportation rises unceasingly in the synthesis transportation status, the container throughput obviously increased faster than that of

the foreign trade. Along with the Yangtze River containerized traffic entering the development phase, the Yangtze River container throughput increased range will have a rational return. Model forecast result relative high.

(2) According to the forecast, the Yangtze River container production quantity of middle reaches and the upstream grows quickly than that of the downstream. The result of Yangtze River container throughput forecast model also is that middle and upper reaches' increased range is big, the downstream increased range is small. The reason is the roadway transportation is developed in the downstream, winning a certain portion of the market share of the container transport in the Yangtze River.

In the generalized analysis model forecast result, the production quantity forecast result, and it obtains the Yangtze River container throughput forecast along the route result as shown in Table 3.5.

Table 3.5- The forecast of container throughput in the Yangtze River.

	The throughput in 2010 /10000 TEU	The annual average growth rate /%
The upstream areas	150-200	40-50
The middle reaches	250-300	39-46
The downstream areas	700-800	28-32
Total	1100-1300	36-43

Summary

According to the forecast, we conclude the cargo flow tendency in the Yangtze River, in different areas of the Yangtze River, because of the economic disparities, the

increased rate of container throughput is different. According to the data of recent years, the growth speed of container throughput of upstream areas is higher than that of other two parts of areas; the cargo volume of container throughput of the downstream is bigger than that of other two areas.

Along with this developed tendency, the vessel size and the infrastructure condition are facing the challenges. It needs to optimize the vessel size to display the economical development. Therefore analysis of the vessel size is extremely important. It is generally agreed that, the large scale ships is possibly a good choice.

4. STUDY ON THE LARGE-SCALE TENDENCY OF VESSEL IN THE YANTZE RIVER

4.1 The Major Underlying Forces of the Yangtze River Container Ships Large-scale Tendency.

The growth of cargo quantity leads to the growth of transportation demand. The Yangtze River major ports developed along with the containerized traffic fast development, the competition among the container boating companies or the alliances is also intense day by day. In order to reducing the cost, further displaying the economies of scale benefit, protecting and enhancing the management profit margin, some big container companies started to draw up and to implement the large-scale ships plan. The container ships' large-scale tendency is inevitable. According to the statistics, in 2005, the ships which were engaged in the inter-provincial transportation in the Yangtze River system amounted to 340 tons equally. In the Yangtze River skeleton line ships' average deadweight tonnage amounted to 750 tons, respectively was more than 1.5 times of that of 2000. In 2005 the Yangtze River ships gross tons amounted to 26,300,000 tons, the skeleton line average ton amounted to 7,500,000 tons, the ships specialization and the large scale tendency are obvious.

The large-scale ships' scale benefit, improvement work, and the better navigation performance are the main driving influenced the Yangtze River container ships' large-scale development, appearance of that has the inevitability.

1. The large-scale trend of container ships has brought the remarkable economic efficiency.

(1) Ship construction cost per ton reduces greatly.

Along with the tonnage of ships increasing, the ship construction cost per ton reduces gradually. When probably the load-carrying capacity surpasses 300,000 tons, this tendency will not change obviously. The load-carrying capacity of large-scale container ships on the present Yangtze River is smaller than this value by far, the ship construction cost per ton may has the obvious reduction.

(2) The share of the crew staff costs per ton ship reduces.

In the container ships operation cost, the crew wages probably occupies 15% or even more. On Yangtze River, the container ships' large-scale development, such as the container ship size arrives to 400TEU from 300 TEU; it does not need to increase the extra crew. Therefore the operating expense per ton also has obvious depression.

(3) Under the same speed, the bigger the ships tonnage is, the thrust power which each ton ship needs will be smaller.

Take the Yangtze River 150/200/300TEU three container forms as the example.

Table 4.1- The designed parameter of 150TEU/200TEU/300TEU container ship in the Yang River

Ship Form	**150TEU Container Ship**	**200TEU Container Ship**	**300TEU Container Ship**
Designed Capacity	1691 ton	1932 ton	3400 ton
The Maximum Load-carrying Capacity	2127 ton	2438 ton	4400 ton
The Main Engine Power	2×330kW	2×440kW	2×588kW
Thrust Power of Each Box	4.4KW.	4.4KW	3.92kw

Source:http://www.jctrans.com/qknew/qkwz.asp?id=633&sel=zgsy&tt=w&t=%E8%88%B9%E5%B8%82

According to the Table 4.1, obviously when the tonnage of ships is bigger, the fuel expense per ton per knots will reduce. Moreover the great tonnage ship may use the high efficiency main engine, and the oil consumption also has reduced.

(4) Abundant sources of container cargoes

For enhancing the economies of scale benefit of the container transportation in the Yangtze River, at first it must have the sufficient stable source of goods in the container route. This is because along with the container ships large-scale development and the enhancement of the box quantity carried by the ships, it requests that the source of goods which adapts with box also must be more and more.

If does not have the sufficient suitable box source of goods, the large-scale container ships' superiority of having the unit transportation cost low also not to be able to display.

The Yangtze valley economy development will provide the abundant container sources of goods. Along with the implementation of developing the Yangtze River strategy, the Yangtze valley industry belt further rises and provides the full container source of goods for the Yangtze River major port. In the Yangtze valley, it is distributing the Chinese biggest fresh water group, which is the Chinese famous land of plenty and the agricultural owner production area, the grain yield accounts for 40 percent of nation; The Yangtze valley is the Chinese important automobile production base, the automobile and the spare parts processing output approximately composes 47 percent of the nation; In addition, petrifaction, steel and iron, electric power, chemical fertilizer, building materials in Yangtze valley also hold the pivotal status in the nation. According to the analysis of Chaper3, the container production quantity in the Yangtze River will keep increasing, and promise huge potentials for development..

2．Work performance greatly improved.

(1) The large-scale container ship may arrange more containers in the deck, thus the loading and unloading efficiency may obtain the effective enhancement.
(2) The payload flexibility of large-scale container ships is high. The wider the ships are, the limits of load will be fewer. The heavy box does not need to place to the base of the cabin, which causes the load to have the multiplicity.

3．The navigation performance has the distinct improvement

The container ships needs to pile up the container in the deck, which causes the

center of gravity to elevate, the longitudinal stability drops, simultaneously also causes the hull side wind area to increase, which has the adverse effect to the stability. The large-scale container ships' width increases and the longitudinal stability increases, which causes the lateral stability to improve greatly.

4.2 Optimality Analysis of Vessels Size

At present, there are 5 type of vessel size is popular in the Yangtze River waterway. They are 150TEU, 200TEU, 256TEU, 300TEU, and 400TEU.The related parameters are shown in Table 4.2

Table 4.2- The designed parameters of 150TEU/200TEU/256TEU/300TEU/400TEU container vessel in the Yangtze River.

	Designed Draft /meter	Maximum Draft /meter	Designed Transport Capacity /ton	Deadweight /ton	Engine Power /KW	Trial Speed /KN
150TEU	2.8	3.2	1691	2127	2*330	12.6
200TEU	2.8	3.2	1932	2438	2*440	13.1
256TEU	4.5	4.8	3600	4000	2*810	11.5
300TEU	3.2	3.8	3400	4400	2*588	14.2
400TEU	4.2	4.8	5256	6456	2*910	12

Source:http://www.jctrans.com/qknew/qkwz.asp?id=633&sel=zgsy&tt=w&t=%E8%88%B9%E5%B8%82

The container ships transport operation cost mainly includes: the personnel wages, the insurance, the ships management fee, the harbor fee, the lubricating oil storage, the fuel cost and so on. According to the Table 4.3, the operation cost of vessels of 150 TEU, 200 TEU, 256 TEU, 300 TEU, and 400TEU are 932.3 thousand dollars, 1026.3 thousand dollars, 1282.9 thousand dollars, 1410.3 thousand dollars, and 1771.6 thousand dollars.

When demand of container shipping and the stowage rate reaches to a certain extent, the large vessel size will take the scale economy. If the increase of cargo volume can not occupy the ships, the economic superiority of the large ship can not be display. Moreover the cost of delivery of empty containers will affect the optimal selection of the vessel size. According the following formula, we can calculate and compare the Cost per TEU (including the delivered cost) in the different shipping marketing conditions to obtain the optimal economical vessel type.

The formulas are as following:

The computed process is in the Table – 4.3 and Table- 4.4

$C=（C_E + C_O）/ V_A$

$C_E = C_E' * V_E$

$V_V = L_V + L_E - L_W$

$V_C = V_V * R_E$

$V_E = V_C - L_A$

Turnover equals 14; Empty containers delivered rate is 25%; $C_E' = 1/2 * C_O'$.

Operation cost is showed in Table 4.3.

In the formulas:

C: Cost per TEU (including the delivered cost)

C_E: Cost of delivery of empty containers

C_O: Operation cost

V_A: Annual transported amount

V_E: Extra delivered amount

C_E': Cost of delivery of empty containers per TEU

V_C: Annual amount of delivered empty containers

L_A: Annual westward load

V_V: The volume of the containers in the transportation

R_E: Empty containers delivered rate

L_V: Voyage load

L_E: Eastward load

L_W: Westward load

C_O': Operation cost per TEU

Table 4.3- The operation cost of the various container ships in the Yangtze River.

Ship type	150TEU			200TEU			256TEU		
	Amount	Cost	Percentage	Amount	Cost	Percentage	Amount	Cost	Percentage
Personnel factor	10	15.00	16.09%	10	15.00	14.62%	12	18.00	14.03%
Insurance		2.79	2.99%		3.57	3.48%		5.51	4.30%
Ship management		0.52	0.56%		0.68	0.66%		0.87	0.68%
Ports cost		6.98	7.48%		8.21	8.00%		10.63	8.29%
Bunker of sailing	6	57.50	61.67%	6.5	62.29	60.70%	8	76.66	59.76%
Bunker When Berthing	0.13953	0.33	0.35%	0.16	0.37	0.36%	0.2	0.47	0.36%
M & R		3.14	3.37%		3.57	3.48%		4.33	3.38%
Preserve and Lubricant		6.98	7.48%		8.93	8.70%		11.82	9.21%
Total		93.23	1		102.63	1		128.29	1

Ship type	300TEU			400TEU		
	Amount	Cost	Percentage	Amount	Cost	Percentage
Personnel factor	12	18.00	12.76%	16	24.00	13.55%
Insurance		5.71	4.05%		7.50	4.23%
Ship management		0.96	0.68%		1.33	0.75%
Ports cost		11.07	7.85%		14.17	8.00%
Bunker of sailing	9	86.25	61.15%	11	105.41	59.50%
Bunker When Berthing	0.2	0.47	0.33%	0.03274	0.58	0.33%
M & R		4.29	3.04%		5.42	3.06%
Preserve and Lubricant		14.29	10.13%		18.75	10.58%
Total		141.03	1		177.16	1

Source: Shanghai Changjiang Shipping Corportion

Table 4.4- The computed process of the Cost per TEU (including the delivered cost).

Demand: Eastward: 400TEU*100%, Westward: 400TEU*60%. Cost of delivery of empty containers is half of the cost of the load container.

Ship type	Eastward load	Westward load	Voyage load	Annual load	Annual income	Cost	Coat per TEU	Average Stowage Rate	Annual amount of delivered empty containers	Extra delivered amount	Cost of delivery of empty containers	Cost per TEU (including the delivered cost)
150	150	150	300	4200	336	93.23	221.98	100.00%	1050	1050	11.653779	249.7238
200	200	200	400	5600	448	102.63	183.26	100.00%	1400	1400	12.828343	206.1698
256	256	240	496	6944	555.52	128.29	184.75	96.88%	1792	1568	14.484586	205.6115
300	300	240	540	7560	604.8	141.03	186.55	90.00%	2100	1260	11.752886	202.0999
400	400	240	640	8960	716.8	177.16	197.73	80.00%	2800	560	5.5363255	203.9048

Demand: Eastward: 300TEU*100%, Westward: 400TEU*60%. Cost of delivery of empty containers is half of the cost of the load container.

Ship type	Eastward load	Westward load	Voyage load	Annual load	Annual income	Cost	Coat per TEU	Average Stowage Rate	Annual amount of delivered empty containers	Extra delivered amount	Cost of delivery of empty containers	Cost per TEU (including the delivered cost)
150	150	150	300	4200	336	93.23	221.98	100.00%	1050	1050	11.653779	249.7238
200	200	200	400	5600	448	102.63	183.26	100.00%	1400	1400	12.828343	206.1698
256	256	240	496	6944	555.52	128.29	184.75	96.88%	1792	1568	14.484586	205.6115
300	300	240	540	7560	604.8	141.03	186.55	90.00%	2100	1260	11.752886	202.0999
400	300	240	540	7560	604.8	177.16	234.34	67.50%	2100	-140	0	234.3418

Demand: Eastward: 300TEU*90%, Westward: 400TEU*60%. Cost of delivery of empty containers is half of the cost of the load container.

Ship type	Eastward load	Westward load	Voyage load	Annual load	Annual income	Cost	Coat per TEU	Average Stowage Rate	Annual amount of delivered empty containers	Extra delivered amount	Cost of delivery of empty containers	Cost per TEU (including the delivered cost)
150	150	150	300	4200	336	93.23	221.98	100.00%	1050	1050	11.653779	249.7238
200	200	200	400	5600	448	102.63	183.26	100.00%	1400	1400	12.828343	206.1698
256	256	240	496	6944	555.52	128.29	184.75	96.88%	1792	1568	14.484586	205.6115
300	270	240	510	7140	571.2	141.03	197.53	85.00%	1890	1050	10.370193	212.0516
400	270	240	510	7140	571.2	177.16	248.13	63.75%	1890	-350	0	248.1266

Demand: Eastward: 300TEU*80%, Westward: 400TEU*50%. Cost of delivery of empty containers is half of the cost of the load container.

Ship type	Eastward load	Westward load	Voyage load	Annual load	Annual income	Cost	Coat per TEU	Average Stowage Rate	Annual amount of delivered empty containers	Extra delivered amount	Cost of delivery of empty containers	Cost per TEU (including the delivered cost)
150	150	150	300	4200	336	93.23	221.98	100.00%	1050	1050	11.653779	249.7238
200	200	200	400	5600	448	102.63	183.26	100.00%	1400	1400	12.828343	206.1698
256	240	200	440	6160	492.8	128.29	208.27	85.94%	1680	896	9.3303306	223.4129
300	240	200	440	6160	492.8	141.03	228.95	73.33%	1680	280	3.2053325	234.1558
400	240	200	440	6160	492.8	177.16	287.6	55.00%	1680	-1120	0	287.6013

Demand: Eastward: 300TEU*70%, Westward: 400TEU*50%. Cost of delivery of empty containers is half of the cost of the load container.

Ship type	Eastward load	Westward load	Voyage load	Annual load	Annual income	Cost	Coat per TEU	Average Stowage Rate	Annual amount of delivered empty containers	Extra delivered amount	Cost of delivery of empty containers	Cost per TEU (including the delivered cost)
150	150	150	300	4200	336	93.23	221.98	100.00%	1050	1050	11.653779	249.7238
200	200	200	400	5600	448	102.63	183.26	100.00%	1400	1400	12.828343	206.1698
256	210	200	410	5740	459.2	128.29	223.51	80.08%	1470	686	7.666232	236.8611
300	210	200	410	5740	459.2	141.03	245.7	68.33%	1470	70	0.8599672	247.2031
400	210	200	410	5740	459.2	177.16	308.65	51.25%	1470	-1330	0	308.6453

Table 4.5- The order of selection of the optimal container vessel.

Demand	Eastward: 400TEU*100%, Westward: 400TEU*60%.		Eastward: 300TEU*100%, Westward: 400TEU*60%.		Eastward: 300TEU*90%, Westward: 400TEU*60%.		Eastward: 300TEU*80%, Westward: 400TEU*50%		Eastward: 300TEU*70%, Westward: 400TEU*50%.	
The Order of Selection	The Order of Selection of Ship Type	Cost per TEU(including the delivered cost)	The Order of Selection of Ship Type	Cost per TEU(including the delivered cost)	The Order of Selection of Ship Type	Cost per TEU(including the delivered cost)	The Order of Selection of Ship Type	Cost per TEU(including the delivered cost)	The Order of Selection of Ship Type	Cost per TEU(including the delivered cost)
1	300TEU	202.0999	300TEU	202.0999	256TEU	205.612	200TEU	206.1698	200TEU	206.17
2	400TEU	203.9048	256TEU	205.6115	200TEU	206.17	256TEU	223.4129	256TEU	236.861
3	256TEU	205.6115	200TEU	206.1698	300TEU	212.052	300TEU	234.1558	300TEU	247.203
4	200TEU	206.1698	400TEU	234.3418	400TEU	248.127	150TEU	249.7238	150TEU	249.724
5	150TEU	249.7238	150TEU	249.7238	150TEU	249.724	400TEU	287.6013	400TEU	308.645

According to the mathematical table, a conclusion that an order of selection of container vessel size (Table 4.5) can be received:

In the quite booming time in the shipping market, namely the demand is big, when the demand 400TEU ship is satisfied, because the realistic situation is its rate of the empty container in the westward route is high, developing the 300TEU vessel form is quite to be economical.

In the booming time in the shipping market, namely the demand is less big, when the demand 400TEU ship satisfies, also developing the 300TEU ship is quite to be economical.

In medium-booming time, although the small vessel form still might achieve to the full load, but because empty container transported cost, therefore developing the medium vessel form 256TEU is economical.

In the non-booming stage, it suggested to develop the 200TEU vessel form.

Summary

According to above analysis, we can see that the vessel selection depends on the market situation. In the different part of the Yangtze River, the economic situation is different, there are gap among the shipping market condition of different areas. Therefore we concluded the different optimal vessel form in different areas of the Yangtze River.

After calculating the cost per TEU of the container ships we get the optimal vessel size in the Yangtze River, but the coming question is whether the ships with the optimized vessel size can be operated in the practice smoothly. Therefore, we need analyze the restrictive conditions including ports and navigation aspects, which lead the paper to the next Chapter.

5. ANALYSIS OF THE RESTRICTIVE CONDITIONS OF THE VESSEL SIZE DEVELOPMENT

5.1 Navigation Channel.

5.1.1 General Situation

According to navigation condition and economical development situation, Yangtze River can be divided into upstream, middle reaches and downstream three sections. Upstream section is from Sichuan's Ipin to Hubei's Yichang. It spans 1044 kilometers. The middle reaches section is from Yichang to Nanjing. It spans 1359 kilometers. Yangtze River downstream section is from Nanjing to Changjiang delta. It spans 418 kilometers.

1. Yangtze River upstream navigation. Since 1981 Gezhouba Dam Gezhouba Water Control Project was filled, the reservoir water level was enhanced; the navigation from Badong to Yichang has become smooth. The material demonstrated that, in 660 kilometer Yangtze River routes from Yichang to the Chongqing, there is 550 kilometers is occupied by the jet stream, the rapids and the shoal. At present it only can go through 1500 ton level fleets. Nowadays the Three Gorges stored water, the radius of navigation increased to above 1000 meters, the minimum water depth increased to 3.5 meters, the single track navigation width expands to above 100 meters. The 10 thousand-ton large-scale fleet could through navigation of Yichang to Chongqing.

2. Yangtze River middle reaches route. The width of river surface increased greatly, the river average width is about 1000-1500 meter, and the river bed is the silt soft base. The current of water is steady, and the navigation condition is good. Considered to from the point of disadvantage factors of the navigation, because the middle

reaches route flows across the alluvial plain, the river course is curving, the silt have been continuously deposited, then created some shallow canals, the event that ships reaches a deadlock occurred from time to time. It needed to do scour maintenance frequently, to guarantee the big tonnage ships navigation security. Take the Wuhan section of Yangtze River route as the example, the all previous years maximum high-water 27.86 meters (the Yellow Sea elevation, similarly hereinafter) most low water level 8.21 meters, main channel dry season water depth generally about 3.5 meters, flood period generally in 9~10 meters. The port area route standard water depth is 4 meters, and the deepest place 9 meters, the shallowest part is 1 meter. The narrowest place of the route is 80 meters, widest place is 1060 meters.

3. Yangtze River downstream navigation section. The topography is smooth, and the river is extravagant, the speed of flow is gentle. From the point of factors that influenced navigation, there still a few shallow canals, but also the gale weather appears frequently. The navigation section from Nanjing to the Wu Songkou, the water depth is 12 meters. It may be open to navigation 30000 ton level ships whole year. Because of the Three Gorges Project, the Yangtze River downstream delivery capacity also obtains very big enhancement. Before the project completes, in the dry season current capacity is only 3000 cubic meters, now it enhance to 5000 cubic meters each second, the shipping condition is greatly improved, the river transportation capacity greatly obtained the release. Take the Nanjing section route as the example, at present from Long Zhuayan to the Yanziji route, maintenance water depth - 10.5 meters, spaciously in 200 meters, the route radius of turn by far is bigger than 5 times to be open to navigation ships captain. The full load pale drinking water water depth - 9.70 meters following sea boats may year to year be open to navigation. Because of Changjiang Bridge at Nanjing clean-up height and the route water depth limit, the bridge above 5000 ton level ship may reach Wuhu, when flood level may reach Jiujiang and Wuhan; 3000 ton level ships may reach Wuhan and the Chenglingji.

5.1.2 The Main Restrictive Problems.

Table 5.1- Maintained Water Depth of the Navigation in the Yangtze River in May, 2007

Areas	Sections of the Yangtze River	Water depth /meter	Tonnage of Vessel /ton
The upstream areas	Yibin-Hejiang	2	500-1000
	Hejiang-Lanjiatuo	2.4	
	Lanjiatuo-Yangjiaotan	3	
	Yangjiaotan-Puling	3.2	
	Puling-Yichang	4.5	
The middle reaches	Yichang-Chenglingji	3.8	1500-3000
	Chenglingji-Wuhan	4	
The downstream areas	Wuhan-Wanhekou	5	3000-5000
	Wanhekou-Wuhu	6	
	Wuhu-Yangziji	7.5	
	Yanziji-Ebizui	10.5	5000-10000

Source: http://www.cjhdj.com.cn/Article/gg/hdgg/ydwhss/200704/Article_20070424165033.html

Taking the water depth of navigation (Table 5.1) and the draft of the existed vessel form into account, we can draw the restriction of the navigation to the vessel size (Table5.2).

Table 5.2- The restriction of the navigation to the vessel size.

Areas	**Sections of the Yangtze River**	**Water depth /meter**	**150TEU**	**200TEU**	**256TEU**	**300TEU**	**400TEU**
Draft /meter			**2.8~3.2**	**2.8~3.2**	**4.5~4.8**	**3.2~3.8**	**4.2~4.8**
The upstream areas	Yibin-Hejiang	2					
	Hejiang-Lanjiatuo	2.4					
	Lanjiatuo-Yangjiaotan	3	√	√			
	Yangjiaotan-Puling	3.2	√	√		√	
	Puling-Yichang	4.5	√	√		√	
The middle reaches	Yichang-Chenglingji	3.8	√	√		√	
	Chenglingji-Wuhan	4	√	√		√	√
	Wuhan-Wanhekou	5	√	√	√	√	√
The downstream areas	Wanhekou-Wuhu	6	√	√	√	√	√
	Wuhu-Yangziji	7.5	√	√	√	√	√
	Yanziji-Ebizui	10.5	√	√	√	√	√

We choose the 150TEU, 200TEU, 256TEU, 300TEU, and 400TEU as the examples, these ship types were already in existence in the Yangtze River. Because the water depth of the navigation in May is nearly at the average level of the whole year, we choose the water depth of month as the standard. According to the navigation data and ship information in these two tables, in May, 2007, not considering other factors, it is obvious in that 256 TEU container ship and 400TEU container ship are only suitable to operate in the downstream areas of the Wuhan. They can navigate smoothly in these areas. 150TEU, 200TEU, and 300TEU can go through in the downstream areas of Puling port.

5.2 Port Capability

5.2.1 The Situation of Major Ports in the Yangtze River.

At present in the Yangtze River system, the number of the ports which developed container loading and unloading service is 32, 13 of that are the ports opening to the outside world. Only Chongqing, Wuhan, Wuhu, Nanjing, Zhenjiang, Jiangyin, Zhangjiagang, Nantong these 8 ports have the container special-purpose wharf (altogether 15), other harbors basically load and unload containers with the multipurpose wharf, the foreign trade wharf, and the grocery wharf.

Influenced by the region economy developed degree, the Yangtze River containerized traffic development is not balanced. The Yangtze River downstream area is the Jiangsu Province where the economy is developed, the harbor is multitudinous, the container throughput is big. The middle and upper reaches of the Yangtze River limited by the current economic condition, the volume of goods handled is small, only Wuhan and Chongqing's container throughput is big because of the geographical position superiority. Nanjing, Wuhan, Chongqing these three big harbors' container throughput are higher than the approaching harbor by far, occupy the main item position in the Yangtze River waters containerized traffic.

1. Nanjing port.

It has standard container berth and advanced equipment, presently has 4 container relay special-purpose berth, the traffic capacity per year may achieve about 300,000 standard containers. It is the harbor which has biggest throughput on the Yangtze River. The Nanjing port presently opens several routes, including Nanjing - Hong Kong, Nanjing - Japan, Nanjing - South Korea's scheduled international transportation service; Will relay rather in Shanghai Nanjing to Shanghai the branch altogether 150 class of/months, but prompt the Nanjing port will leave transports cabinet delivery world each place; Simultaneously has 40 class of/month Nanjing--Guangzhou, seaport, Shekou, Zhanjiang, Tianjin, Dalian, Qingdao route domestic container regular flight. In 2006, the container throughput of Nanjing port surpassed 80,000 TEU.

2. Wuhan port.

The Wuhan port expanded Hanyang and Yangsi container ports area in 2004, after that the designed container throughput reached 97,800 sign box/year, actual traffic capacity reached 150,000 box/year. Simultaneously it plans to construct additional container special-purpose berth in 2006-2010 year, total container handling capacity achieves 250,000 boxes. Wuhan invested large amount of money to developing the Yangluo international container transportation center. The Yangluo international container port was put into service in February, 2004, designed container throughput is 100,000 sign box/year.

3. Chongqing port

The Chongqing harbor has already undertaken 85% of imports and exports. The prospect is bright. After the Three Gorges constructed, it obviously improved the condition of rivers navigation--“the danger, anxious, shallow, and curved”. The navigated time from Chongqing to Shanghai's reduces one day compared to before. At the same time, along with water level promotion of the Yangtze River branch, Chongqing will increase 22 new branch routes; the additional navigation is 119.35 kilometers, the shipping radiating area increases greatly. The Chongqing harbor has

established Kowloon container special-purpose berth of which the annual handling capacity is 200,000 TEU and Cuntan container special-purpose berth of which the annual handling capacity is 400,000 TEU. Chongqing port has becomes biggest port in the western area, the equipment is most advanced, the function is most perfect, and has the highest standard container berth.

5.2.2 The Main Restrictive Problems.

1. Water draught wharf side

The port draft indicated the harbor condition and the basic boundary that may admit the biggest ships. Ships' large scale tendency, request larger harbor water depth and handling equipment efficiency. The ships large-scale tendency causes the wharf and the berth to have the deep transformation for adapting this demand. The business cost of container ships transport is high, if ships must enter or clear when the tide is rising, the shipping company will suffer a quite big loss. Therefore along with the large scale of the Yangtze River container ships day by day, the route and the berth water depth will also enhance greatly.

The ships large-scale tendency, requests harbor water depth and the loading and unloading efficiency coordinate with it. In order to meeting the challenge and the opportunity that the shipping industry rapid development brings, on the Yangtze River many ports such as Wuhan port, Nanjing port, and Chongqing port all unceasingly expands the port area, improves the natural condition of port.. However, the Yangtze River various harbors present situation is that only part of big harbor (for example: Nanjing, Wuhan and so on) their water depth can receive bigger container ships. Other ports' water depth is very difficult to adapt the large-scale container ships docking.

Limited by port draft, the large-scale container ships usually reduce the number of port calls when planning the schedule, but choose some ports as the hub ports, other ports uses skeleton line/branch line pattern(Hub-Spoke). We knew that, the

large-scale container ships economies of scale manifests in the water transportation, once stopping on the port, its scale efficiency will reduce largely. However, because the number of port calls reducing, the majority of containers will concentrate in main several hinge port loading and unloading. Limited by the present harbor loading and unloading efficiency, from the first container are dismounted, to unloading finished and installs the last container to leave the ports, the container ships' port-standby-period will also greatly lengthen in.

2. cargo-handling efficiency

The container large scale on objective requests the higher harbor efficiency to adapt, proposed higher requirement to the ports. If the ports loading and unloading efficiency is too low, then the time of ships staying in the port increases, the ships shipping cost will rise, which brings the scale not to be economical. Facing port throughput grows day by day, developing the new technology positively, further improving the loading and unloading technology, enhancing the operation efficiency, the cargo turnover will be speed up, and the harbor unit area utilization ratio and synthesis traffic capacity will be enhanced, satisfies the requests that boating company desires to reduce the ships in the port time. The findings confirmed in "Large-scale Container Ships' Economies of scale" studied by K.Collins shows a basic conclusion: The container ships economies of scale mainly are decided by the harbor efficiency. The global harbor efficiency continuation universal enhancement, will radically improve large-scale container shipping cost environment. Without any technical restraint condition, all route container ships' scale also will continue to increase like the past.

The port efficiency affects the turnover of container ships, thus affects the freight volume.

In the route, the time of a round-trip voyage is the total duration which ships complete a circulation in the space. Its formula is:

$$\sum T_{round} = \sum T_{going} + \sum T_{coming} + \sum T_{ia} + \sum T_{ma} + \sum T_{fa}$$

In the Formula, $\sum T_{round}$, $\sum T_{going}$, $\sum T_{coming}$ is respectively stand for the time of round-trip voyage, the time of going voyage, and the time of coming voyage.

$\sum T_{ia}$, $\sum T_{ma}$, $\sum T_{fa}$ -----The anchor time of the ship in the initial port, midway ports, and final port.

To the shipping company, is absolutely not willing to let the time of the ships anchor excessively long, because this meant the cost increases, and will reduce the ships turnover. If container ship size increases, the time of berthing, off shoring, loading and unloading will grow, but navigation time will reduce. The large-scale ships superiority is weaken imperceptibly; the opportunity of obtaining the opportunity cost will reduce along with it.

We carry on the following supposition:

The ships accommodates alongside the same harbor in midway, the ports are not congested. Loading and unloading quantity of the port of call is calculated as 5% of ships capacity. The loading rate of the ships in initial and final port is 80%, the loading and unloading speed of ports is 10TEU/hour, and the speed of ship is 12 nautical miles/hours. It supposed that the port carries on the handling operation immediately after ship berthing, and after finishing loading and unloading, leaves immediately (temporarily not according to existing scheduled arrangement). Considering the time of non-working because of the weather conditions and the overhaul is 15 days, the actual operation time is 350 days per year, take Wuhan to Nanjing route as the example, the route is about 700 nautical miles, according to above formula, and we carry on the comparison in the different vessel size and different port efficiency.

Table 5.3-The Operation Time of the Different Container Vessel Forms

The loading and unloading efficiency is 10TEU/hour.

Ship Type /TEU	The load in the Original Port /TEU	Loading Time in the Original Port /Hour	Navigation Time /Hour	Port Calls	Berthing Time /Hour	The loading and unloading quantity per port call	Total Residence Time	Unloading quantity in Destination /TEU	Time of Unloading in Destination /Hour	Single-Way Time /Hour	Actual days	Turnover /Times	Transport Amount /TEU
150	120	12	58.33333	2	15	7.5	8.25	120	12	90.58	3.774	92.7323	11127.87
200	160	16	58.33333	2	20	10	11	160	16	101.3	4.222	82.8947	13263.16
256	204.8	20.48	58.33333	2	25.6	12.8	14.08	204.8	20.48	113.4	4.724	74.0915	15173.94
300	240	24	58.33333	2	30	15	16.5	240	24	122.8	5.118	68.3853	16412.48
400	320	32	58.33333	2	40	20	22	320	32	144.3	6.014	58.1986	18623.56

The loading and unloading efficiency is 20TEU/hour.

Ship Type /TEU	The load in the Original Port /TEU	Loading Time in the Original Port /Hour	Navigation Time /Hour	Port Calls	Berthing Time /Hour	The loading and unloading quantity per port call	Total Residence Time	Unloading quantity in Destination /TEU	Time of Unloading in Destination /Hour	Single-Way Time /Hour	Actual days	Turnover /Times	Transport Amount /TEU
150	120	6	58.33333	2	15	7.5	7.875	120	6	78.21	3.259	107.405	12888.65
200	160	8	58.33333	2	20	10	10.5	160	8	84.83	3.535	99.0177	15842.83
256	204.8	10.24	58.33333	2	25.6	12.8	13.44	204.8	10.24	92.25	3.844	91.0536	18647.78
300	240	12	58.33333	2	30	15	15.75	240	12	98.08	4.087	85.6415	20553.95
400	320	16	58.33333	2	40	20	21	320	16	111.3	4.639	75.4491	24143.71

The loading and unloading efficiency is 30TEU/hour.

Ship Type /TEU	The load in the Original Port /TEU	Loading Time in the Original Port /Hour	Navigation Time /Hour	Port Calls	Berthing Time /Hour	The loading and unloading quantity per port call	Total Residence Time	Unloading quantity in Destination /TEU	Time of Unloading in Destination /Hour	Single-Way Time /Hour	Actual days	Turnover /Times	Transport Amount /TEU
150	120	4	58.33333	2	15	7.5	7.75	120	4	74.08	3.087	113.386	13606.3
200	160	5.3333333	58.33333	2	20	10	10.33333	160	5.33333333	79.33	3.306	105.882	16941.18
256	204.8	6.8266667	58.33333	2	25.6	12.8	13.22667	204.8	6.82666667	85.21	3.551	98.5761	20188.39
300	240	8	58.33333	2	30	15	15.5	240	8	89.83	3.743	93.5065	22441.56
400	320	10.666667	58.33333	2	40	20	20.66667	320	10.6666667	100.3	4.181	83.7209	26790.7

According to the Table 5.3, along with the port efficiency going fast, more container cargoes can be delivered throughout a year. In the Figure 5.1, the lines stand for when the loading and unloading efficiency is 10TEU/hour, 20TEU/hour, and 30TEU/hour, the developed tendency of the transport capacity. Along with the Port Efficiency increasing, the slope of the lines also increase, it means in these port efficiency, acceleration of the development of the transportation capacity becomes higher with the vessel size growth. This figure indicates the high efficiency of the port will accelerate the vessel size development. Similarly, when the port efficiency is low, the transport amount and the growth rate both will be negatively affected.

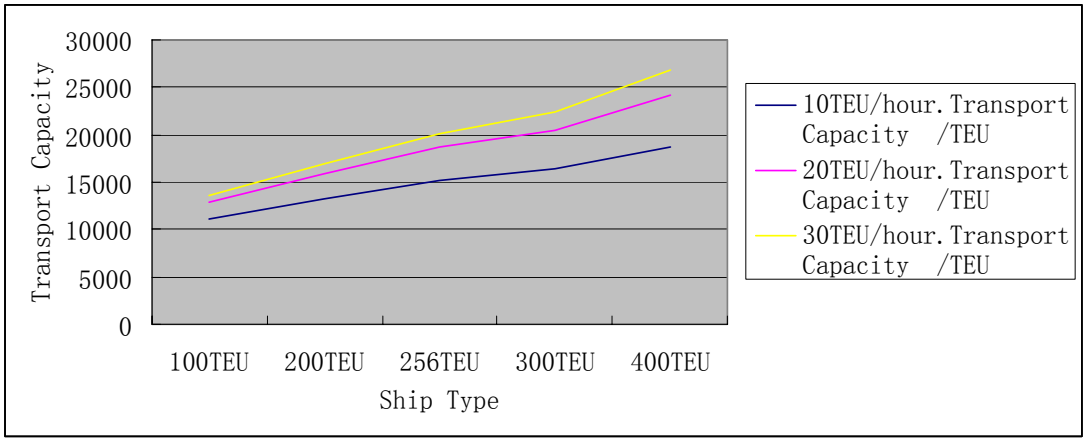

Figure 5.1 Developed tendency of the transport capacity in different port efficiency.

3. The shipping infrastructures.

The large-scale container ships should further consider a series of questions such as wharf facility, yard, the logistics replenishment, the computer system and the interior transportation and so on. The bigger the container ships are, the more the railroad and expressway traffic ability will be need. Because the containers that are unloaded from ships need to transport to the destinations by railroad or expressway. If there is not the good infrastructure to take the backing, putting container large-scale tendency into practice is accepted very difficultly.

If the Yangtze River port infrastructure improvement lags in the container ships' large-scale step, it will be able to become the bottleneck which restrict container large-scale tendency. The reorder of the quayside container cranes, the chassis vehicle maintains having enough logistics replenishment, as well as the computer system improvement, all needs quite a period of time, and the berth dredging the depth, container delivery system improvement and yard expansion need longer time. In addition, the fund and the technical question also are difficulties which the container ships large scale can not but face.

The ships further large scale means that the ports' earthwork construction scale, the harbor facilities criterion and the performance as well as the route and the port draft of the ports on the Yangtze River all must further increase, which needs huge investment, thus causes the ports expense enhancement. At that time, it will restrict the boating company to use larger-scale ships. Therefore, for adapting the ships size, ports development in the Yangtze River also need to be supposed positive and careful.

Summary

The restrictive conditions of large-scale vessel development lie in the navigation and port. In the navigation part, the main factor is the water depth. Whether the container may operate depends on whether the water depth is deep enough. In the ports aspect, the main factors are the water depth and the port efficiency. Port efficiency influences the turnover and the transported amount of the ships directly.

After considering these conditions, the decision of the vessel size selection is affected, we have to consider the vessel size again, the conclusion will be showed in the next chapter.

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Through the analysis of the cargo volume tendency, the optimal analysis of vessel size and the restrictive condition including ports and navigation, we can draw two aspects of the conclusion.

1. Market prospect of container transport in the Yangtze River waterway.

Compared to the middle reached and downstream areas of the Yangtze River, cargo quantity of the upstream quite is low and increases fast in recent years as a result of the industrial structure adjustment as well as the foreign trade development. The demand growth is very quick, but the structure adjustment of harbor wharf could not follow the speed of adjustment of source of goods and the ships structure. Except the navigation in Three Gorges storehouse district is good enough to favor the ships large-scale development, navigation condition of other areas are all in the natural situation. The cost of construction of harbor in upstream of the Yangtze River is big due to limitation of the mountainous area rivers natural condition. Investment is hard to arrive. Has the large-scale container special-purpose wharf except the Chongqing harbor, for example, the Cuntan standard container berth, the designed surpassed capacity is 400,000 TEU, other harbors are lack of the special-purpose standard container berth. Because in the last few years, cargo quantity climbed and the Three Gorges storehouse district route improved rapidly, the large-scale container ships developed rapidly but only existed between the big wharf transportation.

In Yangtze River middle reaches, compared with the downstream, cargo volume of container throughput is very low, but along with the foreign trade and industry develops in the middle reach, increases speed of containerized goods is to be quick, The partial routes are being renovated vigorously, now it could pass through 3000-5000 ton level ships, the potential of large-scale of container vessel is big.

The downstream cargo quantity growth tendency quite is stable and starts to postpone, because other way transport mode also develops extremely rapidly in the downstream; the competition quite is also intense. The Yangtze River downstream infrastructure and the natural condition are best in all areas of the Yangtze River, and the harbor condition is also better than that of middle reaches and upstream areas. Because the fund is sufficient and the development is quick, the ships large scale potential is extremely big.

2．The Decision about vessel size in the Yangtze River

Regarding the existing 150 200 256 300 400 container vessel forms:

In Upstream areas, the navigation and the harbor condition are not very good. Considered from the ships draft aspect, 150TEU, 200TEU, 300TEU container vessel are able to move smoothly. According to the situation that the transported goods volume quite is low and the rate of rise is quick, it may develop 300TEU container vessel. But after taking the harbor efficiency in to account, 200TEU container vessel is possibly the quite economical ship at present.

In the middle reaches and downstream areas in the Yangtze River, the navigation condition is good enough to through the 1500-5000. Above Wuhan, 150TEU, 200TEU, 300TEU may pass through, but in this part of route the scenery bearing is not high, developing the 200TEU ship is quite to be economical. Below Wuhan 256TEU and 400TEU container ship may pass through. In this part of route, container shipping market of main route quite is booming, such as Wuhan- Nanjing, Wuhan- Taitsang. There are quite many transportation amount in these routes, developing the 256TEU container ship is quite to be economical. But in the routes between small ports, market situation belongs to medium booming. The small vessel form still might achieve the unidirectional full load, but because of empty box transported cost, using the medium body form (200TEU and 256TEU) is to be economical.

In the Yangtze River delta area, container market is in the booming time, the route are many, the harbor develops quickly, the navigation condition is good, developing 300TEU is quite to be economical.

6.2 Recommendation

6.2.1 Develop the containerized special-purpose vessel forms and the equipments.

According to the Yangtze River navigation's characteristics, unifying the Yangtze River's containerized traffic's needs, we will develop the special-purpose container vessels which suit Yangtze River's situation, change the situation that the specialization level of container vessels is low at present and the transportation cost is high. At present, the Ministry of Communications has already begun to formulate the ships standard of Three Gorges of the Yangtze River area, but the container vessel had its own characteristic, thus it should design corresponding standardization container ships according to the container the characteristic. The design of special-purpose container vessel form needs to consider following two factors:

1. According to the containerized traffic principle: the steamship matches the big line, this means that the vessels of Nanjing, Wuhan, and Chongqing should big. Although the present box quantity is insufficient, but according to the container tendency which is predict in Chapter 3, it will grow fast in the future, and the carrying capacity of big ships may reduce the cost effectively. But influenced by the port and the navigation limits, the ships size also has the limit.

2. It should design the appropriate standard container vessels, satisfying the request of shallow-draft and low-height. It suggested that learning the containerized traffic experience of the Rhine River, study special-purpose body form series which suits the Yangtze River's containerized traffic, the economical practical, enhance the transported efficiency, benefit and the technical level of equipments, and provide the fund and the technical support to the companies which develop the standardization

ships, specially encourage the big state-operated companies to develop the standardized ships in advance.

6.2.2 Speed up the construction of navigation.

The low draft of partial Yangtze River navigation has limited the entry of advanced container ships, simultaneously the draft of the middle and upper reaches route drops fast in dry season, moreover maintenance ability was bad, which has affected the route's though capability. Therefore, it should adopt following measures to enhance the navigation's construction and supervising.

1. It should establish the construction and maintenance fund of the Yangtze River.

Since long ago, the investment of Yangtze River shipping infrastructure is not enough, the navigation maintenance cost depends on receiving the additional expense from the shipping enterprises, but the Yangtze River shipping enterprises' strength is generally weak, the payment is insufficient, which lead the navigation to be in bad repair year by year, the through capacity to be backward. Therefore, it must establish the construction and maintenance fund of the Yangtze River, make sure to satisfy the needs of shipping development. At the some time of maintaining and the developing the downstream route, it should also strengthen the middle and upper reaches' maintenance. Not only maintain the Yangtze River skeleton lines, but also enhance its main branch such as Hanjiang River, the Xiangjiang River as well as the Grand Canal, Huaihe River, Tai Lake, Hongze Lake. Only the river system extends in all directions can the Yangtze River can display the functions as a gold route comprehensively. The economy of downstream area (Jiangsu Province) is developed, it may consider collecting the route construction fund voluntarily by this area, invest on the Grand Canal, Huaihe River, Tai Lake, Hongze Lake. The local economic potentiality of the middle and upper reaches is weak. These areas need the national allocation overall plan construction. Therefore, it suggested that the country delimits a fund from the financial revenue to take middle and upper reaches Yangtze River and the main branch shipping construction, the maintenance fund every year,

fundamentally improve the Yangtze River shipping infrastructure construction.

2. It should enhance the Harbor Superintendency Administration's function of supervising and managing. Harbor Superintendency Administration supervises and manages various foreign trades ships strictly at present, it should take all berths (no matter size, state-operated or private) under the management, enhance harbor information networking, establishes a one whole safety-control network, protecting the navigation security. At the same time, it must attack severely illegally digging-the-sand behavior, avoiding the navigation destruction.

3. It supposed to enhance the management level of navigation, implement the strategy of invigorating shipping though science and technology, which means depending upon the advance in technology, promote the navigation maintenance management level. We will widely apply the new science and technology, the new material, the new craft; revolve around the key project of navigation to carry on the technical attack. It should promote and develop the scientific and technical payoffs, like the promotion of electron route chart, the navigation aid real-time monitoring system in the section below Nanjing and applying the global positioning system in the entire line of the Yangtze River route, raising the management level practically.

6.2.3 Concentrate on the construction of ports.

1. Enhance the construction of harbor infrastructures. In view of low status equip and technical level of the present Yangtze River ports, it should study the special-purpose loading and unloading machinery and the transport vehicle which suits the Yangtze River standard container berths, support the harbor and the enterprise to renew the container truck positively, safeguard the containers' door-to-door transportation.

2. Strengthen the cooperation among the Yangtze River waterway various ports.

In the Yangtze River downstream area (mainly is Jiangsu Province), because the developed level of economy is quite high, there are multitudinous ports which form

the competition situation, and the regional protectionism has been obvious. The containerized traffic is the developed tendency of ports, its linkage benefit far exceeds other transportation modes, and developing containerized traffic has some superiority to the local economy. At present many harbors start to built or reconstruct container berth, but the cost of newly building container berth is as 3 times as that of constructing a general cargo wharf. Studies according to the expert, in our country, only the pots' container throughput achieves above 50,000 TEU, may establish a new container special-purpose berth, but when the container throughput is less than 30,000 TEU, it may establish multipurpose wharf first. Therefore, when newly build or reconstruct a container berth, the provincial level controlling organization should strengthen the coordination, construct the wharf reasonably, avoiding the resources waste. At the same time, the local authority should cancel the regional protectionism policy, encourages the superiorities' supplementary, enhance the cooperation, use the fund reasonably. Considered the local economy as well as the harbor position, it should take Nantong, Zhangjiagang, Nanjing, Wuhan, Chongqing five harbors as the center, and give priority to develop the containerized traffic, forming the scale effect.

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