World Maritime University

Shanghai, China

ITL - 2011

"Liner shipping lane planning from Shanghai Port to Guangzhou Port of Shanghai Baoyin Shipping Co., Ltd"

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China

A research paper submitted to the World Maritime University in partial Fulfillment of the requirement for the award of the degree of

MASTER OF SCIENCE

In

INTERNATIONAL TRANSPORT AND LOGISTICS

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DECLARATION

I certify that all the material in this dissertation 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 dissertation reflect my own personal views, and are not necessarily endorsed by the University.

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ACKNOWLEDGEMENT

First, I am thankful to the World Maritime University and Shanghai Maritime University for giving the chance to study international transportation and logistics.

Second, I am thankful to Ms. Zhou Yingchun, Ms. Hu Fangfang and all the others who working in the administration office. They gave me so much help both in study and in daily life. I am also grateful to all the professors who gave us excellent classes and share the profound knowledge.

Third, I want to give my wholehearted appreciation to my supervisor Professor Qu Linchi, who kindly gives me lots of guidance, supports and encouragements during the whole process of my paper work. I am also benefit a lot for the future from her attitude towards details and structure to academic, which is not easy to be learned in books.

Finally, I would like to show my indebtedness to my beloved parents, who offered me full supports and always encourage me during the whole studies in Shanghai.

ABSTRACT

Title of Dissertation: **Liner shipping lane planning from Shanghai Port to Guangzhou Port of Shanghai Baoyin Shipping Co., Ltd**

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

Abstract: Due to discovering that Shanghai Baoyin shipping Co., Ltd has a relatively lower profit in its domestic coastal liner shipping. Through choosing a most suitable type of ship, a best schedule and an optimal route's port of call, Baoyin Co., Ltd can realize its liner shipping profit maximization from Shanghai Port to Guangzhou Port. I evaluate this container shipping lane step by step, from its operating indexes to its ship financial indexes and ship investment indexes.

As a result, I obtain the best calling port, the fittest type of ship and the schedule of voyage. I also analyze the influencing factors during the transportation such as freight rates, traffic volume, oil price and ship price to reach the goals of saving the shipping costs, optimizing the route structure and developing Baoyin Shipping Company's liner shipping coastal transportation.

Keywords: Lane Optimization, Operating index, Ship financial index, Ship investment index, Sensitivity analysis

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List of abbreviation

NPV： Net Present Value

NPVI：Net Present Value Index

AAC： Average Annual Cost

RFR： Required Freight Rate

BCR： Benefit-Cost Ratio

IRR： Internal rate of return

PBP： Pay Back Period

Chapter1. Introduction

1.1. Development of Domastic Trade Container Transportation in China

In recent years with the rapid development of international container transportation, optimum cargo volume fitting the container is improved, break-bulk transportation atrophies. Besides heavy and oversize cargo, bulk, liquid and container have become the main body of transportation; this is because container transportation has obvious advantages. It is also the embodiment of the economic development and social progress. The global economy gradually blends and it gets everyone's approval.

Meanwhile, China domestic costal transport also has qualitative change. Companies which have domestic costal transport including big companies such as China Shipping and COSCO, small and medium size shipping companies such as Nanqing, Tianhai, Yangzijiang, Sanfeng, Zhenghe, SITC, SYMS, Zhejiang Shipping, COFCO and etc gradually come into the market. This meets the market demand which is the shortage of highway and railway capacity. Whether using water transport or highway transport, no one was in charge of the loss or damage of the break bulk cargo before. However, container transportation just makes up for the insufficient. Therefore, the advantage and development speed of the domestic coastal transportation will have a high speed period during the coming three to five years.

But the development of China's coastal container transportation is not satisfactory, despite more than 20 companies entering the capacity. So far the domestic main shipping conpanies haven’t been formed, such as the era of planned economy Guangzhou, Shanghai, Dalian three maritime bureaus dominating domestic coastal transportation has gone. Because of not existng main force fleet, domestic coastal container transportation is now in a crumbling stage, and international lanes shipping companies serve this market as storage pond of the capacity. When the international market is good, they take out their ships and when the international market is bad, they return into coastal line. Because the big shipowners have strong force to make coastal transportation market whether capacity or the spaces being not stable.

This leads to that the medium and small shipping companies which are ineligible in operating the international lanes lay in a very passive, awkward position. This causes whether shipowners or dock, cargo owners were all deeply passive: when the number of vessels is big, tariffs decline and port congestion; when the number of vessels is small, goods can’t be transported and quay overstock. Many cargo owners are going waterways today and tomorrow to transport by land, even both buyers and sellers are unable to understand what it is all about, so that isn’t benefit to the development of coastal container transportation, and due to the coastal capacity vessel sizes don't match, access to the lane line is too low, also cause the service level too low, and make container transportation advantage not fully play out. Nowadays, big shipping companies have big vessels but few lanes and density is insufficient; Medium-sized companies have good network coverage, but feeder lanes EQ is insufficient and speed is slow and delivery date is long; in small companies the vessel goes after the cargo and can’t form competitive advantage and have low rate of return, especially pretty many vessels are distributed amphibious ships to cause instability of supply and demand of coastal transportation capacity. Therefore, this blocks the development of coastal container transportation.

As is known to all, transportation is vanguard commander in national economy, facing precious land, burden on the traffic line, in order to relieve the pressure from south to north traffic lines, we should strongly advocate maritime transport, especially we have advantaged th Bohai Sea, the Huanghai Sea, the East China Sea, the South China Sea and connect Yangtze river and Pearl river two water system. This is the valuable wealth for our Chinese Nation and we have no reason not to take her into good use to create more wealth and save unnecessary waste of resources.

In this thesis, I design the container lane for Baoyin Shipping from Shanghai Port to Guangzhou Port and analyze the change of various elements during the transportation such as the feederage, slot capacity, oil price, vessel price and so on in order that Baoyin Shipping can save the cost of the transportation, optimize the structure of the lane and promote the development of the containter transportation.

1.2. Introduction of Shanghai Baoyin Shipping Co., Ltd

Shanghai Baoyin Shipping Co., Ltd’s key business is waterway transport, combined road and railway freight transportation, transit and warehousing. It is a modern shipping logistics enterprise specially engaged in the third party logistics. This company was established in April 1998 and its registered capital is 30 million yuan, with six subordinate enterprises and more than thirty ships. Its vessels’ total capacity is about 150 thousand tons. It has several hundred long-term cooperation ships and annual cargo transport volume exceeds by six hundred thousand tons. This company undertakes all kinds of domestic and foreign large bulk cargo, miscellaneous goods, container cargos, ro/ro car and other cargos’s waterway transportation whole logistics planning and transport services.

Trade Services:

- Main international lanes: from domestic coastal and Yangtze River to main ports in Hongkong, Taiwan, Korea, Japan, Philippines, Malaysia, Indonesia and so on.
- Domestic coastal lanes: from Dantong to Fangcheng
- Yangtze River lanes: from Chongqing to Shanghai
- Inland River lane: branch lanes of Yangtze River, including Shanghai, Anhui, Zhejiang, Fujian, Jiangxi.

However, they don’t have the lanes from Shanghai to Guangzhou. We can select a vessel to operate this lane.

1.3. Literature Review

In recent years with the rapid development of international container transportation, optimum cargo volume fitting the container is improved, break-bulk transportation atrophies. Besides heavy and oversize cargo, bulk, liquid and container have become the main body of transportation; this is because container transportation has obvious advantages. It is also the embodiment of the economic development and social progress. The global economy gradually blends and it gets everyone's approval. Research of the liner shipping route planning is very important. There are a lot of methods to optimize the liner shipping routes all over the world in recent years. None of a country can get away from liner shipping.

In YAN Yong’s (1999) article “An Improved Ants Genetic Algorithm to Solve the Problem of Route Optimization” points out that “Ants genetics algorithm” is a good way to optimize the route. Its essence is to choose the shortest route. It is a combination of the “Ants algorithm” and “Parent Genetic algorithm (PGA)”. By running the algorithm and controlling the number of ants travel, it can firstly find a better solution of the route optimization problem. Compared with ASA algorithm, it greatly reduces the search time. Secondly, it uses the expression of better route that as the initial stocks what is designed as the parent, directly operated gene group and delimitation, significantly reduced randomness of PGA algorithm. The experiments demonstrate that the proposed algorithm is a good algorithm to solve the problem of route optimization. It is a better way to choose the shortest route.

In Dengjia and Le Meilong’s (2007) article “Study on Optimization of Domestic Coastal Liner Shipping Routes”, they use a hybrid model to solve Chinese domestic coastal liner shipping allocation problem. With the rapid development of the domestic coastal container transportation, how to arrange shipping routes to create the greatest profit becomes the focus. According to the freight in the major coastal routes, a hybrid model which is made of the nonlinear and integer programmingis built in the paper and typical routes are chosen to form a transport network. The mathematical model can be used to solve the domestic coastal liner shipping problem.

It has the objective function:

Constraints：

1. Capacity constraint

2. Departure and arrival constraint

3. Traffic volume constraint

4. Network constraint

5. Time constraint

The basic parameters hypotheses and calculation

1. Ship type

2. Traffic volume

3. Ship route

4. Time

To substitute the certain parameters into the model respectively and using Lingo software, you can find out the biggest profits—Objective value：2933316.

Analyzing the result of the above route optimization, it is not hard to find that the port transport demand has become a factor to choose the port of call. Guangzhou, Shanghai, Tianjin are the coastal ports who have relatively bigger demand for traffic volume. Along one route, the situation container freight volume of the passing ports is very high is not common. Therefore, not every port could be the port of call.

This paper only chose one type ship to calculate, different types of ships have different orders of callings. No matter which kind of ship can use this mathematical model for route optimization calculation, so it serves as a guide for overall planning of the coastal liner shipping transportation.

In Jiang Yi's (2006) paper "Study on Tai Chang Power Plant ship distribution of coal shipping", it studies the issue of Tai Chang power plant's coal shipping optimization. By selecting appropriate ships to transport coal by vessel, the total cost of transportation can be minimized.

With the progress of China's power industry reform, particularly since theseparation of generation from the transmission functions, every generation company has been paying more attention on the profit making capability, the majority of which comes from the coal purchasing and transportation. As the coal price maintains at a high level, the cost of coal accounts for 80% to 85% of a power plant's total cost.

Additionally, influenced by the soar of the international crude oil price, the coal transportation expense tends to be higher. The cost of fuel which was 25% of the transportation cost, accounts for 35% at present. The cost of shipping has been increased dramatically. The generation company, although subject to the prearrangement of the voyage line by the transportation company, requires optimizing the shipping arrangement so that the total coal transportation expenditure can be minimized. This paper studies the ship distribution of coal transportation routine arranged by Shanghai Time Shipping Company Ltd, after Tai Chang Power Plant Second Phase expansion .This paper studies the issue of Tai Chang power plant's coal shipping optimization. By selecting appropriate ships to transport coal by vessel, the total cost of transportation can be minimized.

This paper discusses the background of Tai Chang Power Plant project and the current research both domestically and abroad. It also analyzes power plant coal mines situation and the condition of some major coal loading harbors throughout China. This paper explores the methodology of linear programming and the solution of spreadsheet method of integral programming. It also verifies the economical analyzing method for shipping operation so that several of operation parameters of shipping companies can be determined, which serves the basis of the establishment of Ship Distribution Model in shipping routines, targeting at minimizing the total shipping cost. Spreadsheet method is employed to compute the solution of the model, and ultimately gives the result of optimized coal transportation scheme for the power).

In Chen Chao and Zeng Qingcheng's (2006) article "Robust optimization model for asset deployment in a container shipping line", it studies asset deployment in a container line experiencing uncertainty. After considering the characteristics and requirements of a container line, a deterministic model for the problem was developed based on the equilibrium principle. The objective was to optimize ship size, the number of containers, and slot allocation. The deterministic model was expanded to a robust optimization model that considers uncertain factors. Ship size and slot allocation were treated separately as design variables and control variables, when formulating the model. Lastly, effectiveness of the proposed model was demonstrated using the pendulum shipping line as an example. Results indicate that this optimization model considers demand uncertainty, model robustness and risk preferences of decisionmakers simultaneously, thus the model agrees well with practice.

In the dissertation “Study on C container Liner Company’s China-Persian Gulf trade lane optimization” of Shen Xue Chao, he uses This paper adopts some theories of economics, quantitative economics, marine management etc. to study the optimization of container service. The paper puts forward the general views, principles, models, methods and procedures, which can be served as guidelines to the practice of a container trade lane optimization.

The major content of the paper is as follows:
Chapter one makes analysis of the container transportation industry and current container transportation market.

Chapter two makes a general study on the basic factors/elements that can effect on international container service optimization and the basic principles that should be followed when studying on international container service optimization. Finally, Chapter two concludes some general conclusions.

Chapter three establishes two feasible quantitative mathematical models: Profit or Loss Analysis Model and AHP Model. Firstly, Profit or Loss Analysis Model can quantitatively calculate the Profit or Loss of an international container service and can provide important evidence for the optimization of container services. Then, considering that container liner companies should both calculate the profit or loss of each plan and should synthetically take into account many other factors such as service quality, network of service, ship's employment, market plan etc,. Chapter three establishes the AHP Model to assist the liner company in the decision-making to choose an optimization international container trade lane from several schemes has been produced.

Chapter four analyzes the basic market situation of Far East/Persian Gulf service and makes a study on China/Persian Gulf service of C container line company's firstly,.And then, it studies and concludes optimization schemes of this service, according to the basic factors and basic principles mentioned in Chapter two and Chapter three, Finally, it makes use of the two optimization models mentioned in Chapter three to China/Persian Gulf lane of C Container Lines company and concludes the optimal scheme. This optimal scheme shall be applied to business practice, which can prove the feasibility of the models.

Overall, it appears from the available literature that there are many ways to optimize the liner shipping routes. Each company should choose the one which is most suitable for its practical situation. In relation to the publications, many ship investment indexes, ship financial indexes are not evaluated in the articles. The extent of ship related indexes is unclear in other ones' papers. I will calculate and analyze them in my dissertation.

Chapter2. Influencing factors and basic principles of liner shipping route optimization

2.1. Influencing Factors

Facing the changes of the situation of the international economy and trade, market environment and competitors, shipping companies must adjust and optimize the container liner lanes immediately in order to adapt the change of the market and maintain competitiveness.

The factors influencing the container liner lanes can be divided into external factors and internal factors.

2.1.1 External factors

(1)International market environment

Container liner shipping market is the derivative of the international trade market, which conforms to the basic rules of the international trading market, and it also has the special properties of the derived market.

The development of world economy has a decisive impact on international container transportation market. When considering route optimization, we must pay enough attention to the world economic situation especially the regions' economic situation of the calling ports in the lane and make a relatively scientific forecast for the development prospect in the future, the cargo volume of the lane and the cargo flow.

(2)Port Condition

Port condition includes natural condition of the port channel and the port hinterland source, port charges, wharf facilities, handling efficiency and other factors, among which port hinterland cargo source is the most important factor which decides whether it could be the calling port.

(3)Competitors' lane setting and management tactics

During the adjustment of the lane, we must take the rivals' lane set condition into consideration, including calling ports, port order arrangement, speed of the ship and ship types in order to aviod the same service from the others.

2.1.2. Internal factors

(1) Management efficiency

Fair or foul of the lane operation is an important standard to judge the reasonable lane setting, because maximizing profit-push is the main target of the carrier.

(2) Arrange the capacity reasonably

Route optimization must be considered from the aspect of enterprise capacity adjustment and arrangement, for example, whether the removed capacity can be arranged well is a question which should be taken deliberation.

(3) Changes of the expected goals

Generally speaking, the anticipated goal of the beginning period of the lane is to occupy the market. Secondly, we should consider benefit problem. However, after a period of operating the lane, the anticipated goal will be transferred to the economic benefit.

(4) Capacity of trunk lane and fleet update

In order to obtain the steady development, shipping companies must continually update their vessels, improve the fleet structure and add the capacity. With the large-scale development of container ships, as far as large-scale ships being online, this will cause a series of route adjustment and capacity upgrade of the liner companies.

2.2. Basic Principles

(1) Give consideration to operation benefit of the lane and the development of the whole company

When optimize the lanes, besides that we should consider the route itself, we should also consider the problem from the whole enterprise to strive for the lane benefit and the enterprise whole development and properly deal with the relationship between the two.

(2) Benefit maximization

Enterprise is profit organization, its starting point and destination is profit, enterprises must be able to gain profit in order to have the value of existence. That is to say, the maximization of enterprise value or shareholders' wealth maximization is the target the enterprise pursuit.

(3) Complete the network service

Route optimization is not only optimizing certain route, but we should also take whole network's design and perfect into consideration during the process of optimizing and adjustment. In practice, the below problem should be taken into consideration: How to avoid lane capacity repeating? Whether the connection in the network is comprehensive? How to interwork among the lanes in order to reduce the cost?

(4) Tributary/Feeder Lanes serve the trunk lane

The liner companies using the combination of the trunk and feeders to transport, therefore, we must take the principle of feeders serving the trunks into consideration and consider that feeder adjustment must better transship the trunk cargo, form a network and shorten the transit time. Of course, when we optimize and adjust the feeder capacity, the transshipment of the feeder capacity should be taken into consideration.

(6) Vessel should suit for the lane.

During the lane optimization, proper ship matching the proper lane is the important principle, this includes three aspects: Firstly, the qualification such as ship type should be fit for the lane; secondly, the vessel should have competitiveness in the lane; thirdly, we should make comprehensive assessment on the enterprises' whole lanes to choose the most suitable ship to the lanes.

(6) Fully use the cooperation method

Under the circumstance of the present market situation, cooperation has become the inevitable trend of international container liner shipping. The concrete forms of cooperation include feeder service, shipping space renting, mutual renting, joint dispatch of ships and etc. Cooperation can bring economic benefit such as economies of scale, scope of economic, speed economic, symbiosis economic to the enterprise.

(7) Close to the market dynamics

In the fierce competitive container transportation market, the shipping company must always be full of crisis and have immediate reaction with the changes of the market situation.

Chapter3. Design the route from Shanghai Port to Guangzhou Port of Baoyin Co.,

3.1. Two schemes of choosing the calling ports

1. Shanghai Port (CNSHA)

1) Longitude and Latitude: 121° 31.3' E, 31°23.5' N

2) Tidal range：Biggest tidal range is 3.45m and smallest tidal range is 2.60m.

3) Channel draught limitation: fresh water 9.5m

4) Pilotage Service: compulsory pilotage, pilot 24hours working time

5) Before sunrise and after sunset ships can enter or leave the port.

6) Tugboat: 1X1900HP 3X2600HP 7X980HP 1X2200HP 1X3200HP 1X3500HP

7) Floating crane: 1X32T 1X63T 1X100T 1X200T 1X500T 1X2500T

8) Supply Service: Fuel, fresh water, food

9) VHF: Channel 11or27, working hours 24hours

10) It has maintainance service.

11) Port warehouse condition: warehouse area 3760000m2; yard area 9960000m2

12) Main import and export goods: Import: bulk grain, scattered ore, steel, equipment and wood; Export: Textile chemical products, agricultural and sideline products, petroleum products

Until the end of 2006, Shanghai port has number of various berths about 1140, among which 171 are production berths above megaton, terminal line is 91.6 km. According to the wharf property we can classify: 175 public pier berth, terminal line length is 2.46 km, including 121 production berths, terminal line length is 22.2 kilometers, the annual throughput capacity is 17051 tons; cargo owners have special 965 pier berths and wharf line length is 67 kilometers, including 495 production berths, wharf line length is 38.2 kilometers. Shanghai inland ports have 818 berths and maximum anchorage capacity is 3,000 tonnages.

Data Source: http://friend.jctrans.com

2. Guangzhou Port (CNCAN)

1) Port Name: Guangzhou Port

2) Port Code: CNCAN

3) Port Abbreviation: GUA

4) Anchorage ground: 22-08-00N113-47-00E

5) Berth Draft: Channel limits maximum draught 11.5m

6) Nautical Chart No.: 15455(medium)

7) Port Type: Seaport

8) Port Size: Medium

9) Tide Water：biggest tidal range- 2m，smallest tidal range – 0.9m

10) Pilotage Service: compulsory pilotage, pilot 24hours working time; beginning place of pilotage: garbage tail water pilotage anchorage.

11) Before sunrise and after sunset ships can enter or leave the port.

12) Tug and working ship condition: 18 tugboats, the biggest horsepower 900HP

13) Floating crane: Load 30T

14) Supply Service: Fuel, fresh water, food

15) Port warehouse condition: warehouse area 168043m^2

16) Main import and export goods: grain, sugar, fertilizer, cement, ore, metal machinery, food, groceries.

3. Xiamen Port (CNXMN)

1) Port Name: Xiamen Port

2) Port Code: CNXMN

3) Longitude and Latitude：118°04’15”E 24°29’20”N

4) Tide Water：Highest water level - 7.55m，Lowest water level - 0.25m，Mean high tide - 5.49m

5) Each channel draft restrictions：West of the Monkey island channel max draught is 8.0m

6) Pilotage Service: Foreign vessel is compulsory to have politage; Pilots' working time is in the day time

7) Before sunrise and after sunset ships may enter or leave the port

8) Tug and working ship condition: 1×3500horsepower, 1×4900horsepower, 1×4000horsepower, 1×3200horsepower and 1 × 3600horsepower.

9) Floating crane: 1×100t、1×60 t

10) Supply Services: dock, anchorage ground can add oil, water, and supply food.

11) VHF: Channel 16, 12, 25, working hours-24hours, Callsign Xiamen dialect sets

12) Port library market conditions: warehouse area 51503m^2; stacking area 378873m^2; CY about 70000m^2

13) Main import and export goods: steels, chemical fertilizer, cereal, suger, salt, tea, graphite powder, containers

14) Anchorage: can dock 100,000 DWTs of pilotage and quarantine anchorage

Data Source：http://www.cosco-logisticsxm.com

Lane calling ports scheme is to confirm the ports of call and the order in a lane. The best liner lane calling ports scheme can provide maximal freight revenue and profit. In ports choice, we should consider the source factors and port factors. Shanghai Port and Guangzhou, as the two nation's most important container ports, are belonged the world's top ten container transport ports. Both of the two ports are located in the most developed area in our country with rapid economy development, trading a lot with each other, freight volume also is relatively bigger. Xiamen, as the special economic zone in China, has developed rapidly in recent years and it is located opposite Taiwan from across the sea geographically, so shipping develops faster. Therefore, I choose Shanghai - Guangzhou as the first calling ports plan and Shanghai - Xiamen - Guangzhou as the second calling ports plan.

Distance between the three ports: kilometres

Table 3.1-1

Distance(nm)	CNSHA	CNXMN	CNCAN
CNSHA	-	640	957
CNXMN	640	-	317
CNCAN	957	317	-

Data Source：http://www.jctrans.com/ziliao/port-mileage1.asp

Draught Limitation of each port: metres

Table 3.1-2

Port	CNSHA	CNXMN	CNCAN
DFT(m)	15	13	14

3.2. Schedule of voyages

Lane schedule scheme is to determine the interval time of two voyages. Planning the schedule scheme mainly considers the goods flow on the lane and the influence that the schedule on the competitiveness. Nowadays with the rapid development of domestic trade, domestic coastal container schedule is very close, furthermore according to the combination of the following schedule of round-trip voyage, so I choose five days and seven days schedule.

3.3. Speed of a ship

Under the specific operating environment and economic conditions, using different speeds, ship operating economic effect is not the same. Too slow makes the ship turnover slow and lose the income; too fast, although it can accelerate the ship turnover and increase ship operating income, bunker costs increase sharply and this may cause the loss outweights the gain. When a ship is in the actual use, the operation environment and economic condition may often change, such as lane changing, changes of ample sources, improvement of port handling efficiency, increasing of fuel prices and etc. In actual operation process, we should often follow a ship technical performance, and combine the environmental condition to determine the best speed should be used. According to the practical situation of Shanghai Baoyin Shipping Co., I choose 14.4 knots and 16 knots as the vessel speed.

3.4. Ship Volume

Comprehensive analyzing "Shanghai - Guangzhou" lane cargo volume situation and the voyage time, I choose ships below 1000TEU. Considering from Shanghai to Guangzhou is about 320TEU every week and 350TEU from Guangzhou to Shanghai every week. Further considering direct route can bring cargo increasing and impact by the fiancial crisis, so I choose bigger than 250TEU. Meanwhile, considering Shanghai to Guangzhou Lane maritime distance is 957nm, and the distance is the medium. Analyzing from the aspect of the transportation cost, ship size can’t exceed 800TEU, meanwile in consideration of the slot utlization rate should be more than 70%. Synthesizing the above factors, this paper chooses 319TEU, 412TEU and 610TEU three kinds of ships for the Baoyin Shipping Co., to demonstrate.

Table 3.4-1

<table>
<tr><th></th><th>Ship Type 1</th><th>Ship Type 2</th><th>Ship Type 3</th><th>Remark</th></tr>
<tr><td>Ship Type
(TEU)</td><td>319.00</td><td>412.00</td><td>610.00</td><td rowspan="4">Data Source：China Shipbuilding net http://www.shipbuilding.com.cn/technic_shiptype_show.php</td></tr>
<tr><td>Speed VⅠ
(knot)</td><td>14.40</td><td>14.40</td><td>14.40</td></tr>
<tr><td>Speed VⅡ
(knot)</td><td>16.00</td><td>16.00</td><td>16.00</td></tr>
<tr><td>Main engine fuel consumption OCMⅠ(ton/day)</td><td>15.10</td><td>16.40</td><td>19.17</td></tr>
</table>

Main engine fuel consumption OCMⅡ(ton/day)	4.50	5.10	5.80	
Newbuilding Ship Price (10,000dollars)	1050	1355	1710	

Chapter4. Liner Shipping Route Optimization

4.1. Operating indexes evaluation

4.1.1. Operating time (Operating rate=95%)

According to experience, operating rate takes around 95%, including voyage sailing time, berthing time and etc.

4.1.2. Round-trip sailing time (Tsr)

Tsr=2*L/V （L - voyage distance, V - speed of the vessel）

Under calling port scheme (a), vessel speed is 14.4 knots:

Table 4.1.2-1

	Ship Type 1	Ship Type 2	Ship Type 3	Remark
Speed VⅠ (knots)	14.40	14.40	14.40	Tsr=2*L/VⅠ（L=957nm）
Voyage sailing time Tsr(day)	5.54	5.54	5.54	

Under calling port scheme (b), vessel speed is 16 knots:

Table 4.1.2-2

	Ship Type 1	Ship Type 2	Ship Type 3	Remark
Speed VⅡ (knot)	16.00	16.00	16.00	TsrⅡ=2*L/VⅡ（L=957nm）
Voyage sailing time Tsr (day)	4.98	4.98	4.98	

4.1.3. Voyage anchor time (TPr)

$T_{pr}=Q/M_1+Q/M_2$

Q—single voyage capacity (TEU)

M1、M2—total efficiency of loading&discharging&berthing at POL&POD

These 3 kinds of ships just need a bridge crane to complete. At each port, it takes three minutes to load or discharge a container and it doesn't consider the volume imbalance. Taking M1 = M2, in the (a) calling scheme I take 75% of total capacity and (b) calling scheme taking 85% of total capacity.

Therefore, under calling scheme (a),

Table 4.1.3-1

	Ship type 1	Ship Type 2	Ship Type 3	Remark
Ship Type (TEU)	319.00	412.00	610.00	T_{pr}=Q/M1+Q/M2
Voyage Berthing Time (T_{pr})	1.99	2.58	3.81	

Under calling scheme (b), due to calling at Xiamen Port, the voyage berthing time should plus loading and discharging time at Xiamen Port.

Table 4.1.3-2

	Ship Type 1	Ship Type 2	Ship Type 3	Remark
Ship Type (TEU)	319.00	412.00	610.00	Tpr=Q/M1+Q/M2
Voyage Berthing Time (TPr’)	3.39	4.38	6.48	

4.1.4. Round-trip voyage time (Tspr= Tsr+Tpr)

Assuming the total surplus time of round-trip voyage is one day.

Under calling scheme (a), voyage speed is 14.4 knots,

Table 4.1.4-1

	Ship Type 1	Ship Type 2	Ship Type 3	备注
Voyage Time (Tsr)	5.54	5.54	5.54	TsprⅠ=TsrⅠ+Tpr
Voyage Berthing Time (TPr)	1.99	2.58	3.81	
Total Surplus Time	1	1	1	
Round-Trip Voyage Time (TsprⅠ)	8.53	9.11	10.35	

Under calling scheme (a), voyage speed is 16 knots,

Table 4.1.4-2

	Ship Type 1	Ship Type 2	Ship Type 3	Remark
Voyage Time (Tsr)	4.98	4.98	4.98	TsprⅠ=TsrⅠ+Tpr
Voyage Berthing Time (TPr)	1.99	2.58	3.81	
Total Surplus Time	1	1	1	

Round-Trip Voyage Time (TsprⅠ’)	7.98	8.56	9.80	

Under calling scheme (b), voyage speed is 14.4 knots,

Table 4.1.4-3

	Ship Type 1	Ship Type 2	Ship Type 3	Remark
Voyage Time (Tsr)	5.54	5.54	5.54	TsprⅠ=TsrⅠ+Tpr
Voyage Berthing Time (TPr)	3.40	4.38	6.48	
Total Surplus Time	1	1	1	
Round-trip Voyage Time (TsprⅡ)	9.93	10.92	13.02	

Under calling scheme (b), voyage speed is 16 knots,

Table 4.1.4-4

	Ship Type 1	Ship Type 2	Ship Type 3	Remark
Voyage Time (Tsr)	4.98	4.98	4.98	TsprⅠ=TsrⅠ+Tpr
Voyage Berthing Time (TPr)	3.40	4.38	6.48	
Total Surplus Time	1	1	1	
Round-trip Voyage Time (TsprⅡ’)	9.37	10.36	12.47	

4.1.5. Round-trip times anually (n)

n=operating time/round-trip voyage time

Under calling scheme (a), voyage speed is 14.4 knots,

Table 4.1.5-1

	Ship Type 1	Ship Type 2	Ship Type 3	Remark
Annual operating time (T)	346.75	346.75	346.75	365*0.95 (operating rate is 0.95)
Annual round-trip times (nⅠ)	40	38	33	nⅠ=INT(annual operating time/round-trip voyage time)

Under calling scheme (a), voyage speed is 16 knots,

Table 4.1.5-2

	Ship Type 1	Ship Type 2	Ship Type 3	Remark
Annual operating time (T)	346.75	346.75	346.75	365*0.95 (operating rate is 0.95)
Annual round-trip times (nⅠ’)	43	40	35	nⅠ'= INT(annual operating time/round-trip voyage time)

Under calling scheme (b), voyage speed is 14.4 knots,

Table 4.1.5-3

	Ship Type 1	Ship Type 2	Ship Type 3	Remark
Annual operating time (T)	346.75	346.75	346.75	365*0.95 (operating rate is 0.95)
Annual round-trip times (nⅡ)	34	31	26	nⅡ = INT(annual operating time/round-trip voyage time)

Under calling scheme (b), voyage speed is 16 knots,

Table 4.1.5-4

	Ship Type 1	Ship Type 2	Ship Type 3	Remark
Annual operating time (T)	346.75	346.75	346.75	365*0.95 (operating rate is 0.95)
Annual round-trip times (nⅡ’)	36	33	27	nⅡ'= INT（INT(annual operating time/round-trip voyage time)

4.1.6. Fuel consumption of a single ship anually

Main engine daily voyage fuel consumption: OCM

Auxiliary engine daily voyage fuel consumpion is 10% of the main engine, namely, OCG=0.1OCM

Auxiliary engine and boiler daily berthing fuel consumption=0.8OCG

Main engine 70% sailing time uses bunker oil and 30% sailing time uses light oil; both of the auxiliary engine and boiler use light oil.

Bunker oil: WH = 0.7Tsr *OCM*n

Light oil: Wl=0.3Tsr*OCM*n+0.1Tsr*OCM*n+0.8Tpr*OCM*n=（0.4 Tsr+0.8 Tpr）*OCM*n

Table 4.1.6-1

	Ship Type 1	Ship Type 2	Ship Type 3
Main engine daily voyage fuel consumption OCMⅠ(ton/day)	15.10	16.40	19.17
Main engine daily berthing fuel consumption OCMⅡ(ton)	4.50	5.10	5.80
Round-Trip Voyage time (TsprⅠ)	8.53	9.11	10.35
Round-Trip Voyage time (TsprⅠ’)	7.98	8.56	9.80
Round-Trip Voyage time (TsprⅡ)	9.93	10.92	13.02
Round-Trip Voyage time (TsprⅡ’)	9.37	10.36	12.47

Round-trip times anually (nⅠ)	40	38	33
Round-trip times anually (nⅠ')	43	40	35
Round-trip times anually (nⅡ)	34	31	26
Round-trip times anually (nⅡ')	36	33	27
Bunker Oil - WhⅠ(ton)	2341.55	2415.98	2452.46
Bunker Oil - WhⅠ'(ton)	2265.45	2288.83	2340.99
Bunker Oil - WhⅡ (ton)	1990.32	1970.93	1932.24
Bunker Oil - WhⅡ' (ton)	1896.65	1888.28	1805.90
Light Oil WlⅠ	2301.41	2664.35	3330.87
Lignt Oil WlⅠ'	2330.18	2659.26	3384.10
Light Oil WlⅡ	2529.41	2906.67	3688.45
Light Oil WlⅡ'	2557.77	2974.3	3715.65

4.2. Ship financial indexes evaluation

4.2.1. Ship Price (P)

A vessel is put into operation, we should mainly consider new building ship price.

Table 4.2.1-1

	Ship Type 1	Ship Type 2	Ship Type 3
New building Ship Price (10,000 dallars)	1050.00	1355.00	1710.00

4.2.2. Analysis of Ship’s capital sources and conditions

From the general experience, an ordinary enterprise can only solve about one-third of capital when investing on a ship and two-thirds of capital mainly relys on external source.

4.2.3. Ship cost and depreciation (S1)

(1) Capital cost and depreciation

Usually we use "straight-line depreciation method" to calculate. Through searching the materials I obtain container ship of such type average life is 20 years and the residual value is 8% of the original value, depreciation cost S1，

$$S1= (P-L)/N=P\ (1-8\%)/N=92\%P/N$$

S1——depreciation cost (CNY);

P——Ship Investment Capital (CNY);

L——Ship Residual Value;

N——Depreciation Life (ship expected service life)

Table 4.2.3-1

	Ship Type1	Ship Type 2	Ship Type 3	Remark
Newbuilding Ship Price P (10,000 dallars)	1050.00	1355.00	1710.00	
Depreciation S1 (10,000 dallars)	48.3	62.3	78.7	S1=(P-L)/N=P(1-8%)/N=92%P/N，N=20 years

4.2.4. Annual crew costs (S2)

The crew cost is the crew's (including trainees) all expenditures who is working on the vessels, including crew basic salary, various subsidies and allowances, and training expenses, welfare expenses, travelling expenses and other expenses. In two schedules and two calling ports schemes, crew cost is the same. According to Shanghai Baoyin Shipping Company's datas over the years showes that:

Ship Type 1—319TEU: Annual Crew Cost S2=280,000 dallars

Ship Type 2—412TEU: Annual Crew Cost S2=330,000 dallars

Ship Type 3—610TEU: Annual Crew Cost S2=350,000 dallars

4.2.5. Annual repair expenses (S3)

Ship's daily maintenance and repairing lead to regular maintenance costs and ship's periodic repair costs. Repairing cost is according to the percentage of the ship price, taking 3% of the ship price of the annual maintenance and repairing costs:

S3=P*3%

Table 4.2.5-1

	Ship Type 1	Ship Type 2	Ship Type 3	Remark
New building Ship Price P (10,000 dallars)	1050.00	1355.00	1710.00	
Annual Repairing Cost S_3（10,000dallars）	31.5	40.7	51.3	S_3=P*3%

4.2.6. Annual premium (S4)

The premium is for shipowners to have the insurance of ships, such as ship risks, freight insurance, the crew risks and etc. According to the current situation of the insurance company, in this paper the cost of insurance premium takes 1.0% of the ship price.

Annual Premium: S4=P*1.0%

Table 4.2.6-1

	Ship Type 1	Ship Type 2	Ship Type 3	Remark
Newbuilding Ship Price P (10,000dallars)	1050.00	1355.00	1710.00	
Annual Premium S4 (10,000dallars)	10.5	13.55	17.10	S4=P*1.0%

4.2.7. Annual fuel oil costs (S5=500*WH+650*WL)

WH—annual bunker oil consumption

WL—annual light oil consumption

According to the market fuel price in 2011, bunker oil is 650USD/ton and light oil is 800USD/ton.

Table 4.2.7-1

Scheme	1	2	3	4	5	6	7	8
Lane	SH-GZ	SH-GZ	SH-GZ	SH-GZ	SH-GZ	SH-GZ	SH-GZ	SH-GZ
Ship Capacity/Ship Type (TEU)	319.00	319.00	319.00	319.00	412.00	412.00	412.00	412.00
Ship Speed (knots)	14.40	14.40	16.00	16.00	14.40	14.40	16.00	16.00
Schedule (day)	5.00	7.00	5.00	7.00	5.00	7.00	5.00	7.00
Annual Bunker Oil Consumption (ton)	2341.55	2341.55	2265.45	2265.45	2415.98	2415.98	2288.83	2288.83
Annual Light Oil Consumption (ton)	2301.41	2301.41	2330.18	2330.18	2664.35	2664.35	2659.26	2659.26
Annual Bunker Oil Cost (USD)	1522007	1522007	1472541	1472541	1570388	1570388	1487736	1487736
Annual Light oil Cost (USD)	1841126	1841126	1864140	1864140	2131482	2131482	2127408	2127408
Annual Fuel Oil Cost S_5 I （10,000USD）	336.31	336.31	333.67	333.67	370.19	370.19	361.51	361.51

Scheme	9	10	11	12	13	14	15	16
Lane	SH-GZ	SH-GZ	SH-GZ	SH-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ
Ship Capacity/Ship Type (TEU)	610.00	610.00	610.00	610.00	319.00	319.00	319.00	319.00
Ship Speed (knots)	14.40	14.40	16.00	16.00	14.40	14.40	16.00	16.00
Schedule (day)	5.00	7.00	5.00	7.00	5.00	7.00	5.00	7.00
Annual Bunker Oil Consumption (ton)	2452.46	2452.46	2340.99	2340.99	1990.32	1990.32	1896.65	1896.65
Annual Light Oil Consumption (ton)	3330.87	3330.87	3384.10	3384.10	2529.41	2678.20	2557.77	2392.15
Annual Bunker Oil Cost (USD)	1594100	1594100	1521641	1521641	1293706	1293706	1232825	1232825
Annual Light oil Cost (USD)	2664694	2664694	2707283	2707283	2023526	2142557	2046219	1913719
Annual Fuel Oil Cost S_5 I （10,000USD）	425.88	425.88	422.89	422.89	331.72	343.63	327.90	314.65

Scheme	17	18	19	20	21	22	23	24
Lane	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ
Ship Capacity/Ship Type (TEU)	412.00	412.00	412.00	412.00	610.00	610.00	610.00	610.00
Ship Speed (knots)	14.40	14.40	16.00	16.00	14.40	14.40	16.00	16.00
Schedule (day)	5.00	7.00	5.00	7.00	5.00	7.00	5.00	7.00
Annual Bunker Oil Consumption (ton)	1970.93	1970.93	1888.28	1888.28	1932.24	1932.24	1805.90	1805.90
Annual Light Oil Consumption (ton)	2906.66	3094.19	2974.30	2739.19	3688.45	3830.31	3715.65	3715.65
Annual Bunker Oil Cost (USD)	1281106	1281106	1227382	1227382	1255958	1255958	1173838	1173838
Annual Light oil Cost (USD)	2325331	2475353	2379440	2191353	2950757	3064248	2972519	2972519
Annual Fuel Oil Cost S5 I （10,000USD）	360.64	375.65	360.68	341.87	420.67	432.02	414.64	414.64

4.2.8. Annual lubricating oil costs (S6)

According to the datas in Baoyin Shipping, lubricating oil costs is 7%-10% of the fuel oil cost. Here I take 8% of the fuel oil costs.

4.2.9. Material and supplies costs (S7)

Material and supplies cost is 10% of fuel oil cost.

S7 =fuel oil cost*10%

4.2.10. Annual port charges (S8)

This charge includes harbour dues, agency fee, tug charges and etc occurring in the port.

S8 = Average port charges each voyage * Annual voyage times

Shanghai Baoyin Shipping should pay 65USD port charges in Shanghai Port per TEU and 70USD port charges in Guangzhou Port per TEU.

4.2.11. Administration cost and other costs (S9)

This cost is 20% of the total operating cost.

4.2.12. Total cost (YC)

YC=S1+S2+S3+S4+S5+S6+S7+S8+S9

4.2.13. Annual freight revenue (F)

F=Q*f

Q— Single boat annual capacity (TEU)

F — Lane freight (USD/TEU)

Recently, from Shanghai to Hangzhou the ocean freight maintains around 200-600USD, Shanghai Baoyin Shipping OFT rate is 450USD/TEU.

Data Source: Shipping China, FCL price, http://ship.shippingchina.com/fclprice/index/index.html

4.2.14. Annual income (AⅠ)

AⅠ= freight revenue FⅠ- total cost YCⅠ+ depreciation cost S1

Table 4.2.14-1

Scheme	1	2	3	4	5	6	7	8
Lane	SH-GZ	SH-GZ	SH-GZ	SH-GZ	SH-GZ	SH-GZ	SH-GZ	SH-GZ
Ship Capacity/Ship Type (TEU)	319.00	319.00	319.00	319.00	412.00	412.00	412.00	412.00
Ship Speed (knots)	14.40	14.40	16.00	16.00	14.40	14.40	16.00	16.00
Schedule (day)	5.00	7.00	5.00	7.00	5.00	7.00	5.00	7.00
Annual Fuel Oil Cost S_5 I （10,000USD）	336.31	336.31	333.67	333.67	370.19	370.19	361.51	361.51
Annual lubricating oil costs S_6 I （10.000USD）	26.91	26.91	26.69	26.69	29.61	29.61	28.92	28.92
Material and supplies costs S_7 I （10,000USD）	33.63	33.63	33.37	33.37	37.02	37.02	36.15	36.15
Annual port charges S_8 I （10，000USD）	258.39	258.39	277.77	277.77	317.03	317.03	333.72	333.72
Administration cost and other costs S_9 I	26.11	26.11	26.01	26.01	30.77	30.77	30.45	30.45
Total cost (YC) （10,000USD）	799.65	799.65	815.81	815.81	934.15	934.15	940.29	940.29
Annual freight revenue F (USD)	861.30	861.30	925.90	925.90	1056.78	1056.78	1112.40	1112.40
Annual income （10，000USD）	109.95	109.95	158.39	158.39	184.96	184.96	234.44	234.44

Scheme	9	10	11	12	13	14	15	16
Lane	SH-GZ	SH-GZ	SH-GZ	SH-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ
Ship Capacity/Ship Type (TEU)	610.00	610.00	610.00	610.00	319.00	319.00	319.00	319.00
Ship Speed (knots)	14.40	14.40	16.00	16.00	14.40	14.40	16.00	16.00
Schedule (day)	5.00	7.00	5.00	7.00	5.00	7.00	5.00	7.00
Annual Fuel Oil Cost S_5 I （10,000USD）	425.88	425.88	422.89	422.89	331.72	343.63	327.90	314.65
Annual lubricating oil costs S_6 I （10.000USD）	34.07	34.07	33.83	33.83	26.54	27.49	26.23	25.17
Material and supplies costs S_7 I （10,000USD）	42.59	42.59	42.29	42.29	33.17	34.36	32.79	31.47
Annual port charges S_8 I （10，000USD）	407.63	407.63	432.34	432.34	248.92	248.92	263.56	263.56
Administration cost and other costs S_9 I	36.01	36.01	35.90	35.90	25.94	26.37	25.80	25.33
Total cost (YC) （10,000USD）	1128.24	1128.24	1149.31	1149.31	784.59	799.07	794.59	778.48
Annual freight revenue F (USD)	1358.78	1358.78	1441.13	1441.13	829.72	829.72	878.53	878.53
Annual income （10，000USD）	309.19	309.19	370.47	370.47	93.43	78.95	132.24	148.35

Scheme	17	18	19	20	21	22	23	24
Lane	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ
Ship Capacity/Ship Type (TEU)	412.00	412.00	412.00	412.00	610.00	610.00	610.00	610.00
Ship Speed (knots)	14.40	14.40	16.00	16.00	14.40	14.40	16.00	16.00
Schedule (day)	5.00	7.00	5.00	7.00	5.00	7.00	5.00	7.00
Annual Fuel Oil Cost S_5 I （10,000USD）	360.64	375.65	360.68	341.87	420.67	432.02	414.64	414.64
Annual lubricating oil costs S_6 I （10.000USD）	28.85	30.05	28.85	27.35	33.65	34.56	33.17	33.17
Material and supplies costs S_7 I （10,000USD）	36.06	37.56	36.07	34.19	42.07	43.20	41.46	41.46
Annual port charges S_8 I （10，000USD）	293.12	293.12	312.03	312.03	363.99	363.99	377.99	377.99
Administration cost and other costs S_9 I	30.42	30.96	30.42	29.75	35.82	36.23	35.61	35.61
Total cost (YC) （10,000USD）	898.63	916.87	917.59	894.72	1078.26	1092.06	1084.92	1084.92
Annual freight revenue F (USD)	977.06	977.06	1040.09	1040.09	1213.29	1213.29	1259.96	1259.96
Annual income （10，000USD）	140.76	122.52	184.84	207.71	213.69	199.89	253.69	253.69

From the above table, I can conclude that directly from Shanghai to Guangzhou, using 610TEU vessel, choosing 16knots as ship speed and using five or seven days schedule can make the biggest annual income. (Scheme 11&12)

4.2.15. Net profit

Turnover Tax = Freight revenue * 3%

Annual income tax = (Freight revenue – total cost – turnover cost) * 33%

4.3. Ship investment indexes evaluation

Table 4.3-1

Scheme	1	2	3	4	5	6	7	8
Lane	SH-GZ	SH-GZ	SH-GZ	SH-GZ	SH-GZ	SH-GZ	SH-GZ	SH-GZ
Ship Type (TEU)	319.00	319.00	319.00	319.00	412.00	412.00	412.00	412.00
Ship Speed (knots)	14.40	14.40	16.00	16.00	14.40	14.40	16.00	16.00
Schedule (day)	5.00	7.00	5.00	7.00	5.00	7.00	5.00	7.00
NPV	-220.02	-220.02	141.73	141.73	37.73	37.73	407.29	407.29
NPVI	-0.21	-0.21	0.13	0.13	0.03	0.03	0.30	0.30
AAC (10,000USD)	98.58	98.58	114.75	114.75	29.45	29.45	35.59	35.59
RFR	53.10	53.10	57.49	57.49	12.93	12.93	14.84	14.84
BCR	0.14	0.14	0.19	0.19	0.20	0.20	0.25	0.25
IRR	6%	6%	10%	10%	10%	10%	15%	15%
PBP	6.22	6.22	5.50	5.50	5.50	5.50	3.20	3.20

Scheme	9	10	11	12	13	14	15	16
Lane	SH-GZ	SH-GZ	SH-GZ	SH-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ
Ship Type (TEU)	610.00	610.00	610.00	610.00	319.00	319.00	319.00	319.00
Ship Speed (knots)	14.40	14.40	16.00	16.00	14.40	14.40	16.00	16.00
Schedule (day)	5.00	7.00	5.00	7.00	5.00	7.00	5.00	7.00
NPV	613.59	613.59	1071.27	1071.27	-343.45	-451.56	-53.59	66.75
NPVI	0.36	0.36	0.63	0.63	-0.33	-0.43	-0.05	0.06
AAC (10,000USD)	-13.49	-13.49	7.58	7.58	83.53	98.00	93.53	77.41
RFR	-4.61	-4.61	2.44	2.44	46.70	54.80	49.39	40.88
BCR	0.27	0.27	0.32	0.32	0.12	0.10	0.17	0.19
IRR	17%	17%	19%	19%	3%	2%	9%	9%
PBP	2.80	2.80	2.30	2.30	8.00	8.20	6.00	5.80

Scheme	17	18	19	20	21	22	23	24
Lane	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ
Ship Type (TEU)	412.00	412.00	412.00	412.00	610.00	610.00	610.00	610.00
Ship Speed (knots)	14.40	14.40	16.00	16.00	14.40	14.40	16.00	16.00
Schedule (day)	5.00	7.00	5.00	7.00	5.00	7.00	5.00	7.00
NPV	-292.41	-428.66	36.82	207.64	-99.75	-202.82	199.05	199.05
NPVI	-0.22	-0.32	0.03	0.15	-0.06	-0.12	0.12	0.12
AAC (10,000USD)	-6.08	12.17	12.88	-9.99	-63.47	-49.67	-56.81	-56.81
RFR	-2.89	5.78	5.75	-4.46	-24.27	-18.99	-20.92	-20.92
BCR	0.16	0.13	0.20	0.23	0.20	0.18	0.23	0.23
IRR	5%	3%	9%	11%	9%	9%	12%	12%
PBP	7.50	8.00	5.70	4.00	5.70	6.00	3.30	3.30

4.3.1. Net Present Value (NPV)

NPV means the difference between the present value of cash inflows and the present value of cash outflows. NPV is used in capital budgeting to analyze the profitability of an investment or project. NPV analysis is sensitive to the reliability of future cash inflows that an investment or project will yield.

NPV—Net Present Value (the bigger the better)

P—Ship price

N—Ship use age

A—Ship annual income, asuming that annual income is the same each year

L—Ship residual value (8% of the ship price)

I—12 %(marine enterprise base earnings ratio)

Look up the table and get: (P/A, I, n) = (P/A, 12%, 20) = 7.469

(P/F, I, n) = (P/F, 12%, 20) = 0.104

NPV=NA*(P/A, i, N) + L (P/F, i, N) - P

According to the above calculation from table 4.3-1, I get the same answer as the biggest annual income that directly from Shanghai to Guangzhou, using 610TEU vessel, choosing 16knots as ship speed and using five or seven days schedule are two best choices. (Scheme 11&12)

4.3.2. Net Present Value Index (NPVI)

Net Present Value Index (NPVI) equals Net Present Value (NPV) divide initial investment (P) and its value is also the bigger the better.

NPVI = NPV / P (ship price)

The result is also the same as above from table 4.3-1. (Scheme 11&12)

4.3.3. Average Annual Cost index (AAC)

Here assuming that operating cost every year is the same.

AAC=Y+P(A/P,i,N)-L (A/F,i，N)

Look up the table and get: (A/P, 12%, 20) = 0.104

(A/F, 12%, 20) = 9.646

AAC Ⅰ = total cost Y + P (A/P, i, N) - L (A/F, I, N)

The smaller the AAC is, the bigger the profits are. Therefore from the above calculated table 4.3-1, scheme 21 is the best one which is to choose the second Lane from Shanghai to Xiamen to Guangzhou, use 610TEU vessel, 14.4knots speed and 5days schedule. (Scheme 21)

4.3.4. Required Freight Rate index (RFR)

Required Freight Rate is in order to get to the scheduled base earnings ratio, transporting unit volume can get the needful freight revenue. Its value should be the lower the better.

RFR=ACC/∑Q (1-t)

Q — annual single ship transport volume

T — turnover tax (here we take 3%)

Therefore from the above calculated table 4.3-1, scheme 21 is the lowest one which is to choose the second Lane from Shanghai to Xiamen to Guangzhou, use 610TEU vessel, 14.4knots speed and 5days schedule the same as the result of the ACC. (Scheme 21)

4.3.5. Benefit-Cost Ratio index (BCR)

BCR is investment prioroties' income present value comparing to cost present value. Assuming the annual income and annual total cost are always the same.

BCR=A/YC

BCR—benefit – cost ratio

A—annual income

YC—annual total cost

After calculation, I get scheme 11&12 are the two highest ones. From Shanghai to Guangzhou, using 610TEU vessel, choosing 16knots as ship speed and using five or seven days schedule are two best choices.

4.3.6. Internal rate of return index (IRR)

Internal rate of return is a rate of return used in capital budgeting to measure and compare the profitability of investments. The internal rate of return on an investment or project is the "annualized effective compounded return rate" or discount rate that makes the net present value (NPV) of all cash flows (both positive and negative) from a particular investment equal to zero. That is to say, when making decision analysis of a long term investment, we should choose the program with a bigger internal rate of return.

Σ NCFt ×（P / F，IRR，t）=0

IRR is an investment rate of return that a certain investment's NPV during the economic use period equals zero. Due to IRR index is implicit function, we can't use functional expression directly to solve. Generally, we use interpolation method iteration to get the solution.

Then, we get scheme 11&12's IRR is the biggest one - 19%. Thus directly from Shanghai to Guangzhou, using 610TEU vessel, choosing 16knots as ship speed and using five or seven days schedule are two best choices.

4.3.7. Pay Back Period index (PBP)

Payback period in capital budgeting refers to the period of time required for the return on an investment to "repay" the sum of the original investment. The time value of money is not taken into account. Payback period intuitively measures how long something takes to "pay for itself." All else being equal, shorter payback periods are preferable to longer payback periods.

PBP = Cost of project/ Annual cash inflows

PBP holds that all other things being equal, the better investment is the one with shorter payback time.

$$PBP = \frac{\lg\left(\frac{A}{A - pi}\right)}{\lg(1+i)}$$

A— Annual income (10,000dallars)

After calculating, I get the table row of PBP that scheme 11 and 12 are the two best ones which only need 2.3years Pay Back Period. From Shanghai to Guangzhou, using 610TEU vessel, choosing 16knots as ship speed and using five or seven days schedule are two best choices.

4.4. Comprehensive evaluating indexes

In these twenty four schemes, none of the scheme can make the above indexes come to optimization. Thus we need to convert and synthesize these indexes, namely to use multiobjective method to synthesize the different types of ships and get the best type of ship.

During the process of argumentation, I use linear weighted sum method to analyze and optimize. Through analysis, I give the six indexes NPV, NPVI, ACC, RFR, BCR, IRR and PBP weighting coefficient 0.2, 0.05, 0.15, 0.15, 0.15, 0.15 and 0.15. Here AAC, RFR and PBP do as negative value.

The below table shows the 24 schemes' comprehensive evaluation index:

Table 4.4-1

Scheme	1	2	3	4	5	6	7	8
Lane	SH-GZ	SH-GZ	SH-GZ	SH-GZ	SH-GZ	SH-GZ	SH-GZ	SH-GZ
Ship Type (TEU)	319.00	319.00	319.00	319.00	412.00	412.00	412.00	412.00
Ship Speed (knots)	14.40	14.40	16.00	16.00	14.40	14.40	16.00	16.00
Schedule (day)	5.00	7.00	5.00	7.00	5.00	7.00	5.00	7.00
NPV	-220.02	-220.02	141.73	141.73	37.73	37.73	407.29	407.29
NPVI	-0.21	-0.21	0.13	0.13	0.03	0.03	0.30	0.30
AAC (10,000USD)	98.58	98.58	114.75	114.75	29.45	29.45	35.59	35.59
RFR	53.10	53.10	57.49	57.49	12.93	12.93	14.84	14.84
BCR	0.14	0.14	0.19	0.19	0.20	0.20	0.25	0.25
IRR	6%	6%	10%	10%	10%	10%	15%	15%
PBP	6.22	6.22	5.50	5.50	5.50	5.50	3.20	3.20
Comprehensive indexes	(67.82)	(67.82)	1.92	1.92	0.49	0.49	73.83	73.83

Scheme	9	10	11	12	13	14	15	16
Lane	SH-GZ	SH-GZ	SH-GZ	SH-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ
Ship Type (TEU)	610.00	610.00	610.00	610.00	319.00	319.00	319.00	319.00
Ship Speed (knots)	14.40	14.40	16.00	16.00	14.40	14.40	16.00	16.00
Schedule (day)	5.00	7.00	5.00	7.00	5.00	7.00	5.00	7.00
NPV	613.59	613.59	1071.27	1071.27	-343.45	-451.56	-53.59	66.75
NPVI	0.36	0.36	0.63	0.63	-0.33	-0.43	-0.05	0.06
AAC (10,000USD)	-13.49	-13.49	7.58	7.58	83.53	98.00	93.53	77.41
RFR	-4.61	-4.61	2.44	2.44	46.70	54.80	49.39	40.88
BCR	0.27	0.27	0.32	0.32	0.12	0.10	0.17	0.19
IRR	17%	17%	19%	19%	3%	2%	9%	9%
PBP	2.80	2.80	2.30	2.30	8.00	8.20	6.00	5.80
Comprehensive indexes	125.49	125.49	213.16	213.16	(89.68)	(114.82)	(33.02)	(5.11)

Scheme	17	18	19	20	21	22	23	24
Lane	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ	SH-XM-GZ
Ship Type (TEU)	412.00	412.00	412.00	412.00	610.00	610.00	610.00	610.00
Ship Speed (knots)	14.40	14.40	16.00	16.00	14.40	14.40	16.00	16.00
Schedule (day)	5.00	7.00	5.00	7.00	5.00	7.00	5.00	7.00
NPV	-292.41	-428.66	36.82	207.64	-99.75	-202.82	199.05	199.05
NPVI	-0.22	-0.32	0.03	0.15	-0.06	-0.12	0.12	0.12
AAC (10,000USD)	-6.08	12.17	12.88	-9.99	-63.47	-49.67	-56.81	-56.81
RFR	-2.89	5.78	5.75	-4.46	-24.27	-18.99	-20.92	-20.92
BCR	0.16	0.13	0.20	0.23	0.20	0.18	0.23	0.23
IRR	5%	3%	9%	11%	9%	9%	12%	12%
PBP	7.50	8.00	5.70	4.00	5.70	6.00	3.30	3.30
Comprehensive indexes	(58.40)	(89.87)	3.83	43.35	(7.61)	(31.19)	51.19	51.19

Through the above table, all of us can come to the conclusion that scheme 11 and 12 are the two best choices. Lane first from Shanghai direct to Guangzhou, 610TEU vessel, 16knots ship speed and schedule five or seven days are the most profitable.

Chapter5 Optimal Decision and Sensitivity Analysis

The above indexes' calculation result is based on the determined assumption background. However, actually many parameters are uncertain, for instance fuel oil price will fluctuate, freight rate will be ups and downs, port charges will also change and etc. Parametric uncertainty will lead to result uncertainty, and it will bring us investment risk, so we need to have risk analysis.

Thus in these parameters one or more factors in accordance with the estimated degree will change to beneficial or detrimental direction, then observe the changes impact on the economic analysis to judge these parameters changes' sensitive degree to the schemes, and find out after parameter fluctuations, and how the optimal scheme's main indexes change and the range of the change and law.

This paper chooses fuel oil price and freight rate as two factors, aiming at NPV, NPVI, AAC, RFR, BCR, IRR and PBP indexes to make sensitivity analysis.

Table 5-1 shows that when the ocean freight increases 5% & 10% or decreases 5% & 10%, the degree of the seven indexes change. Chart 5-1 is the line graph which shows the freight rate influencing on each indexes.

Table 5-1

	-10%	-5%	Origional Freight Rate	5%	10%
NPV	-5.11	533.08	1071.27	1609.46	2147.65
NPVI	0.00	0.31	0.63	0.94	1.26
AAC	7.58	7.58	7.58	7.58	7.58
RFR	2.71	2.57	2.44	2.32	2.22
BCR	0.20	0.26	0.32	0.39	0.45
IRR	15%	17%	19%	21%	23%
PBP	2.90	2.60	2.30	2.00	1.70

Chart 5-1

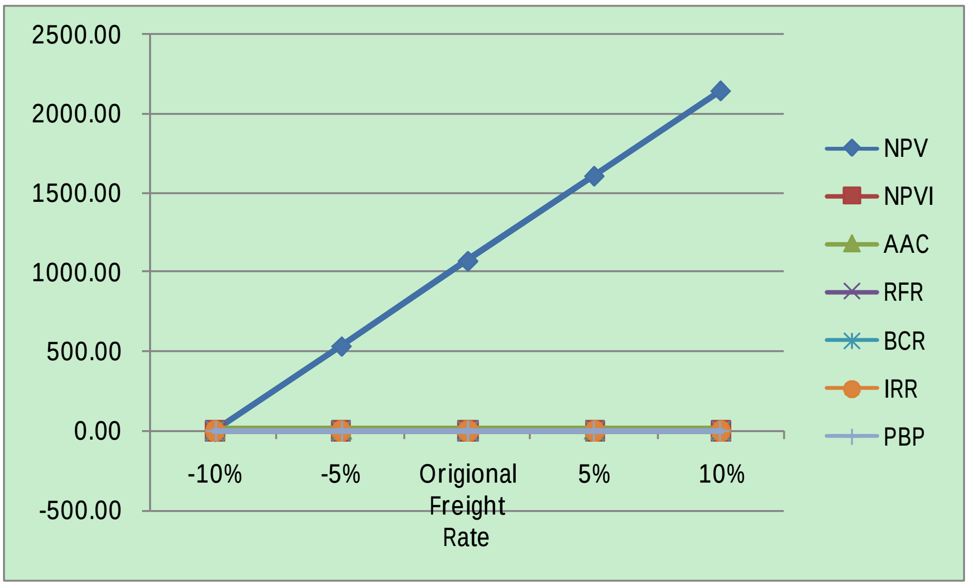
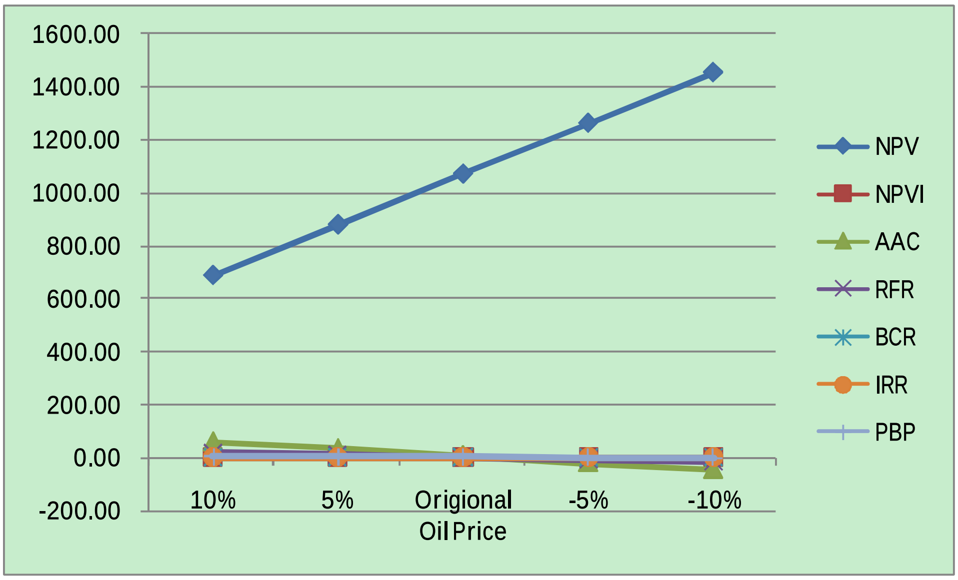


Table 5-2 shows that when the fuel oil price increases 5% & 10% or decreases 5% & 10%, the degree of the seven indexes change. Chart 5-2 is the line graph which shows the fule oil price influencing on each indexes.

Table 5-2

	10%	5%	Origional Oil Price	-5%	-10%
NPV	687.19	879.23	1071.27	1263.31	1455.35
NPVI	0.40	0.51	0.63	0.74	0.85
AAC	59.01	33.29	7.58	-18.13	-43.84
RFR	18.99	10.72	2.44	-5.84	-14.11
BCR	0.27	0.29	0.32	0.35	0.38
IRR	17%	18%	19%	20%	21%
PBP	2.70	2.50	2.30	2.10	1.90

Chart 5-2



From the sensitivity analysis of the above two tables and two charts, we can achieve that the impact by fluctuation of freight rate is bigger than the impact by fluctuation of fuel oil price to these indexes.

Chapter6 Conclusion

From the above calculation and analysis, I come to a conclusion that No. 11 and 12 are the two best choices. Shanghai Baoyin Shipping Co., Ltd can choose to use this scheme which is directly from Shanghai to Guangzhou, using 610TEU container vessel, 16 knots ship speed and schedule five or seven days are the most profitable.

The status quo of China’s coastal container liner shipping is international container transportation in recent years develops rapidly. Optimum cargo volume fitting the container is improved, break-bulk transportation atrophies. Besides heavy and oversize cargo, bulk, liquid and container have become the main body of transportation, because container transportation has obvious advantages. It is also the embodiment of the economic development and social progress. The global economy gradually blends and it gets everyone's approval.

Therefore, a midium-sized shipping enterprise like Shanghai Baoyin Shipping Co., should optimize its profit through opening up a new lane, choosing the calling ports, choosing suitable ships and comfirming the schedule of the voyage and speed of the ship, the profit of this new container lane can reach to the maximization.

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(NPV) Net present value
http://en.wikipedia.org/wiki/Net_present_value

(NPVI) Net Present Value Index (capital budgeting)
http://www.brainmass.com/homework-help/economics/finance/121618

Sensitivity_analysis
http://en.wikipedia.org/wiki/Sensitivity_analysis