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The economic analysis of mega containership

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The Economic Analysis of Mega Containership

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Declaration

I certify that all the material in this research paper that is not my own work has been indentified, and that no material is included for which a degree has previously been conferred on me.

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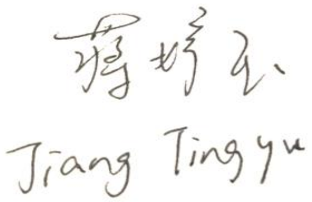

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Abstract

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With the development of global trade and economy, the scale of containerships is becoming bigger and bigger. To keep up with the times, more and more mega containerships show up, which can carry more kinds of goods at a time. The shipping companies pursue the profit maximization and cost minimization when using the mega containerships. As the way to reduce costs, the concept of the enlargement of the containerships comes into being based on the principle of the economy of scale. However, challenges follow. The fluctuation of the global economy, imbalance between supply and demand of the capacity of the routes, limitation of the port infrastructure, and other reasons doesn't make the situation of the mega containerships as well as the shipping companies assumed.

In this dissertation, I will compare the economies of the 13000TEU and 16000TEU containership. By using the NPV as the analysis index to calculate the sensitivity analysis, I will analyze the changes in the uncertainties which influence the economies of mega containerships to find the most sensitive factors.

KEYWORDS: Mega containerships, Economy of scale, NPV, Sensitivity analysis

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Chapter 1 Introduction

1.1. Backgrounds and purpose of the dissertation

International container shipping industry is closely related to the world economy and trade development. There are more than 70% volumes of goods shipped by containerships in the international trade.

According to the news in 2004, with the improved world economy, the shipping market and ship-building market appeared the scene of prosperity which didn't happen in the last decade, especially the containership market. The containership of 7400-8000 TEU was the mainstream custom-made mega containership.

The international shipping market becomes depressed after the financial crisis of year 2008. The maritime container transport market is also affected by the financial crisis that the freight price goes way down. To deal with the situation of the low freight price, ship owners have taken measures to reduce the costs. The enlargement of the containership is one of the major measures to reduce the costs. Therefore, the trend of enlargement of the containership of container transport market is becoming more intense.

According to the Drewry Container Forecaster last year, the annual container throughput is the lowest level ever (1.3%), apart from the global crash in 2009, when growth turned negative. This has been an unexpected double blow for the shipping lines.

Shipping companies are keen on ordering mega containerships to reduce costs. The enlargement of containerships is the production of economy as well. The technology of containership transportation has been mature. Under the impetus of the development of global trade, more mega containerships are ordered to improve market competitiveness. The market is paying more attention on mega containerships. The successful expansion of Panama Canal will also promote the development of the enlargement of containerships.

However, the enlargement of containerships requires certain market conditions for support, will be affected by various factors as well. The mega containerships are promising; however, with the continuous depression of global economy, the supply-demand relation has changed to overcapacity. The economies of mega containerships have been questioned.

The purpose of building of mega containerships is to achieve economy of scale and to get more benefit. The continuous improving ability of the container capacity of the containerships has raised the argument in the container transport industry about how far the enlargement of the container can go. When shipping companies are ordering mega containerships, they consider not only the size of the containership, but also the results brought by the enlargement of the containership.

1.2. Research methodology of the dissertation

The main method for the study is sensitivity analysis. Firstly, select uncertain factors which influence the economics of containership. Secondly, find and analysis the sensitive factors. Finally, evaluate the effect of the economics of mega containerships against the variation of uncertainty factors.

1.3 Literature review

The literature review related to this issue had been divided into three parts. The first part is description of situation of mega containerships market. The second part is advantages and disadvantage of mega containerships. The literatures mainly focus on the economy of scale and limitation of ports. The third part is analysis based on models.

1.3.1 Development of mega containership market

Shao tianjun, (2007), the shipping industry was optimistic about the prospect of containerships because of continuous busy of Asia-Europe route and lower fuel price.

Jin lan, (2011), By the end of March 1, 2011, there were 286 containerships for 8000-11999 TEU; 44 containerships for 12000-15500 TEU. The amount of orders of new containerships was 112 ships for 8000-11999 TEU; 113 containerships for 12000-15500 TEU; 10 containerships for more than 15500TEU.

Shao tianjun, (2012), the reason why the shipping market was in the fever of ordering million boxes container vessels was because of the advantage and economic dividends, energy efficiency, environmental performance, and expansion of the Panama Canal derived from the economy of scale.

Zhu xianchang, Xiang jun, Gu jiajun,(2014),told the development history of the enlargement period of containerships and analyze some factors influencing the development of enlargement such as fuel price, development of world trade, technology of building ships, environmental protection and the condition of harbor and waterways.

Wang hui, (2015), The ultra-large containerships was overcapacity. The demand of ultra-large containerships remained depressed. The vessel capacity on the Asia-Europe route was estimated to increase to 9.1% in 2015.

1.3.2 Advantages and disadvantages of mega containerships

Jiang feng, (1999), the theoretical evidence proved that the building of giant containerships would bring the theory of economy of scale, but the result would be overcapacity. If freight remained unchanged, the profit of unit transportation service would increase with the increase of ship capacity, but more often the bigger the ship, the lower the actual utilization. When the utilization of a 6000TEU containership was under 79%, cost advantage would become a disadvantage. The theory of economy of scale was not a panacea.

Xu wenyu, (2003) Containerships were developing with the needs of trade. The enlargement of the containership leaded to diminishing benefit of theory of economy of scale.

Wu honggao, (2012, June), the enlargement of containership could improve economic benefit of transportation. The theory of economy of scale didn't support the infinite expanding of vessels. The fuel of 10000-ton class vessel should be paid more attention.

Xu zongquan, (2013), the enlargement of containerships brought benefits of economy of scale, environment benefits and promotion of feeder service; challenge on port including waterways, infrastructure, port transportation system and financial pressure and operational risk of shipping company.

Wei wei, (2013), shipping space utilization was the important factor of theory of economy of scale. Overcapacity caused low benefit of theory of economy of scale. If the transportation system of the port was not sufficient, the cargo would be overstocked, which gave heavy pressure on inland transport system. If accidents happened, ports and its surrounding water and environment would be damaged seriously.

Ultra large container ships brings new challenges,(2014), port waterways must be deepen, berth must be extended, container handling equipment and facilities must be improved to keep up with and meet the swell of single ship transport capacity and bigger size of the vessel.

Peter T.Leach, (2015), ITF and WSC publish two reports indicating two totally different views: the total transportation cost of using ultra-large containerships may be considerable because ports and infrastructure need huge amounts of money. With the enlargement of containerships, the effect on reducing cost would be lower; the enlargement of containerships can improve efficiency. Liner companies could share space to improve utilization. ITF paid more attention on the pros of the super vessel, WSC on the contrary.

Zhou hang, (2016), advantage of large ship disappeared because of lower price of shipbuilding, insufficient space utilization, more unit cost and limitation of port infrastructure.

Song zhipeng, (2016), the report "influence of mega ships" indicated that enlargement of containerships was one of the reasons of port congestion. The real work efficiency of each crane was far below the design efficiency. Ultra-large containerships could achieve economy of scale on the sea but create higher cost on land.

1.3.3 Analysis based on models

Guo yonghong, (2000), compared the 6000TEU and 4000TEU containership that fuel cost had saved 20% and compared the standard of income and cost of different types of ships on different route that ship size was not the only factor influencing the economic benefit.

Li Tong, (2006), analyzed the economy of scale of the enlargement of the containership and built the cost model of container shipping. By evaluating the result of the model of calculating the voyage cost at sea, apportioned cost in port and total shipping cost of unit TEU, the optimal scale of ship was 10000TEU, compared with 8000TEU and 12500TEU containership.

Wang xuefeng, (2006), analyzed the real loading rate and built model of transportation cost and inventory cost to get the result that the optimal scale of vessel was 9000TEU, compared with 5754TEU, 8468TEU, and 9600TEU containership.

Zhu mo, Zhang qiang,(2015, September) chose NPV as the reference index of operating economic effect and compared the 13000TEU and 16000TEU containership. The result was that the NPV of 16000TEU was higher than 13000TEU containership, reflecting the advantage of enlargement of containership.

Chapter 2 Current situation of container transportation market

2.1 Trade volume of container cargo

According to the news on the Internet(Report of Global port development, 2016), the container handling capacity of the major global ports have showed a negative growth affected by the slow development of global economy by June this year with the year on year growth rate -0.84%.

In the first quarter, the throughput of Chinese ports fluctuates significantly. Influencing negatively by the economy and trade, the container handling capacity of Chinese ports grow shows a low speed growth. The crude oil price increases sharply, while the demand for the bulk commodity remains low, leading to the slow growth of ports.

The economic recovery of South Korea is not significant. In the first quarter, the economy grows so slowly that the container throughput of Korean port rises 0.54%, growing tends to zero growth.

Affected by the recession of energy market, slowing down growth of global economy, continuous appreciation of dollar, volatility of financial market, the recovery of the United States is inhibited. The throughput rate of major container port is 3.65% increase from the same period last year.

The economy of Euro zone continues to recover and show a slowly increasing trend. The container throughput capacity of major ports grows only 0.37% year on year.

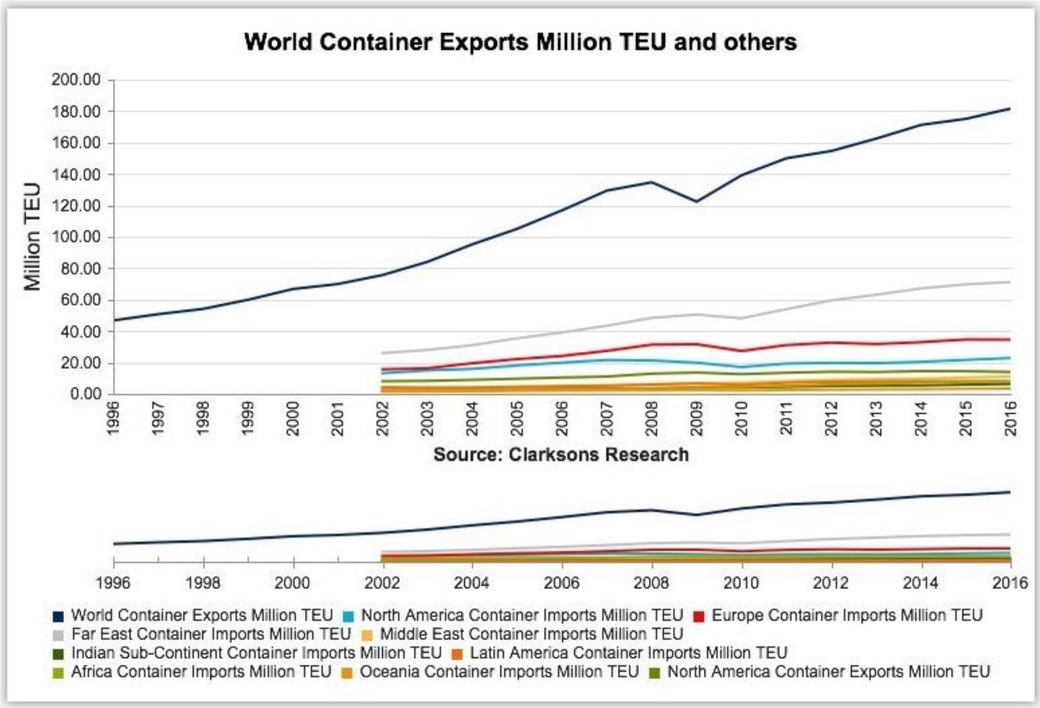


Figure 2-1-World Container Exports

Source: Clarksons Research Services (up to July, 2016)

As shown in figure 2.1, the general trend of the world seaborne container trade is upwards, although the trade volume of the world seaborne container trade decreased during year 2008 and 2010 because of the financial crisis. Through year 1996 to 2016, the volume of the world container trade had increased from the 45 million TEU at the beginning of 1996 to 120 million TEU in 2006 and now up to July, 2016, the volume of the world container exports had increased to 181.67 million TEU.

In the figure 2.1, the largest import country of the container was Far East, far beyond the rest. The volume of the container imports of Far East increased rapidly from 2010 to 2016, increasing about 20 million TEU. The following two big import countries were Europe and North America. The trend of the volume was not as same as the Far East. The import volume of Europe and North America didn't increase a lot from 2010 to 2016. The import volume of Europe increased only 10 million TEU from 2010 to 2016, while the import volume of North America increased less than 5 million TEU.

Table 2-1- Estimated volume changes in container activity

'000 teu	2009	2014	2015	2015 vs 2014	2015 vs 2009
NORTH AMERICA	**42,791**	**55,688**	**57,300**	**1,612**	**14,510**
East Coast North America	15,698	20,568	21,365	797	5,667
Gulf Coast North America	3,623	4,558	4,848	290	1,226
West Coast North America	23,470	30,563	31,087	525	7,617
EUROPE	**92,201**	**120,962**	**117,010**	**-3,952**	**24,809**
North West Europe	44,895	56,968	55,887	-1,081	10,992
Scandinavia & Baltic	6,733	10,535	8,716	-1,819	1,982
West Mediterranean	22,062	26,134	25,887	-247	3,824
East Mediterranean & Black Sea	18,511	27,326	26,522	-805	8,011
ASIA	**247,420**	**367,017**	**374,229**	**7,212**	**126,808**
North Asia	44,550	62,330	62,332	2	17,782
Greater China	134,852	209,488	214,820	5,332	79,968
South East Asia	68,019	95,199	97,077	1,878	29,058
WORLD	**482,554**	**680,342**	**689,091**	**8,749**	**206,537**

Source: Drewry Container Forecaster (Q4, 2015)

As shown in table 2-1, the world container volume increased about 200 million TEU from year 2009 to 2014. The container volume of Asia accounted for a very large proportion in the world container volume among the three. The main trend of the container volume of North America, Europe and Asia was increasing from year 2009 to 2014. The estimated volume of container trade of the three was increasing, except the container volume of Europe decreased from 2014 to 2015.

The container trade volume of the West Coast of North America took the major part of the overall the container volume of North America. The container trade volume of North West Europe took the major part of the overall the container volume of Europe. The container trade volume of China took the major part of the overall the container volume of Asia. Compared the data of 2015 with 2009, the volume of the container of the West Coast of North America increased the most among North America; the container trade volume of North West Europe still took much proportion; the volume of the container of China increased much more than any routes. We can see that China would play the important role in the future world trade development.

2.2 Development of container vessel

The history of containerization has been nearly half a century from the beginning. Containerships enlarge with the increase of transportation volume.

The containership has developed 60 years. From the first 1,530TEU containership in 1968 to the 20,000TEU containership by Maersk now, the enlargement of the containership is inevitable. The development of containership has gone through 6 generations.

The first generation of the containership started from 1957. Containerships are mainly transformed from general cargo ships and cabins of small tramps which can load containers. The typical ship type was 400-700 TEU, from today's perspective, very small.

The second generation of the containership started from 1966. Sealand Company opened the North Atlantic Shipping Line from Europe to United States Atlantic Coast and California routes with Showa Line and NYKLine. This period was the dawn of the container transport. The typical ship type was 1000-2000TEU.

The third generation of the containership started from 1971, which officially carried out the container transport. Containerization started in a succession of routes---Trans-Pacific line, Asia to Europe, Europe to Australia, and the north-south routes. The typical ship type is the period was 2000-3000TEU.

The fourth generation of the containership started from 1982. Due to the participation of operation of Asian shipping companies, the cost competition sharpened. With the popularity of the containerization and decreased ship price of containerships, the barrier of participating container shipping disappeared. The typical type size of containership was 3000-4000TEU.

The fifth generation of the containership started from 1988. The core of container shipping moved from the Atlantic to East Asia and the land bridge transportation of North America developed quickly. At the same time, container global routes used the pendulum mode of transport. With the impetus of the economy of scale, the trend of the enlargement of containerships on each route became more and more intense. The container transport quickly entered into Ultra Panama Era. The typical type of the containership was 4000-8000TEU.

The sixth generation of the containership started from 1999. This period was also called Mega Ship Era. With the rapid development of container transport and rapidly advanced of shipbuilding technology, more and more mega containers hips came out. The size of the containerships was about 8000-15000TEU. (Zhang mengmeng, 2013, p16,17)

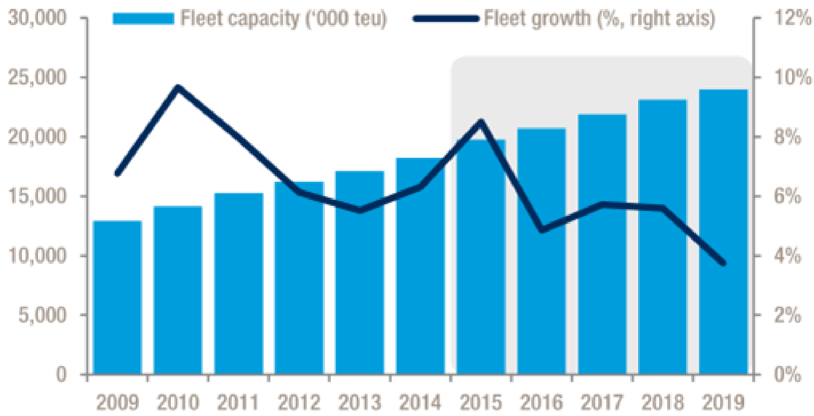
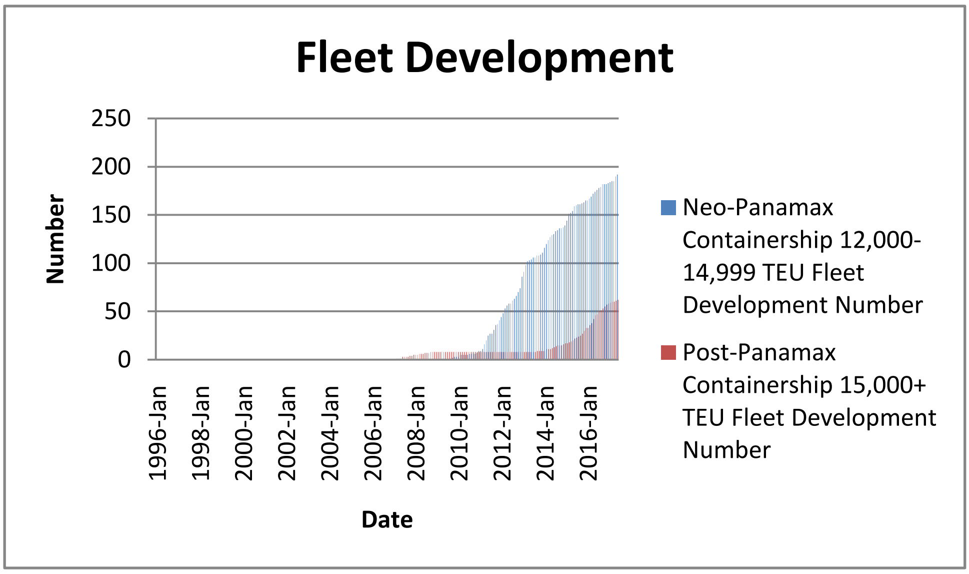


Figure 2-2- Containership fleet development

Source: Drewry Container Forecaster (Q4, 2015)

As shown in figure 2.2, the fleet capacity of the containership fleet kept rising deeply from year 2009 to 2010, which was the highest point of the fleet capacity during the five years. Because of the financial crisis, the fleet capacity was low in 2009. After the financial crisis, the economy began to recover and the containership fleet began to grow with the enlargement of the containerships. After year 2010, the containership fleet started to decline until year 2013, which began to rise after fall. The growth rate was declining. According to the forecast of Drewry, although the fleet would still grow after 2014, the general trend of the containership fleet development would be declining, which was possibly because of the oversupply of the containership fleet.

Figure 2.3 tells the fleet development of the containership which is larger than the 12000TEU containership. We can tell that the fleet development of the 15000+ TEU containership started earlier than the fleet development of the 12000-14999TEU containership. However, the number of the 12000-14999TEU containership was much more than the number of the 15000+ TEU containership. The fleet number of the 15000+ TEU containership increased from one fleet in September, 2006 to 62 fleets in July, 2016. The change of the fleet number was relatively stable during the first 7 years. After that, the fleet number began to increase faster and reached 62 in 2016. The fleet number of the 12000-14999 TEU containership continued to grow during the seven years, growing from one fleet in January, 2009 to 192 fleets in July, 2016.



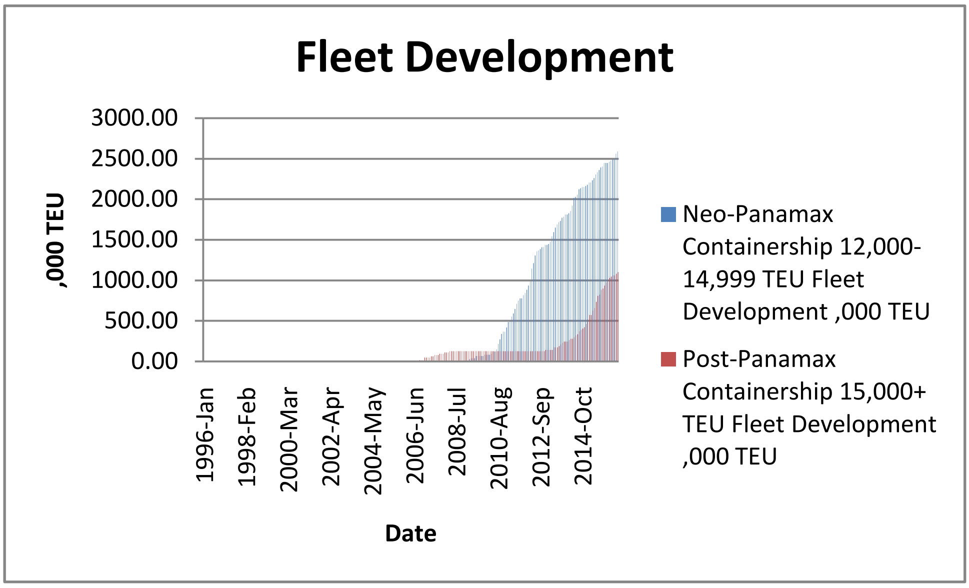


Figure 2-3- Fleet development of 12000+ TEU containership

Source: Clarksons Research Services (up to July, 2016)

2.3 Capacity of mega containerships

Table 2-2- Different shipping lines using mega containership (unit: TEU)

Routes Year	Far East-Europe	Trans-Pacific	Transatlantic	North-South
1998	7,500	6,250	4,500	3,000
2000	7,500	6,700	4,500	3,500
2007	13,500	8,100	6,500	3,500
2010	14,500	9,000	6,500	3,500
2015	14,500	10,500	10,000	4,000

Source: The British Shipping Consulting Company, 2014

The table 2-2 tells the data of the capacity of the mega containerships put in different shipping lines before year 2014 and the forecast capacity of the mega containerships of year 2015. The Far East- Europe route had been put the most capacity of mega containerships among the four main shipping lines seen from table 2-2.

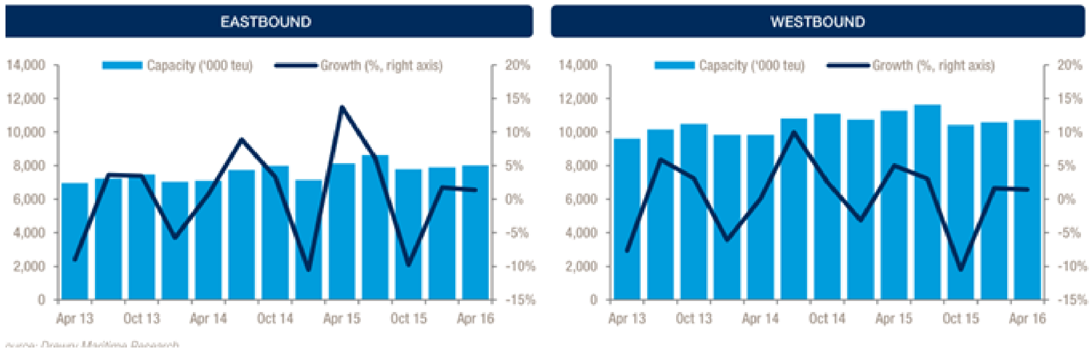


Figure 2-4-Annualised Asia-North Europe Capacity, 2013-2016

Source: Drewry Container Forecaster (Q4, 2015)

Since I choose the Asia to Europe route to calculate the economics of the containership, I briefly tell the capacity of the Asia-North Europe route from all the shipping lines. We can see from the figure 2.4 that the growth rate of the annualized Asia- North Europe changed greatly and the capacity of the containerships put in the westbound of Asia- North Europe was more than the capacity in the eastbound. The change of the capacity in each bound of Asia- North Europe fluctuated little during the years.

Table 2-3 summarizes the number of 13000+ TEU containerships ordered by the major shipping companies a few years ago, which has been in operation. Shipping companies tends to order mega containerships to reduce the costs and achieve the economy of scale of mega containerships. The shipping companies started to order ultra-large containerships, especially Maersk, which has ordered twenty18270TEU containerships.

Table 2-3-Statistics of ordering containerships of main Shipping Companies (13000+ TEU containership, up to July, 2016)

Type	Size	Unit	Number	Owner	Status
Container	13,000	TEU	2	MSC	In Service
Container	13,050	TEU	5	MSC	In Service
Container	13,092	TEU	4	Hanjin Group	In Service
Container	13,102	TEU	3	MSC	In Service
Container	13,200	TEU	5	MSC	In Service
Container	13,386	TEU	8	China COSCO Shipping	In Service
Container	13,800	TEU	8	MSC	In Service
Container	13,880	TEU	5	CMA-CGM	In Service
Container	14,000	TEU	10	CMA-CGM	In Service
Container	14,000	TEU	4	MSC	In Service
Container	14,074	TEU	8	China COSCO Shipping	In Service
Container	15,550	TEU	8	A.P. Moller	In Service
Container	16,020	TEU	3	CMA-CGM	In Service
Container	17,722	TEU	3	CMA-CGM	In Service
Container	18,270	TEU	20	A.P. Moller	In Service
Container	19,100	TEU	5	China COSCO Shipping	In Service

Source: Clarksons Research Services

Chapter 3 Qualitative analysis of the economics of mega containership

3.1. Positive elements of the economics of mega containership

3.1.1 Efficiency

Since the mid-1950s, container shipping has become the main mode of liner shipping with its strong competitive advantage. After the centuries of development, the technology of container transportation has come to maturity. The container shipping not only has the advantage of being fast, safe, high quality and low cost, but also achieves the door to door transport by utilizing varieties of transport mode including rail, road, water and air. Container transport speed up the circulation process, reduce the cost of circulation, save the labor consumption of logistics. This is a high efficiency, high benefit and high quality transport mode.

Mega containerships can carry more cargo at a time because the capacity of the ship in a single voyage is bigger. With the enlargement of the containerships, the designed speed is increasing. So the mega containerships can deliver more cargo one time and can deliver faster than the smaller size of containerships, which can save lots of time. Calculated by per unit container, the energy efficiency of mega containership is higher. Therefore, from the economic consideration, it is inevitable to use the mega containerships.

Generally speaking, the larger the containership, the less the unit ship cost, oil consumption and port charges will be, thus the fixed cost will be reduced. According to the data of the ship construction, compared with small and medium size of the containerships, mega containerships can reduce 50% of the unit fuel consumption and greenhouse gas emission and reduce 30% of the container transporting cost by improving the capacity of unit ship.

The expansion of the Panama Canal opened up successfully on June 26 this year, which greatly reduce the cost of transportation and the north-south trade, promote the development of the local economic and global trade. Based on the official 'New Panamax' dimensions, the new locks will allow containerships of up to around 13,500 TEU (dependent on the precise design) to transit. Only 207 box ships in today's fleet will be too large to pass through. The amount of TEU capacity able to pass through the canal will rise from 37% to 85% of the fleet. So the opening of the new locks in Panama is big news for bigger box ships. (New Opening Big news For Bigger Box ships, by Mr. Trevor Crowe, 01 July 2016 'Shipping Intelligence Weekly' Issue No.1228) After the expansion, the navigation capability of this waterway doubled, more mega containerships can go through the canal, saving much time and bringing more efficiency.

3.1.2 Economy of scale

The basic reason why shipping companies compete to build mega containerships is the economy of scale of the containerships. Theoretically, the bigger the ship size, the less the unit cost. The costs of container units will reduce a lot with the increase of the loading capacity of the ships. Many shipping companies are taking this strategy to reduce the costs and increase the profit as far as possible. They order bigger size ships or increase the capacity of the containerships. In economics, if the containership can keep the stable capacity utilization, its marginal revenue will be greater than its marginal cost; the profit of the shipping company will tend to maximization. If shipping companies want to win the market share and profit in the transportation market, they have to gain cost advantage by putting mega containerships on the main routes to achieve the economy of scale of the containerships.

Table 3-1 shows the operating cost of unit container of the 4000TEU, 6000TEU, 10000TEU, and 18000TEU containership. With the growth of the ship size, each cost of operating cost declines gradually, except the maintenance and repair cost. The maintenance and repair cost of the 18000TEU containership is higher than which of the 10000TEU containership, but lower than which of the 6000TEU containership. The operating cost of the 6000TEU containership has saved nearly 20% compared with the 4000TEU containership; the operating cost of 18000TEU containership has saved nearly 40% compared with 4000TEU containership.

Table 3-1- Operating cost of unit container (unit: US dollar)

Ship size Factors	4000TEU	6000TEU	10000TEU	18000TEU
Staff element	233	133	83	83
Ship management	34	33	33	17
Insurance	200	167	183	167
Port charges	500	450	300	283
Maintenance & repair	217	167	100	133
Store up & lube	50	50	17	30
Fuel	1067	950	717	700
Total	2301	1950	1400	1413

Source: Drewry Shipping Consultants, 2014

However, since the achievement of the economy of scale of mega containership is based on high utilization, it is possible for these ships to develop to diseconomy of scale if the utilization rate is not guaranteed.

3.1.3 Environmentally proved

In recent years, the increasingly severe of the environmental legislation encourage the enlargement of containership. The purpose of formulating the legislation is to reduce the exhaust emission of the ships. The benefit of mega containerships on the environment is that the exhaust gas released by each TEU will be less. According to the literature, a 16000TEU containership has reduced by 20% of the capital cost and 40% of the fuel cost compared by two 8000TEU containerships. In addition, the carbon dioxide emissions of the 18000TEU containership have reduced 20% of the 11000TEU containership (Liu Min, 2014). The 3E containership of Maersk has the excellent environmental performance. The carbon emissions of its unit container produce 50% less than the average carbon emissions of the ships operating on the Asia-Europe route (Xu zongquan, 2013)

In 2011, IMO has passed the new ship indicator of energy efficiency, which can reduce the carbon emissions of the ships in order to decrease the effect of shipping on global warming. IMO stipulates that since 2013, all the new ships must comply with the new energy efficiency design index. With the improvement of the level of science and technology, the hardware and software system of shipbuilding industry has been greatly improved, the level of shipbuilding technology has been improved, and the large container ship has obvious advantages in environmental protection.

3.2 Limiting factors of the economics of mega containership

3.2.1 Unbalanced capacity distribution

The ordering of mega containerships is the trend, but it is not always a good solution for the shipping companies to gain profit. The global economy hasn't recovered yet. Ordering too much mega containerships can lead to overcapacity, which may become the burden for the shipping companies. When using the mega containership to replace with the smaller size of the containership, the shipping company should also consider how to use the smaller size of containership and how to balance the ships to minimize the costs. Because of the slow development of the global economy, the shipping lines are not enough for the mega containerships. Situation of overcapacity can easily happen. If the capacity is not deployed properly, the mega containership will lose its advantage over the smaller size of containership, and cause more cost of the shipping companies.To develop the scale and flexibility of the development of the mega containerships, the diversity of the route should be guaranteed.

According to the Alphaliner(July 6th, 2016), the American market is now in weak demand, forcing the container shipping companies to find new home for the 13000TEU containerships. Due to the current capacity deployment, the 13000TEU containership and the ships are bigger than 13000TEU become homeless. Many ships which are originally set aside for the Pacific Asia- the United States route need to be redeployed. At the same time, some shipping companies decide to reduce the capacity across the Pacific Ocean starting from June this year.

CMA CGM has given up deploying the capacity of 17800TEU containership on the Asia-USWC route. This year, many classes of 13000TEU containerships are phasing out the trade between Far East and Europe, since the emergence of new 19000TEU containerships has made them homeless. Some ships have also joined the trans-Pacific trade, which others will be reallocated to the north-south trade. Shipping companies are exploring other alternative options for this 13000TEU tonnage.

October, 2015, Maersk announced that a 18270TEU 3E containership will stop sailing. November 5th, Maersk gave up the order of 6 new 19630TEU containerships. The liner company didn't obtain benefit from these mega containerships.

3.2.2 Conditions of ports

Although more mega containerships can go through the Panama Canal after expansion, there are not enough ports can contain all the mega containerships. The speed of building mega containerships is so fast that not all the ports have kept up.

The number of big ports is limited. There are probably several ports can hold 13000+ TEU containerships on one route. If one of the ports is not big enough, the ship have to pass and look for other big ports, which may take more time for one voyage. Then the shipping companies have to spend more time on the route planning. Since the number of big ports is limited, port congestion can easily happen. Mega containerships will be crowded with those big ports, which can cause port congestion and accidents.

The infrastructure of the port is limited too. The draught of mega containerships may exceed 15m, but the depth of water of many ports is not enough for the berth of ships. At present, there are few ports such as Hongkong, Rotterdam, Singapore, and Antwerp that are 15m depth of water. To hold these mega containerships, port handling system has to upgrade, such as adding more berths and cranes. The collecting and distributing system of ports has to be more efficient in order to handle with the mega containerships, so that the containers can be centralized or distributed as quickly as possible. The enlargement of containerships is really a big challenge for the ports.

3.2.3 Utilization ratio

The liner companies are tends to order larger containerships to achieve benefit. In the actual operation process of the containerships, the containership transportation company will take advantage of the capacity ability and space as much as possible and load the maximum container cargo after considering the stowage requirement, draft and other factors. However, the theory is different from the reality. The shipping companies don’t take full advantage of the loading capacity of the containerships because of a variety of reasons such as the depression of the economy. The utilization of the vessels doesn’t remain high.

The waste of this part of capacity can directly lead to lower earnings of shipping companies. The bigger the ships, the higher the possibility of empty positions, the more serious of the waste of capacity will be. If the mega containership can’t maintain a high capacity utilization rate, the position of the mega containership will not be guaranteed. The shipping companies will tend to use smaller size of containerships to reduce the cost and avoid the loss. In this way, the mega containerships are likely to be laid aside, which greatly increases the burden of the shipping companies.

Therefore, the utilization ratio is one of the restrictive factors of the enlargement of containerships. When a new mega containership is full-loaded on the route, the company is more likely to gain profit, and the company is more like to achieve the goal of the economy of scale.

3.2.4 Safety and environment

First, the waterline of the smaller size of containership is shallower than the waterline of the mega containerships, which may easily cause the stranding of the mega containerships. Second, it is difficult for the mega containership to avoid collision with other containerships when going through the narrow gate waterway. Mega containerships are more difficult to control. If something urgent happens, the mega containership can't stop or swerve immediately because of its large inertia. Third, when the mega containership berths alongside the port, because of the hard controllability the mega containerships, collision with the surrounding ships or the port can happen if controlling the mega containership not carefully. If accidents of mega containerships happen, it must be serious accidents. Run aground and oil spilling is the most common accident.

It is reported that the 18000TEU Arab containership called "Barzan" caught fire once again on September 15th, 2015. This ship is one of the world's largest containership, the greenest mega containership and is the largest capacity among the Arab fleet, delivered on May 8th, 2015. This fire accident happened just less than half a month after the last fire accident. No one was wounded. The first accident happened in the engineer room, and sailed again on the second day of the accident. (Sep 22th, 2015)

May 8th, 2016, the Maersk containership "SAFMARINE MERU" collided with "NORTHERN JASPER" and got fire near the sea area of Zhoushan. The fire is too large, so the ship's 22 crew members abandoned the ship because of lack of fire-fighting equipment. All the 11 hazardous containers are transferred away from the site of accident. This is another marine incident near the sea area of Zhoushan after which happened on May 3th, "COSCO FUKUYAMA" colliding with one chemical tanker. Fortunately, there was no oil spill or personal casualty.

It's fortunate for mega containerships if no accidents happen. But if it ever happens, it must be serious, especially for the dangerous cargo. If accidents happen such as fire accident or oil spill, it damage the sea environment. The cleaning job is not easy. The equipment on the new mega containerships should be complete. The crew must be trained with regularity and do anything to avoid the accidents whenever possible. Therefore, the ship companies are facing great responsibility to safeguard the safety of navigation and environmental protection when operating mega containerships.

Chapter 4 Quantitative analysis of the economics of mega containership

4.1 Factors affecting the economics of mega containership

4.1.1 Freight price

The freight price can directly influence the revenue of the shipping company. When the freight price goes higher, the company will have more revenue to have the chance to cover the cost; if the freight price decreases, the company will gain less.

In recent years, the freight price fluctuates widely. The minimum of the freight price of the Far East to North Europe route is nearly half of the maximum of the freight price, making ship owners' revenue increase or decrease sharply. Since the operating cost won't rise or fall sharply with the shipping market, but continue to rise, the declined freight price is likely to bring ship owner loss.

According to the latest container forecaster released by Drewry, the container freight price has reached the historic lowest point and is expected to recovery slightly in the next 18 months. However, it is not enough for the container market to revive. The present performance of the container market is similar to which of the global financial crisis.

From figure 4.1, we can see the fluctuation is big enough. The first big decline of the CCFI was during the financial crisis. The SCFI started from October, 2009. The biggest decline was during the year between 2011 and 2012. The change trend of the four indexes is basically the same. After 2012, the indexes fall and rise but the general trend is declining.

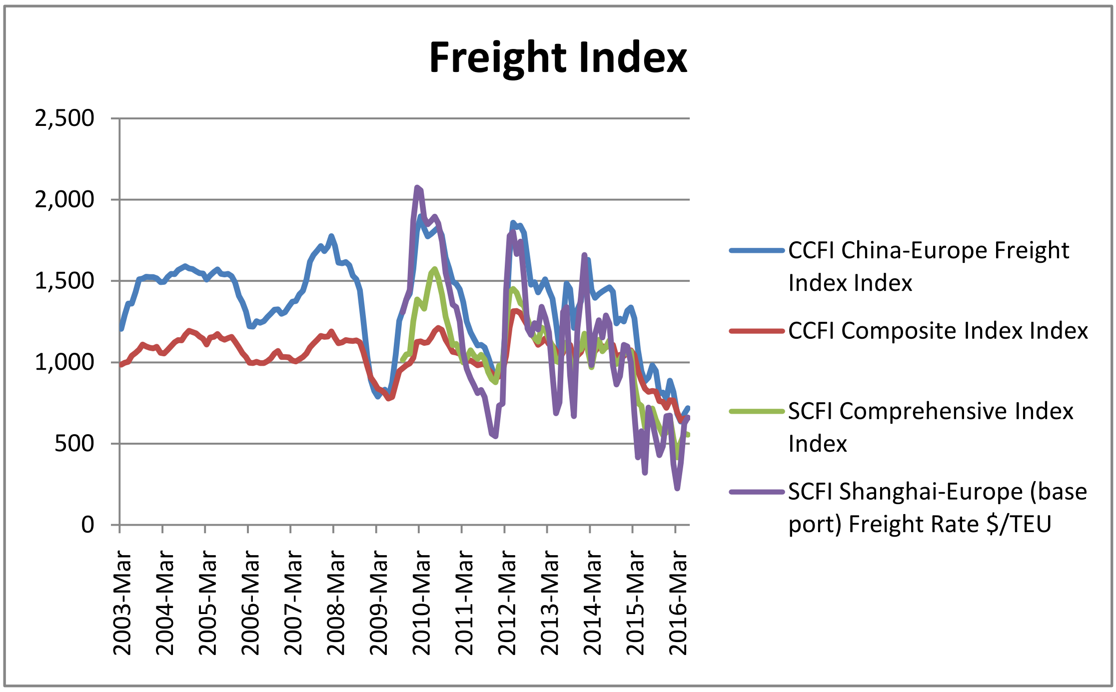


Figure 4-1- Freight index

Source: Clarksons Research Services (up to July, 2016)

4.1.2 Bunker price

The bunker price is the factor which is as important as the freight price for the economies of the containerships. The bunker cost takes a very large proportion in the voyage cost. When the bunker price goes higher, the bunker cost will be increased more. Change in the bunker price is always along with the change of the freight price.

The influence on the economies when the bunker price and freight price increase or decrease simultaneously is different from the situation what the two prices change in the opposite direction. If the speed of sailing is faster, the need of bunker will increase, and then the freight price may be influenced.

According to the container forecaster of Drewry last year, year 2015 has been some of the highest ever freight rate volatility in the container market as well as historically low spot rates on a number of key routes. After an encouraging start to the year, helped by the low oil prices, many ocean carriers will now end the year making a loss. Figure 4.2 shows the fluctuation of the crude oil price from 2002 to 2015.

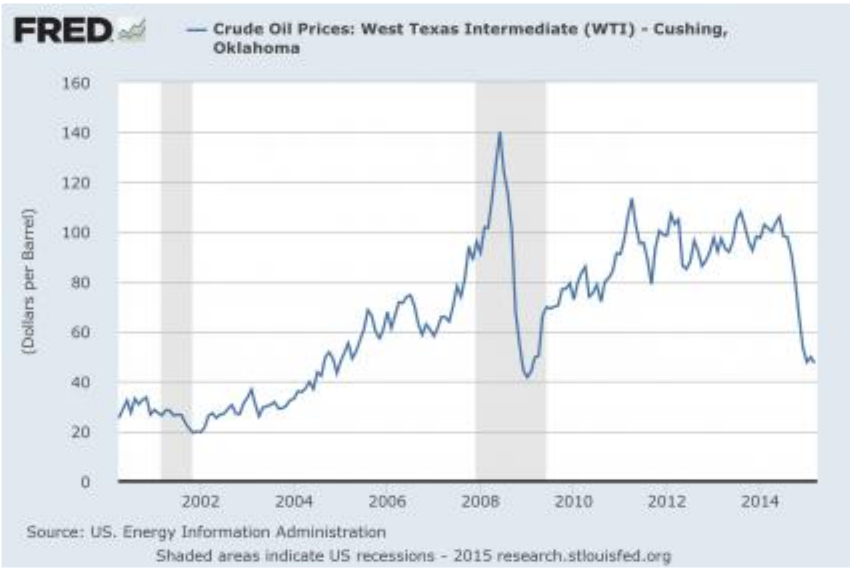


Figure 4-2- Crude oil prices (2002-2015)

Source: US, Energy Information Administration

4.1.3 Containership New-building Prices

The new-building price of the containership also affects the profit of the shipping company. The expenditure of the new-building mega containership also takes certain proportion in the costs. With the increased number and size of scale of the mega containerships, the new-building price of the mega containerships will change also.

The new-building price is quite influenced by the supply and demand condition of the shipping market. At the beginning of the appearing of the 13000TEU containership, the size of the 13000TEU containership is rare to see, so the price of building a new 13000TEU containership will be really expensive. But after more 13000TEU containerships show up and other bigger size containerships turn up, the price of building a new 13000TEU containership will be lower than the start.

From figure 4-3, we can clearly see the moving trend of the price. The new-building price of 13000TEU was high in June, 2008 and the general trend was declining until November, 2014 the bigger size of containership appeared. The bigger size of containership, the more expensive will the new-building price be.

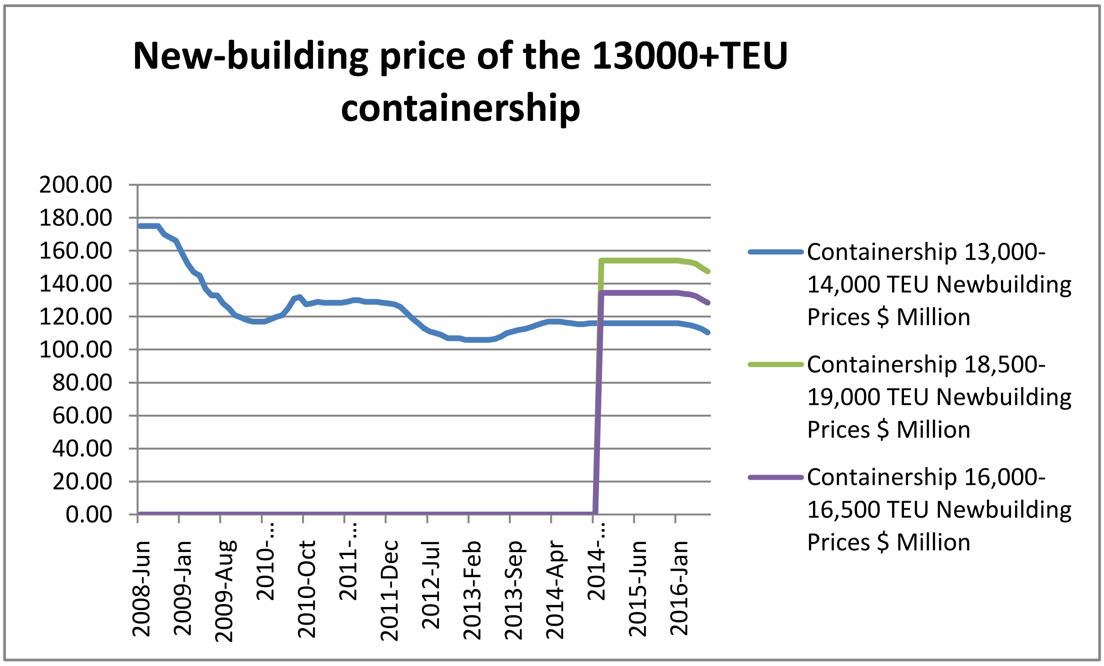


Figure 4-3-World Container Exports

Source: Clarksons Research Services (up to July, 2016)

4.1.4 Capacity utilization

The world economy is now recovering slowly, so the demand and supply of the containership hasn't been balanced yet. For the mega containerships, they can rarely fill up the containership. The eastbound and westbound of the capacity utilization of each route is different as well. Not high capacity utilization can cause the waste of capacity especially for the mega containerships. The bigger the containership, the higher the rate of the empty space, the lower the benefit of the shipping company will be. So the capacity utilization is also the factor influencing the economies of the mega containerships.

The table 4-1 shows the capacity utilization of 3 main ship routes----- Trans-Pacific Trade, Asia/ Europe route and the Atlantic Line from year 1999 to 2001. The last two columns of the table show that the capacity utilization of the eastbound and westbound is different. Basically when the eastbound capacity utilization is high, the westbound is low; vice versa.

Table 4-1- Capacity utilization of 3 main routes (unit: thousand TEU)

Routes	Year	Net supply of container lot		Volume of goods transported		Capacity utilization (%)	
		Eastbound	Westbound	Eastbound	Westbound	Eastbound	Westbound
Trans-Pacific Trade	1999	7578	5865	6343	3389	83.70	57.78
	2000	9049	7025	7237	3732	79.98	53.12
	2001	9832	7616	7706	3929	78.38	51.59
Asia/ Europe route	1999	3290	4336	2422	3420	73.62	78.87
	2000	3517	4629	2678	3765	76.14	81.34
	2001	3982	5198	2817	4165	70.74	80.13
the Atlantic Line	1999	2704	2708	1500	2014	55.47	74.37
	2000	2687	2697	1543	2091	57.42	77.53
	2001	2980	2930	1618	2264	54.30	75.72

Source: Containerisation International, July, 2001, p.15

4.1.5 Port efficiency

Since more mega containerships appear, the ports are facing great challenges. The number of ports which can hold big size containership is limited. The efficiency of cargo handling of the ports is also essential to the benefit of the shipping company. If the port can handle quickly, which can save the voyage time of the containership and save fuel costs, the shipping company can gain more benefit. If not, when the mega containerships spend too much time in port because of port congestion or other causes, the economics of mega containerships will greatly decrease.

In the process of operating the containerships, various unstable factors can cause fluctuation of the operating incomes. From the analysis mentioned above, we can see that the freight price, bunker price, new-building price, capacity utilization change frequently, so to further analyze the impact of changes of each factor on the operating benefits of the shipping company and the changes of the benefits when the factors change, I will compare these four factors of the 13000TEU and 16000TEU containership on the Asia to Europe route to see how they changes.

4.2 Economic evaluation

4.2.1 Basic data

I pick the Asia to Europe route to analysis the 13000TEU and 16000TEU containership. Chose ports of call are Shanghai port, Ningbo port, Yantian port, Le Harve port, Rotterdam port, and Hamburg port. The basic information of the vessels and lines, the capacity of the time and other revenue and expenses are shown in the following tables.

Table 4-2- Basic data of the 13000TEU and 16000TEU containership

Vessel size (TEU)	13,000	16,000
1. Ship & Lines characteristics		
Containership size	13,000	16,000
Fuel Consumption (tons/day)	270	288
Number of employees required	23	23
2. Service schedule		
Distance of single trip (n mile)	11,178	

Port of calls on round voyage	6	
Total voyage time (days)	64	66
Operating days (days)	350	348
3. Capacity utilization		
Eastbound Capacity Utilization (%)	60	
Eastbound Containers shipped (TEU)	5,850	7,209
Westbound Capacity Utilization (%)	75	
Westbound Containers shipped (TEU)	9,750	12,015
4. Costs		
New-building price ($)	128,000,000	165,000,000
Depreciation ($)	6,400,000	8,250,000
Operating cost per year	27,996,318	32,406,940
Wage of crew per year	850,000	850,000
Fixed costs per year	24,765,650	28,488,110
Bunker price ($/ton)	580	
Port cost ($/call)	67,600	75,200
5. Freight price		
Eastbound freight price ($/TEU)	1,000	
Westbound freight price ($/TEU)	1,500	

Source: Martin Stopford, Maritime economics 3rd edition;

Liu min, (2014), Scale economics effect of container ship based on cost model, Unpublished master's thesis, Dalian Maritime University, Dalian;

Zhu mo, Zhang qiang,(2015, September), Economic analysis for ultra large containerships subject to fluctuating market factors, *Navigation of China*,38(3),121-125

4.2.2 The original value of NPV

I choose the net present value as the analysis index to compare the economies of the 13000TEU and 16000TEU containership.

Assumption:

1. Benchmark yield of the company is 8%;
2. Period of use of the containership is 25 years.
3. Here take 5% of the new-building price of the vessel as the depreciation.
4. The amount of the revenue or cost is the same at set intervals during 25 years.
5. For convenience of calculations, use TEU × capacity utilization × freight price to calculate the revenue; and take the bunker cost as the expenses, ignoring other costs, using bunker price × fuel consumption × total voyage time to calculate the bunker cost.
6. The number of the crew of the two containerships is the same. According to the research of Drewry Shipping Consultants, assume the crew member is 23; the salary for the crew per year is 850,000 dollars.
7. The calculation formula of capital cost per annum:

$$C = P \times \frac{i(1+i)^n}{(1+i)^n - 1} - R \times \frac{i}{(1+i)^n - 1} \qquad (4\text{-}1)$$

In which, C --- Capital cost per year;

P --- New-building price of the vessel;

i--- Benchmark yield；

n--- Period of use of the ship；

R--- Depreciation value of the ship.

8. The calculation formula of NPV:

$$V_{NPV} = -P + (FR - E) \times \left(\frac{P}{A}, \text{Benchmark yield}, \text{Period of use}\right) + P_D \times (P/$$
$$(P/F, \text{Benchmark yield}, \text{Period of use})$$

(4-2)

In which, P--- New-building price of the vessel;

FR--- Freight revenue per year;

E--- Total costs per year;

R--- Depreciation value of the ship.

Note:

(P/A, Benchmark yield, Period of use) means the Present-Value Interest factors of Annuity. According to the table of present value of annuity, (P/A, 8%, 25) = 10.6748

(P/F, Benchmark yield, Period of use) means the Present Value Interest Factor. According to the table of present value, (P/F, 8%, 25) = 0.1460

9. The Maintenance costs per year here take 20% of Capital cost per year.

<u>Calculation formula:</u>

1. V = DO / TT (4-3)

In which, V- Voyages per year;

DO - operating days;

TT - total voyage time.

2. $FR = AT \times V \times (F_1 \times C_1 + F_2 \times C_2)$ (4-4)

In which, FR- Freight revenue per year;

AT- Actual capacity of TEU;

V- Voyages per annum;

F_1, F_2 – Eastbound freight price, westbound freight price

C1, C2 – Eastbound capacity utilization, westbound capacity utilization.

3. $C_M = C \times 20\%$ (4-5)

In which, CM – Maintenance cost per year;

C- Capital cost per year.

4. $C_O = C_C + C_M + C_F$ (4-6)

In which, C_O- Operating cost per year;

C_C- Wage of crew per year;

C_M- Maintenance cost per year;

C_F- Fixed cost per year.

5. $C_B = P_B \times FC \times TT \times V$ (4-7)

In which, C_B - Bunker cost per year;

P_B – Bunker price;

FC – Fuel consumption;

TT – Total voyage time;

V – Voyages per year.

6. $PC = C_P \times N_P \times 2 \times V$ (4-8)

In which, PC- Port charge per year;

C_P- Port cost;

N_P- Number of ports of call;

V- Voyages per year.

7. $C_V = C_B + PC$ (4-9)

In which, C_V- Voyage cost per year;

C_B - Bunker cost per year;

PC - Port charge per year.

Table 4-3-Results of the calculation ($)

Vessel size (TEU)	13,000	16,000
1. Service schedule		
Voyages per annum	5.5	5.3
2. Costs		

Capital cost per year	11,903,340	15,344,149
Maintenance cost per year	2,380,668	3,068,830
Operating cost per year	27,996,318	32,406,940
Bunker cost per year	54,810,000	58,129,920
Port cost per year	4,415,552	4,743,734
Voyage cost per year	59,225,552	62,873,654
3.Revenue		
Freight revenue per year	122,064,541	145,087,613
4. NPV		
NPV	117,807,178	204,088,753

Table 4-3 is the results of the calculation according to the formulas.

Table 4-4- Annual income and expenditure statistics ($)

Vessel size (TEU)	13,000	16,000
1. Annual revenue		
Freight revenue	122,064,541	145,087,613
2. Annual costs		
Capital cost	11,903,340	15,344,149
Operating cost	27,996,318	32,406,940
Wage of crew	850,000	850,000
Maintenance costs	2,380,668	3,068,830
Fixed costs	24,765,650	28,488,110
Voyage cost	59,225,552	62,873,654
Bunker cost	54,810,000	58,129,920
Port cost	4,415,552	4,743,734
Total cost	99,125,210	110,624,742

3. Annual profit	22,939,332	34,462,871

4.2.3 New NPV values against variable factors

Considering ±5% and ±10% variation range of all the sensitive factors, I calculate the new NPV values see in table 4-5, 4-6, 4-7, and 4-8. I draw the figure according to the data of table 4-5 and table 4-7 see in figure 4-4 and figure 4-5.

Table 4-5-±5% and ±10% variation range of all the sensitive factors (13000TEU)

Rate of change	Freight price		Bunker price	New-building price	Capacity utilization	
	Eastbound	Westbound			Eastbound	Westbound
-10%	900	1,350	522	115,200,000	54.00%	67.50%
-5%	950	1,425	551	121,600,000	57.00%	71.25%
0	1,000	1,500	580	128,000,000	60.00%	75.00%
5%	1,050	1,575	609	134,400,000	63.00%	78.75%
10%	1,100	1,650	638	140,800,000	66.00%	82.50%

Table 4-6- New NPV values against variable factors (13000TEU)

Rate of change		-10%	-5%	0	5%	10%
Freight price	Eastbound	72,484,932	95,146,055	117,807,178	140,468,301	163,129,423
	Westbound	32,827,967	75,317,572	117,807,178	160,296,783	202,786,388
Bunker price		176,315,757	147,061,467	117,807,178	88,552,888	59,298,599
New-building price		130,607,178	124,207,178	117,807,178	111,407,178	105,007,178
Capacity Utilization	Eastbound	72,484,932	95,146,055	117,807,178	140,468,301	163,129,423
	Westbound	32,827,967	75,317,572	117,807,178	160,296,783	202,786,388

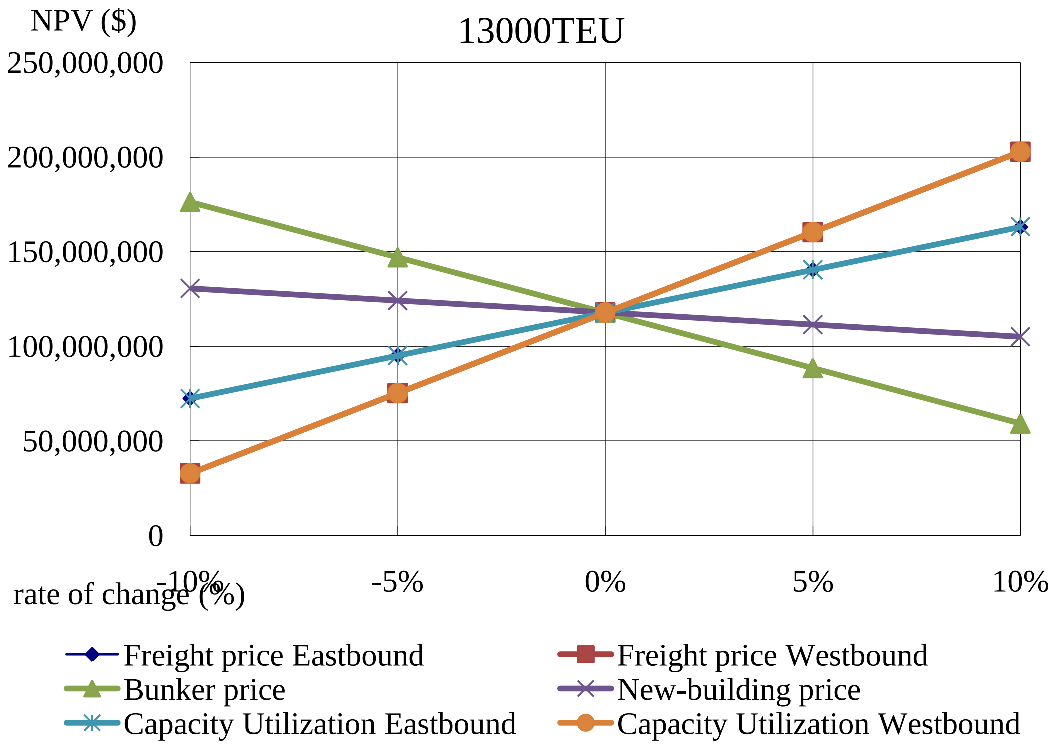


Figure 4-4- New NPV values against variable factors (13000TEU)

The above calculations show that the impact of the change of freight price is the same as the impact of the change of capacity utilization on the NPV. That's why there are four lines in figure 4-5.So I will discuss the freight price in the following.

Table 4-7- ±5% and ±10% variation range of all the sensitive factors (16000TEU)

Rate of change	Freight price		Bunker price	New-building price	Capacity utilization	
	Eastbound	Westbound			Eastbound	Westbound
-10%	900	1,350	522	148,500,000	54.00%	67.50%
-5%	950	1,425	551	156,750,000	57.00%	71.25%
0	1,000	1,500	580	165,000,000	60.00%	75.00%
5%	1,050	1,575	609	173,250,000	63.00%	78.75%
10%	1,100	1,650	638	181,500,000	66.00%	82.50%

Table 4-8- New NPV values against variable factors (16000TEU)

Rate of change		-10%	-5%	0	5%	10%
Freight price	Eastbound	150,218,101	177,153,427	204,088,753	231,024,080	257,959,406
	Westbound	103,081,280	153,585,017	204,088,753	254,592,490	305,096,226
Bunker price		266,141,280	235,115,017	204,088,753	173,062,490	142,036,226
New-building price		220,588,753	212,338,753	204,088,753	195,838,753	187,588,753
Capacity Utilization	Eastbound	150,218,101	177,153,427	204,088,753	231,024,080	257,959,406
	Westbound	103,081,280	153,585,017	204,088,753	254,592,490	305,096,226

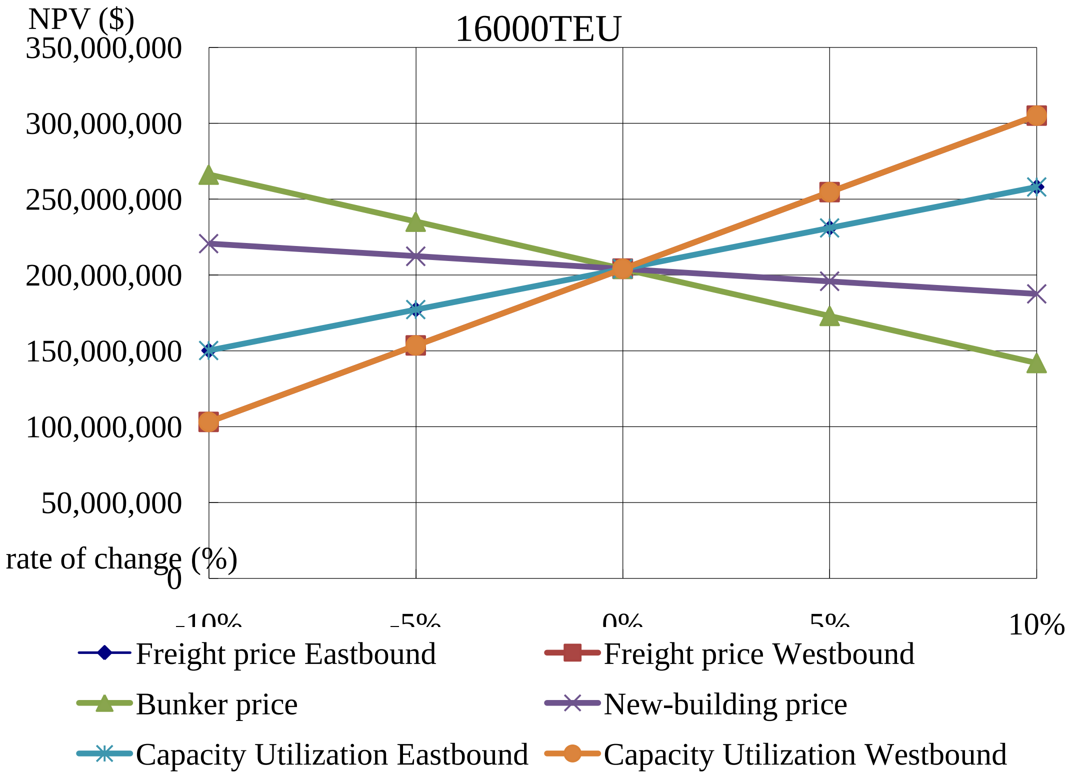


Figure 4-6- New NPV values against variable factors (16000TEU)

We can see intuitively from the graph that the most sensitive factor is the westbound freight price.

4.3 Risk evaluation

4.3.1 Calculation of sensitivity coefficient

Use the formula $E = \frac{\Delta A}{\Delta F}$ to calculate the sensitivity extent of the analysis index to the uncertain factors. The higher the sensitivity coefficient, the higher extent of the sensitivity will be.

In which, E --- the sensitivity coefficient of the analysis index A to the uncertain factor F;

ΔF --- the rate of change of the uncertain factor F;

ΔA --- the rate of change of the analysis index A.

Using the 13000TEU for example, when the rate of change of the bunker price is -10%, $\Delta A = \frac{176{,}315{,}757 - 117{,}807{,}178}{117{,}807{,}178}$ = 49.66%, $E = \frac{\Delta A}{\Delta F} = \frac{49.66\%}{-10\%}$ = -4.97

Other calculation is similar.

Table 4-9- Sensitivity coefficient (13000TEU)

Rate of change		-10%	-5%	5%	10%
Freight price	Eastbound	3.85	3.85	3.85	3.85
	Westbound	7.21	7.21	7.21	7.21
Bunker price		-4.97	-4.97	-4.97	-4.97
New-building price		-1.09	-1.09	-1.09	-1.09
Capacity Utilization	Eastbound	3.85	3.85	3.85	3.85
	Westbound	7.21	7.21	7.21	7.21

Table 4-10- Sensitivity coefficient (16000TEU)

Rate of change		-10%	-5%	5%	10%
Freight price	Eastbound	2.64	2.64	2.64	2.64
	Westbound	4.95	4.95	4.95	4.95
Bunker price		-3.04	-3.04	-3.04	-3.04
New-building price		-0.81	-0.81	-0.81	-0.81
Capacity Utilization	Eastbound	2.64	2.64	2.64	2.64
	Westbound	4.95	4.95	4.95	4.95

From these two tables, we can see that the sensitivity coefficient of the bunker price and new-building price are all less than zero, which means that these two factors change the negative direction with the change of the evaluation index. Other factors are more than zero, which proves that they change the same direction with the change of NPV. By comparing the absolute value of the data, the westbound freight price is the most sensitive to the NPV, then the bunker price. The sensitivity coefficient of the freight price and capacity utilization is the same.

4.3.2 Calculation of critical values

Take the 13000TEU as example, the critical value of the new-building price:

Set the critical value of the new-building price is I, so V_{NPV} = -I + (122,064,541 - 11,903,340 - 27,996,318 - 59,225,552) × 10.6748+ 6,400,000 × 0.1460 = 0, I = 181,548,652

Set the critical value of the bunker price is R, so V_{NPV} = -128,000,000 + (122,064,541 - 11,903,340 - 27,996,318 - R× 270 × 64.3 × 5.4 - 4,415,552) × 10.6748+ 6,400,000 × 0.1460 = 0, R = 697

Set the critical value of the eastbound of the freight price is H, so V_{NPV} = -128,000,000 + ((13,000 × H × 60% + 14,625,000) × 5.4 – 99,125,210) × 10.6748+ 6,400,000 × 0.1460 = 0, H = 740

Set the critical value of the westbound of the freight price is K, so V_{NPV} = -128,000,000 + ((13,000 × K × 75% + 7,800,000) × 5.4 – 99,125,210) × 10.6748+ 6,400,000 × 0.1460 = 0, K = 1,292

Set the critical value of the eastbound of the capacity utilization is M, so V_{NPV} = -128,000,000 + ((13,000 × M ×1,000 + 14,625,000) × 5.4 – 99,125,210) × 10.6748+ 6,400,000 × 0.1460 = 0, M = 44%

Set the critical value of the westbound of the capacity utilization is N, so V_{NPV} = -128,000,000 + ((13,000 × N × 1,500 + 7,800,000) × 5.4 – 99,125,210) × 10.6748+ 6,400,000 × 0.1460 = 0, N = 65%

In the similar way, for the 16,000TEU, I '=257,767,502; R '=771; H '=621; K '=1,197; M ' =37%; N ' = 60%

If the uncertain factor exceeds the critical value of itself, the project will change from feasibility to infeasibility.

Table 4-11- Sensitivity analysis table (13000TEU)

No.	Uncertain factors		Rate of change	NPV	Sensitivity coefficient	Critical value
	Basic project			117,807,178		
1	Bunker price		-10%	176,315,757	-4.97	697
			-5%	147,061,467	-4.97	
			5%	88,552,888	-4.97	
			10%	59,298,599	-4.97	
2	New-building price		-10%	130,607,178	-1.09	181,548,652
			-5%	124,207,178	-1.09	
			5%	111,407,178	-1.09	
			10%	105,007,178	-1.09	
3	Freight price	Eastbound	-10%	72,484,932	3.85	740
			-5%	95,146,055	3.85	
			5%	140,468,301	3.85	
			10%	163,129,423	3.85	
		Westbound	-10%	32,827,967	7.21	1,292
			-5%	75,317,572	7.21	
			5%	160,296,783	7.21	
			10%	202,786,388	7.21	
4	Capacity utilization	Eastbound	-10%	72,484,932	3.85	44%
			-5%	95,146,055	3.85	
			5%	140,468,301	3.85	
			10%	163,129,423	3.85	
		Westbound	-10%	32,827,967	7.21	65%
			-5%	75,317,572	7.21	
			5%	160,296,783	7.21	

			10%	202,786,388	7.21	

Table 4-12- Sensitivity analysis table (16000TEU)

No.	Uncertain factors		Rate of change	NPV	Sensitivity coefficient	Critical value
	Basic project			204,088,753		
1	Bunker price		-10%	266,141,280	-3.04	771
			-5%	235,115,017	-3.04	
			5%	173,062,490	-3.04	
			10%	142,036,226	-3.04	
2	New-building price		-10%	220,588,753	-0.81	257,767,502
			-5%	212,338,753	-0.81	
			5%	195,838,753	-0.81	
			10%	187,588,753	-0.81	
3	Freight price	Eastbound	-10%	150,218,101	2.64	621
			-5%	177,153,427	2.64	
			5%	231,024,080	2.64	
			10%	257,959,406	2.64	
		Westbound	-10%	103,081,280	4.95	1,197
			-5%	153,585,017	4.95	
			5%	254,592,490	4.95	
			10%	305,096,226	4.95	
4	Capacity utilization	Eastbound	-10%	150,218,101	2.64	37%
			-5%	177,153,427	2.64	
			5%	231,024,080	2.64	
			10%	257,959,406	2.64	
		Westbound	-10%	103,081,280	4.95	60%
			-5%	153,585,017	4.95	

			5%	254,592,490	4.95	
			10%	305,096,226	4.95	

4.4 Comprehensive analysis on the economics of mega containership

According to the economic evaluation of the NPV of 13000TEU containership and 16000TEU containership, we can see that under the setting premise, the NPV of the 16000TEU containership is about 204 million dollars; the NPV of the 13000TEU containership is about 118 million dollars. This shows that under the same marketing environment, the operating performance of the 16000TEU containership is obviously superior to the economy of scale of the 13000TEU containership, which also reflects advantage of the economy of scale of the enlargement of the containership.

The sensitivity evaluation further stated that I choose the variable proportion of 5% to change each uncertain factor, the range of variation is -10% ~ 10%. We can see from the table and graph of the sensitivity analysis, the influence of the change of various factors on the two containerships is mainly the same. The new-building price and bunker price is the cost factor, so the change direction of these two factors is contrary to the change direction of the NPV; the change direction of the freight price and capacity utilization is the same as the change direction of the NPV.

In the figure4.4 and 4.5, the largest angle of the intersection with the abscissa is the most sensitive element. We learn from the figure 4.4 and 4.5 that the effect degree of the freight price and capacity utilization on the NPV of these two containerships is the same. The degree of the influence on the NPV from big to small is the westbound freight price (westbound capacity utilization), new-building price, bunker price, eastbound freight price (eastbound capacity utilization). It shows that the income factors affect more than the cost factors on the operating performance.

In addition, considering from the actual shipping market, freight price and bunker price are the two most fluctuant factors and most affective to the revenue. Hence, do the two-factor sensitivity analysis. Hypothesis, one situation is that the bunker price and freight price increase or decrease at the same time; another situation is that the bunker price increases and freight price decreases or bunker price decreases and freight price increases.

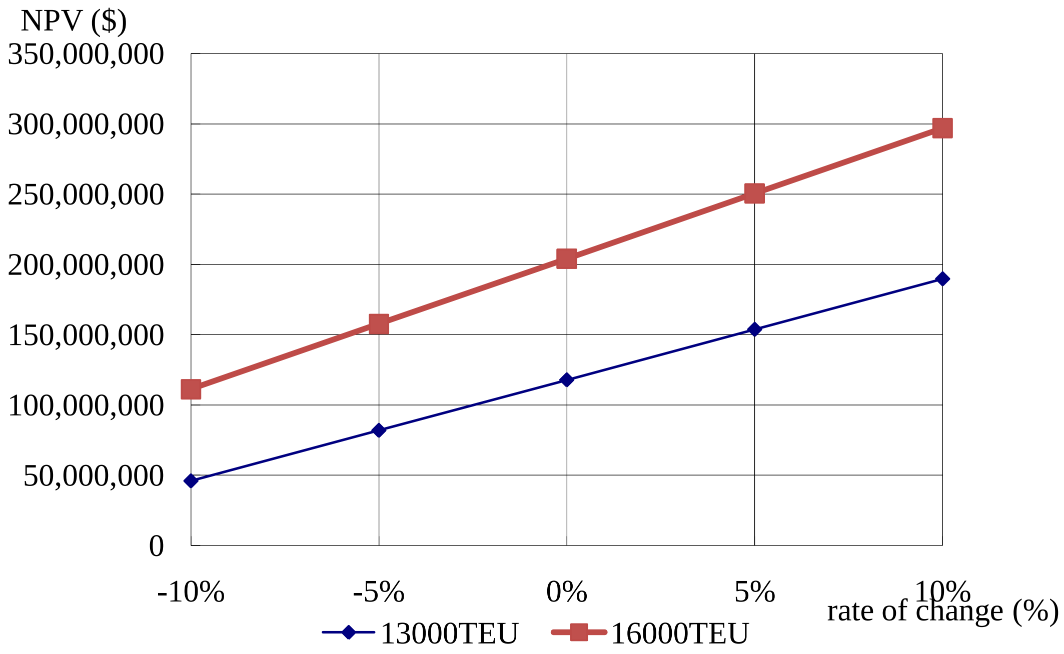


Figure 4-7-New NPV when only the freight price and bunker price change in the same direction under the ±5% and ±10% variation range of all the sensitive factors comparing two size of containership

As shown in figure 4.6, when the bunker price and freight price increase at the same time, the NPV of the 16000TEU containership is always higher than the NPV of the 13000TEU containership. However, when the bunker price and freight price decrease lower than probably 20%, the trend of the NPV of the 13000TEU containership will overtake the NPV of the 16000TEU containership.

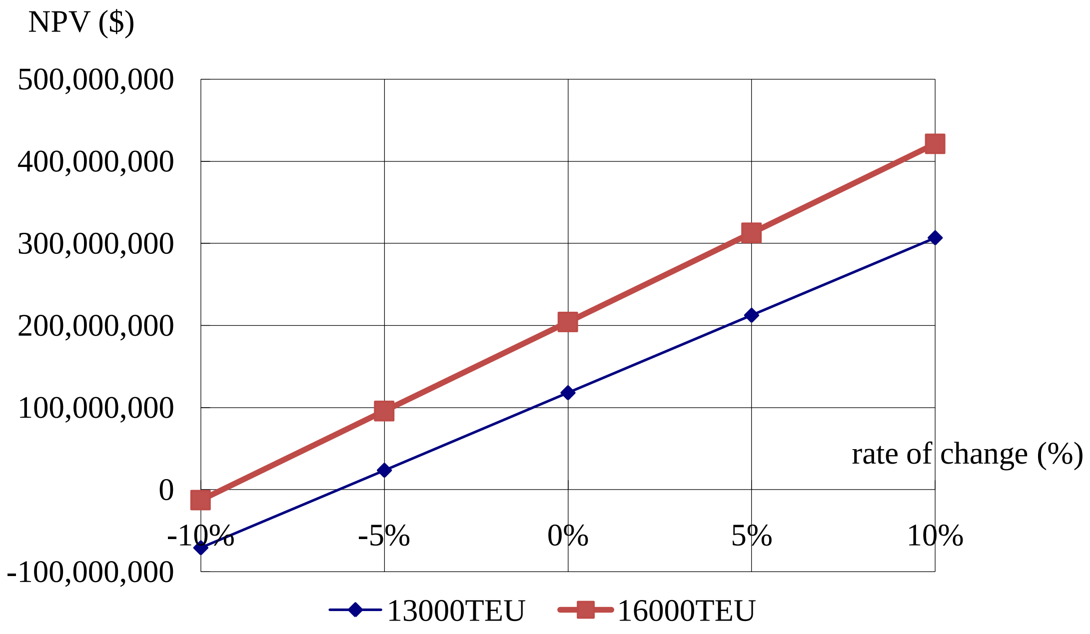


Figure 4-8- New NPV when only the freight price and bunker price change in the opposite direction under the ±5% and ±10% variation range of all the sensitive factors comparing two size of containership

As shown in figure 4.7, the right of 0% is the situation of increased freight price and decreased bunker price; the left of 0% is the situation of decreased freight price and increased bunker price. Under the right situation, the NPV of the 16000TEU containership is still higher than the NPV of the 13000TEU containership, and the gap between the NPV of these two containerships is smaller than the first situation.

Especially the left situation is the key point of the risk evaluation. When the freight price decreases lower than maybe 20% and the bunker price increases higher than maybe 20%, the NPV of the 13000TEU containership will be higher than the NPV of the 16000TEU containership.

When the freight price decreases more than 20%, whether the bunker price rises or falls, the 16000TEU containership loses its advantage. Therefore, the freight price affects the 16000TEU containership more than the 13000TEU containership.

Chapter 5 Summary and Conclusions

5.1 Summary

The shipping industry is closely related to the world economy and trade. After the financial crisis, the shipping market is recovering slowly. Under this circumstance, the enlargement of the containership has become the focus of attention of shipping industry. As we all know, the enlargement of the containership is promoted by the economy of scale. However, the economy of scale of the containership can be affected by some factors. In this paper, I use NPV as the evaluation index to compare the 13000TEU and 16000TEU containership on the Asia-Europe route to analyze the economics of mega containerships.

First is the qualitative analysis. On the one hand, mega containerships have its advantages. Mega containerships can improve the efficiency of energy and speed of delivery. According to the economy of scale, the unit cost and unit carbon emission of the mega containership can be reduced. On the other hand, there are also factors limiting the economics of mega containerships. Under the trend of the enlargement of the containership, the operation of the vessels is restricted by the unbalanced capacity distribution, depth of the port water, facilities of the ports, the efficiency of the handling of the port, capacity utilization and safety.

Second is the quantitative analysis. I choose the freight price, bunker price, capacity utilization, and the new-building price of the containership as the factors which influence the economy of the mega containership. Then I collect the data of 13000TEU and 16000TEU containership and calculate the annual revenue and annual cost according to the formulas by using the sensitivity analysis. The result of the NPV indicates that the value of the NPV of the 16000TEU containership is higher than the value of NPV of the 13000TEU containership. Then I choose the variation change of

$\pm 5\%$ and $\pm 10\%$ of the factors to see how the value of each NPV changes. The result of the two containerships is similar. The most sensitive factor is the freight price (capacity utilization). To evaluate the risk, I calculate the sensitivity coefficient and critical values of two containerships (see table4-11, table 4-12)

The last part is analysis of the calculation result. Since the freight price and bunker price fluctuate most frequently, I choose them to do the two-factor sensitivity analysis--how the value of NPV changes when the two prices increase or decrease at the same time, or two prices increase in the opposite direction (see figure4-6,figure4-7). The result is that no matter how the bunker price changes, the 16000TEU containership will lose its advantage when the freight price decreases more than 20%.

5.2 Conclusion

By comparing the value of NPV of 13000TEU and16000TEU containership under the determined circumstance, the enlargement of the containership has the certain advantage when the ship can maintain certain capacity utilization during the operation process, which reflects the economy of scale of mega containerships do exist to some degree.

The sensitivity analysis can tell us the main factors influencing the operating profit of the shipping company. Seeing from the results, the change of the freight price or capacity utilization does influence more on profit than the factor of bunker price, or new-building price. This reflects profits of the ship depends more on the increase of the freight price and increase transport demand.

We can learn from this research paper that the NPV value changed with the variable factors, such as freight price, bunker price, capacity utilization and new-building price of the containership and such influence is more obvious for the 13000TEU containership than the 16000TEU containership. Through table 4.8, 4.9, each of the absolute value of the sensitivity coefficient of the 16000TEU containership is smaller than the absolute value of the sensitivity coefficient of 13000TEU containership. So when the factors change, the effect of the factors on the economics of the containership does more on 13000TEU containership.

5.3 Suggestion

To improve the economics of the containership, we can improve the capacity utilization and ensure the certain capacity as far as possible when going on one route. Choose the appropriate size of the containership according to the cargo capacity. When doing the route planning, we should consider the admissible port and choose the cost minimize route. Opening up more routes which is suitable for the mega containerships has become an important premise for the development of future containerships. To develop the scale and flexibility of the development of the mega containerships, the diversity of the route should be guaranteed. The diversity of the route can develop the potential advantages of mega containerships. The most important thing is to ensure the safety and decrease the possibility ratio of the accidents, which the crew and the shipping company should always keep in mind.

This analysis has limitation as well. In this analysis, when one factor changes, other factors are supposed to be unchanged, while in the real economic activity, the factors are affected by each other. Therefore it worth to be further studied in the future.

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Appendices

1 元复利现值系数表

期数	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	12%	14%
1	0.9901	0.9804	0.9709	0.9615	0.9524	0.9434	0.9346	0.9259	0.9174	0.9091	0.8929	0.8772
2	0.9803	0.9712	0.9426	0.9246	0.9070	0.8900	0.8734	0.8573	0.8417	0.8264	0.7972	0.7695
3	0.9706	0.9423	0.9151	0.8890	0.8638	0.8396	0.8163	0.7938	0.7722	0.7513	0.7118	0.6750
4	0.9610	0.9238	0.8885	0.8548	0.8227	0.7921	0.7629	0.7350	0.7084	0.6830	0.6355	0.5921
5	0.9515	0.9057	0.8626	0.8219	0.7835	0.7473	0.7130	0.6806	0.6499	0.6209	0.5674	0.5194
6	0.9420	0.8880	0.8375	0.7903	0.7462	0.7050	0.6663	0.6302	0.5963	0.5645	0.5066	0.4556
7	0.9327	0.8606	0.8131	0.7599	0.7107	0.6651	0.6227	0.5835	0.5470	0.5132	0.4523	0.3996
8	0.9235	0.8535	0.7874	0.7307	0.6768	0.6274	0.5820	0.5403	0.5019	0.4665	0.4039	0.3506
9	0.9143	0.8368	0.7664	0.7026	0.6446	0.5919	0.5439	0.5002	0.4604	0.4241	0.3606	0.3075
10	0.9053	0.8203	0.7441	0.6756	0.6139	0.5584	0.5083	0.4632	0.4224	0.3855	0.3220	0.2697
11	0.8963	0.8043	0.7224	0.6496	0.5847	0.5268	0.4751	0.4289	0.3875	0.3505	0.2875	0.2366
12	0.8874	0.7885	0.7014	0.6246	0.5568	0.4970	0.4440	0.3971	0.3555	0.3186	0.2567	0.2076
13	0.8787	0.7730	0.6810	0.6006	0.5303	0.4688	0.4150	0.3677	0.3262	0.2897	0.2292	0.1821
14	0.8700	0.7579	0.6611	0.5775	0.5051	0.4423	0.3878	0.3405	0.2992	0.2633	0.2046	0.1597
15	0.8613	0.7430	0.6419	0.5553	0.4810	0.4173	0.3624	0.3152	0.2745	0.2394	0.1827	0.1401
16	0.8528	0.7284	0.6232	0.5339	0.4581	0.3936	0.3387	0.2919	0.2519	0.2176	0.1631	0.1229
17	0.8444	0.7142	0.6050	0.5134	0.4363	0.3714	0.3166	0.2703	0.2311	0.1978	0.1456	0.1078
18	0.8360	0.7002	0.5874	0.4936	0.4155	0.3503	0.2959	0.2502	0.2120	0.1799	0.1300	0.0946
19	0.8277	0.6864	0.5703	0.4746	0.3957	0.3305	0.2765	0.2317	0.1945	0.1635	0.1161	0.0829
20	0.8195	0.6730	0.5537	0.4564	0.3769	0.3118	0.2584	0.2145	0.1784	0.1486	0.1037	0.0728
21	0.8114	0.6598	0.5375	0.4388	0.3589	0.2942	0.2415	0.1987	0.1637	0.1351	0.0926	0.0638
22	0.8034	0.6468	0.5219	0.4220	0.3418	0.2775	0.2257	0.1839	0.1502	0.1228	0.0826	0.0560
23	0.7954	0.6342	0.5067	0.4057	0.3256	0.2618	0.2109	0.1703	0.1378	0.1117	0.0738	0.0491
24	0.7876	0.6217	0.4919	0.3901	0.3101	0.2470	0.1971	0.1577	0.1264	0.1015	0.0659	0.0431
25	0.7798	0.6095	0.4776	0.3751	0.2953	0.2330	0.1842	0.1460	0.1160	0.0923	0.0588	0.0378
26	0.7720	0.5976	0.4637	0.3604	0.2812	0.2198	0.1722	0.1352	0.1064	0.0839	0.0525	0.0331
27	0.7644	0.5859	0.4502	0.3468	0.2678	0.2074	0.1609	0.1252	0.0976	0.0763	0.0469	0.0291
28	0.7568	0.5744	0.4371	0.3335	0.2551	0.1956	0.1504	0.1159	0.0895	0.0693	0.0419	0.025
29	0.7493	0.5631	0.4243	0.3207	0.2429	0.1846	0.1406	0.1073	0.0822	0.0630	0.0374	0.022

Appendices 1

表 2-4

1 元年金现值系数表

期数	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	12%
1	0.9901	0.9804	0.9709	0.9615	0.9524	0.9434	0.9346	0.9259	0.9174	0.9091	0.8
2	1.9704	1.9416	1.9135	1.8861	1.8594	1.8334	1.8080	1.7833	1.7591	1.7355	1.6
3	2.9410	2.8839	2.8286	2.7751	2.7232	2.6730	2.6243	2.5771	2.5313	2.4869	2.4
4	3.9020	3.8077	3.7171	3.6299	3.5460	3.4651	3.3872	3.3121	3.2397	3.1699	3.0
5	4.8534	4.7135	4.5797	4.4518	4.3295	4.2124	4.1002	3.9927	3.8897	3.7908	3.6
6	5.7955	5.6014	5.4172	5.2421	5.0757	4.9173	4.7665	4.6229	4.4859	4.3553	4.
7	6.7282	6.4720	6.2303	6.0021	5.7864	5.5824	5.3893	5.2064	5.0330	4.8684	4.
8	7.6517	7.3255	7.0197	6.7327	6.4632	6.2098	5.9713	5.7466	5.5348	5.3349	4.
9	8.5660	8.1622	7.7861	7.4353	7.1078	6.8017	6.5152	6.2469	5.9952	5.7590	5.
10	9.4713	8.9826	8.5302	8.1109	7.7217	7.3601	7.0236	6.7101	6.4177	6.1446	5.
11	10.3676	9.7868	9.2526	8.7605	8.3064	7.8869	7.4987	7.1390	6.8052	6.4951	5.
12	11.2551	10.5753	9.9540	9.3851	8.8633	8.3838	7.9427	7.5361	7.1607	6.8137	6
13	12.1337	11.3484	10.6350	9.9856	9.3936	8.8527	8.3577	7.9038	7.4869	7.1034	6
14	13.0037	12.1062	11.2961	10.5631	9.8986	9.2950	8.7455	8.2442	7.7862	7.3667	6
15	13.8651	12.8493	11.9379	11.1184	10.3797	9.7122	9.1079	8.5595	8.0607	7.6061	6
16	14.7179	13.5777	12.5611	11.6523	10.8378	10.1059	9.4466	8.8514	8.3126	7.8237	[illegible]
17	15.5623	14.2919	13.1661	12.1657	11.2741	10.4773	9.7632	9.1216	8.5436	8.0216	[illegible]
18	16.3983	14.9920	13.7535	12.6896	11.6896	10.8276	10.0591	9.3719	8.7556	8.0216	[illegible]
19	17.2260	15.6785	14.3238	13.1339	12.0853	11.1581	10.3356	9.6036	8.9601	8.3649	[illegible]
20	18.0456	16.3514	14.8775	13.5903	12.4622	11.4699	10.5940	9.8181	9.1285	8.5136	[illegible]
21	18.8570	17.0112	15.4150	14.0292	12.8212	11.7641	10.8355	10.0168	9.02922	8.6487	[illegible]
22	19.6604	17.6580	15.9369	14.4511	13.4886	12.3034	11.0612	10.2007	9.4424	8.7715	[illegible]
23	20.4558	18.2922	16.4436	14.8568	13.4886	12.3034	11.2722	10.3711	9.5802	8.8832	[illegible]
24	21.2434	18.9139	16.9355	15.2470	13.7986	12.5504	11.4693	10.5288	9.7066	8.9847	[illegible]
25	22.0232	19.5235	17.4131	15.6221	14.0939	12.7834	11.6536	10.6748	9.8226	9.0770	[illegible]
26	22.7952	20.1210	17.8768	15.9828	14.3752	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Appendices 2

Source: Cao huimin, (2013), Financial Management, Lixin Accounting Publishing House, p484,488