Erasmus University Rotterdam

MSc in Maritime Economics and Logistics

2010/2011

The impacts of large scale container vessels on container terminals: Simulation of Triple-E class container vessel calling at Yantian International Container Terminal

By

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Acknowledgement

After four years study in Dalian Maritime University and one year work in Dalian Shenpeng Ocean Shipping Co.Ltd, I got a preliminary understanding on international shipping industry and accumulate much professional knowledge and many practical skills. Because of the requirement of shipping industry on international communication and cooperation, I realized the importance of further study and strong background on maritime economics. Meanwhile, my curiosity about the socio-economic level of western world and development of shipping industry makes my plan for over-sea study. At the last half of 2010, I had the honour for applying the MCs in MEL. After nearly one year study here, I felt that I made a right option. In MEL, I learnt the speciality theoretic knowledge. What is more important, I got the opportunity to visit the major international ports in Europe like Port of Rotterdam and Antwerp. For all these, I thank the instructors in MEL for imparting knowledge to me and opening my mind.

In writing this thesis, I would like to mention my supervisor Professor Gujar Girish. His guide and help is the strongest support of my finishing this research. At the same time, I should thank Mr. Linjie Li from Dalian Shenpeng Ocean Shipping Co.Ltd, Mrs. Shuyun Wang from Shenyang Yinxin Co.Ltd and Professor Ming Zhong from Dalian Maritime University. Their suggestions and helps are also of great help.

In addition, I will dedicate this thesis to my parents. Their supports in finance and spirit in this year help me finish the study in Netherlands. In particular my mother, although cannot help me too much in professional knowledge, give me great metal encouragement in the time when I study in a distant country.

Lastly, I will thank all the students in MEL 2010/2011 and other friends in Netherlands. Thank you for giving me a wonderful year here.

Good luck!

Abstract

After global economic crisis, the speeds of economic improvements in new emerging markets and developing countries are faster than that in developed economies, and these two entities have become the major force of world economic recovery. In international shipping market, the global container volume increases dramatically. And China has become the world's biggest country in import and export because of its rapidly developing manufacture.

At the same time, the profits brought by economy of scale has attracted attentions from international shipping participants, The container shipping gets advantages from economics of scale in maritime shipping, inland transportation and transshipment. The container shipping companies are interested to increase the vessel size because of increasing the vessel capacity it could make lower cost/TEU. Under this background, the large scale container vessels start to bring out.

Today, the mega container vessels, which own transport capacity of over 10000 TEUs per single ship, have been put into use. Although these mega vessels can meet the requirement in current container shipping market, they also make new requests for container terminals all over the globe. These requests are from almost all aspects like geographical position, natural conditions, infrastructures and superstructures. During the competition in the tendency of large scale container vessels, many ports lose their former positions in container shipping market. And many ports which possess all the conditions above become the new core in this time.

Yantian International Container Terminal is one of the four international container transfer ports and the container terminal with the highest container throughput in China. Seen from the natural conditions, quality of infrastructures and efficiency of custom clearance, YICT has the potential to become the core container terminal in China or in the whole range of Far East. In Chapter4, I simulate that the world's biggest container vessel in the next five years – Triple-E class container vessel from Maersk Line call at YICT to test its terminal capacity (the capacity in berth and container yard, and their service quality) to see YICT's ability of serving large scale container vessels. I conclude some advantages and disadvantages of YICT in serving the mega vessels.

In this thesis, I make suggestions on the development of YICT and, using YICT as an example, analyse the impacts of large scale container vessels on container terminals.

Key words: large scale container vessel, economy of scale, Triple-E class, berth capacity, container storage capacity

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Chapter 1. Introduction

1.1 The current overall trend of global economic and trade development

In 2010, the world economy keeps its trend of recovery in general. However, influenced by the decreasing effects of reflationary policy, serious natural disasters and human accidents, this trend shows a “First high and last low” behaviour. Meanwhile, the imbalance in global economic recovery becomes clear, and the development of the world economy presents a framework of “Two speed”. The speeds of economic improvements in new emerging markets and developing countries are faster than that in developed economies, and these two entities have become the major force of world economic recovery. Among the developed economies, the economic recovery in USA and Japan tend to be slow and complicated. In EU, the differentiation is getting worse between core countries like Germany or France and some peripheral countries. (United Nations 2011) International Monetary Fund (IMF) publishes its World Economic Outlook on April 11, which indicates that the world economic growth in 2010 is 5%, with 3% in developed economies and 7.3% in emerging markets and developing countries.

Calculated in nominal exchange rate, in 2010, the world GDP grows with a rate of 3.6%. Specifically, the GDP in developed economies increases by 2.6%, and that in developing countries and emerging markets is 7%. It is worth to notice that the world economic growth in the first half of the year is staggering, and the trend got slow in the second half because of the crisis of sovereign debt in Europe.

Concerning the world trade, in 2010 the global trade shows a rapid growth. Calculating in a stable price, the global exports increase by14.5%, and the global imports rise by 13.5%. Influenced by the increase in price of primary products and dollar depreciation, the global cargo exports rise by 22%, while the import increase by 21% (calculated in normal price). At the same time, the world service exports increase by 8%, and imports increase by 9%. (Homi Kharas, 2010)

1.2 The global container volume is undergoing a strong increase

According to the relevant indices of global container shipping lines in the 2010's report from MDS Transmodal local and global transport and logistics research institution (UK), the global container market rapidly thrived from the first half of 2010. Especially, the container transport volumes of paper, paper pulp, beverage, food, reefer cargo and vehicle parts increase dramatically, most of which are containerized cargo exported from Far East to North America and Europe. Compared with 2009 over the same period, the increasing rate of container volume is 12% in the first quarter, and that in the second quarter is high at 22%. The second half of 2010 shows the same strong upward trend. So we can see the increasing trend of the container volume in the global market. The container transport volume indices in global ocean lines in the last quarter rise by 29.3% on year-on-year basis. If there were not the negative influence of Finance Crisis in 2008-2009, the increasing rate could be higher.

Table 1-1 The container transport volume indices on Global ocean lines 2006-2010 (Using 2006 as 100)

Quarter/Year	2006	2007	2008	2009	2010
1	100	105.8	118.1	104.3	123.2
2	100	106.9	117.1	106.3	126.1
3	100	108.9	114.8	109.4	127.6
4	100	107.3	103.5	110	129.3

Source: MDS Transmodal

One thing should be pointed out is that the increasing rates in each container lines are not keeping pace, but having nothing common with each other. The container transport volume index in the last quarter in 2010 increase to 129.3 compared with the same period in 2006. This includes the Trans-Asia international container shipping line which take a relatively high increasing rate, but does not include the Trans-America and European lines, whose increasing rates are far lower.

In addition, because of the increasing numbers of the fleet of large scale container vessel, the average transport capacity of a single vessel is also increasing in the global range. The average capacity is 3990 TEUs in 2009, and rapidly climbed up to 5150 TEUs in 2010. As can be predicted, it will raise to 6050 TEUs and 7015 TEUs in the end of 2011 and 2012. At the same time, the overall transport capacity of the global container fleet is also increasing. In 2008, the new coming capacity in global container fleet is 157 million TEUs, and the data are 107 million and 142 million in 2009 and 2010. Up to the end of December 31st, 2010, the overall transport capacity in global container fleet has reached 1430 million TEUs. As predicted, in 2011-2012, the global container fleet will gain another capacity of 140 million TEUs.

1.3 China's dominant position in manufacturing

In 2010, China has become the world's biggest manufacturer, defeating the US who had taken this position for about 110 years. US consultancy IHS Global Insight estimated that in 2010, China accounted for 19.8% of global manufacturing output, compared with the US share of 19.4%.

In 2000, the developed countries in Europe, North America and Japan, accounted for 72% of global manufacturing output, down from 80% in 1990. By 2010, the wealthy nations accounted for a little more than half of world goods production. The BRIC countries (Brazil, Russia, India and China) accounted for just over a quarter of the total, up from 11% in 2000. China's share of factory output was 6.9% of total manufacturing in 2000; its share has tripled in a decade.

The rapidly developing manufacture can obviously propel China's import and export trades. According to the report from Maritime Customs Administration of China, the total amount of China's normal import and export trades is 1488.71 billion USD in 2010, increased by 39.9%. Specifically, export trades take 720.73 billion USD, with an increasing rate of 36%; Import trades take 767.98 billion USD, increasing by 43.7%. Normal trade deficit is 47.25 billion USD, increasing by 9.5 times compared with that in 2009. In 2010, China's import and export for processing trade reached 1157.76 billion USD, increasing by 27.3%. Export trades take 740.33 billion USD, with an increasing rate of 26.2%; Import trades take 417.43 billion USD, increasing by 29.5%. Surplus in processing trade is 322.9 billion USD, increased by 22.2%.

In 2010, despite of the crisis of sovereign debt, the trading tie between China and Europe still maintained the healthy momentum of growth. The volume of bilateral trade increased dramatically and exceeded the level before Finance Crisis. According to Statistical Office of the European Union, in the first nine months in 2010, export volume from EU to China reached 82.3 billion Euros, increased by 39% on year-on-year basis. This increasing speed is only slower than that of Brazil among EU's main trade partners. EU's import volume reached 204.5 billion Euros, increased by 30% on year-on-year basis. As EU and China both step in a new stage of adjusting the economic developing ways, the cooperation between EU and China will be deepened and expanded.

1.4 Brief introduction of large scale container vessel

It has been 50 years since the first container vessel came into use. 50 years ago, American Macklin reconfigured an old crude carrier used in World War II into a container ship which could carry a dozen of 35' road-dedicated containers and put it into the service in the world's first container line between New York and Houston. This invention in transportation reached a great success and opened a new chapter in the development of global transportation. After that container shipping underwent a period of rapid growth.

The development of container vessels divided into six sections, which began in the era of first use of container in the 1950s until the last generation of container vessels at the present. The six generations of container vessels are shown as following:

First Generation (1960s):

In the 1960s, the first generation of container vessels traveled cross Atlantic and Pacific. These container vessels are mostly remodeled from bulk ships, with a gross tonnage of 17000-20000 tons. Each container vessel can carry an average of 700-1000 TEU. There are two typical kinds of the first generation of container vessels.

- Converted Cargo Vessel, with 500 TEU capacity, 15-19 knots speed, and 135 m length.
- Converted Tanker, with 800 TEUs capacity, 15-19 knots speed, and 200 m length.

Second Generation (1970s):

In 1970s, the gross tonnage of container vessels increased to 40000-50000 tons, and the capacity of them rose to 1800-2000 TEUs. Comparing with the first generation, the shipping speed of container vessels went up from 23 knots to 26-27 knots. The container vessels in this period were definite as the second generation.

Third Generation (mid 1970s - mid 1980s):

Since the oil crisis in 1973, the second generation of container vessels was recognized as the representative of an uneconomical type, which was taken place by the third generation of container vessels. In this generation, the shipping speed of container vessels decreased to 20-22 knots. However, as the ship size was enlarged, the transport efficiency was improved. The capacity of the container vessels reached 3000 TEUs. So, the third generation of the container vessels was efficient and energy-saving.

Fourth Generation (later 1980s – mid 1990s):

In the late 1980s, the shipping speed of container vessels was further increased. The criterion of container ships becoming larger is passing through the Panama Canal. The container vessels in this period were considered as the fourth generation. The vessels in this generation have an average capacity of 4400 TEUs. By using the high strength steel, the total weight of the vessel decreased by 25%. The design of high-powered diesel engines reduced the fuel cost to a large extent. Besides, the development of the ship automation, reduced the number of crews, which made the economical efficiency improved further onwards.

Fifth Generation (earlier 1990s):

As the pioneer of the fifth generation of the container vessels, the APLC-10 container vessels which made in Germany could carry 4800 TEUs. This kind of vessel had a length/beam of 7~8, which improved the recoverability of the vessel.

Sixth Generation (mid 1990s-):

The Rehina Maersk container vessels which were completed in spring of 1996 could carry up to 8000 TEUs. The six generation of container vessels was recognized to raise the curtain here. In 2000s, there has been a new kind of container vessel having a capacity of about 11,000 TEUs, with 24-25 knots speed, 335 m length and 13-14 m draft.

The figure below (Figure 1-1) visually shows the evolution process of container vessels.

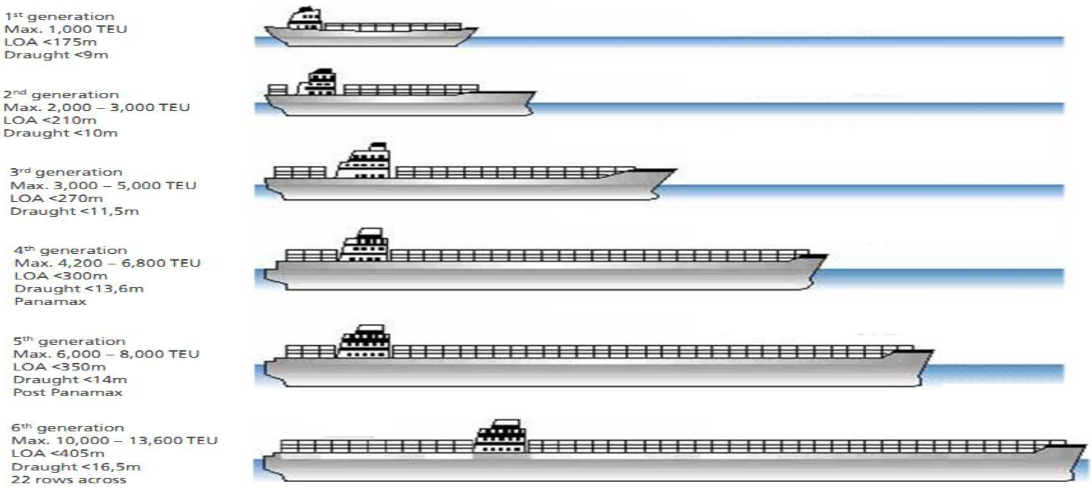


Figure 1-1 The evolution process of container vessels
Source: Y.A. Saanen, J.C.Rijsenbrij, 2010

1.5 The Economic of Scale in Container Shipping

The definition of economic of scale is a reduction in cost per unit resulting from increasing production, or in the other word to operational efficiencies. Economy of scale can be realized because as increasing production it would be make the cost of each additional unit producing would be lower, in the container shipping its mean cost/TEU are reduced as ship size increase refer to the relevant costs for pricing and competitiveness. The economy of scale from transportation pattern is the innovation trigger in container shipping. The container shipping gets advantages from economics of scale in maritime shipping, inland transportation and transshipment. The container shipping companies are interested to increase the vessel size because of increasing the vessel capacity it could make lower cost/TEU. The increasing of the vessel capacity it could make increasing problem too, the large amount of containers to transshipped take a long time in the port. The shipping company really wants to reduce their port time as short as they can, but the large vessel capacity, it is not easy to reduce the port time as well as the small vessel capacity.

The transshipment of container from the larger vessel could be another problem to reduce the port time, larger type and cranes quantity on the quay and stacking yard, larger land quantities for container operations, congestion, too many trucks/trailer converging towards the terminal gates, that could be leads to diseconomies.

As an illustration, Figure 2 below shows the amount of costs incurred per TEUs in the Maritime Shipping, Transshipment and Inland Transportation in any quantity per TEUs capacity.

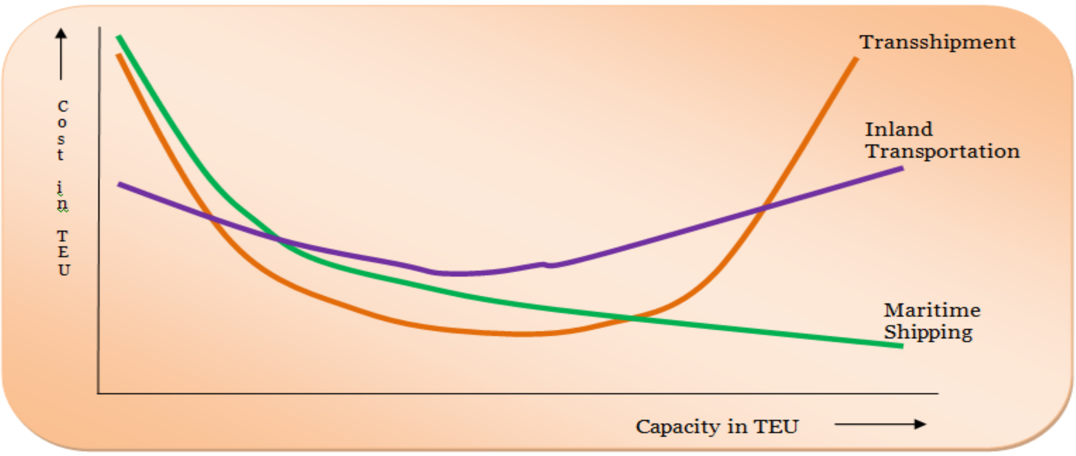


Figure 1-2 The relation between Capacity and Cost in container shipping
Source: Y.A. Saanen, J.C.Rijsenbrij, 2010

1.6 The problems and challenges faced by container terminals and their managers

At present, there is no doubt that many international container terminal management enterprises receive great successes, and their futures are glorious. Anyway, these enterprises also face huge challenges in global contaniner terminal managements.

1.6.1 Large scale container vessels continue to bring out

The increasing size of container vessels will totally change the business strategies and management modes of international container terminal operators. Today, the mega container vessels, which own transport capacity of over 10000TEUs per single ship, have been put into practical use. In order to catch the rapid development of global shipping and adapt to the new concepts of this time, the international container terminal operators need to reconsider the conception of arrival ships – a huge monster. They must push substantive evolutions in strategic investments on terminals, operating and management modes and the scheduling of ships in shipping lines all over the world. In theory, the higher tonnages and more slots of container vessels, the lower bunker cost and expenses of canal taxations will split into each TEU. The daily cost of mega container vessels is 30% lower than that of Panamax container vessels if calculating the total operating cost. (Bing Liu, Deli Chen, 2005) When we talk about the mass advantages and benefits of current container transportation brought by mega container vessels, we must recognize clearly that the functions of international core container terminal will be more outstanding.

The mega container vessels continue to bring out in the range of the whole world. This attracts the attentions of terminal operators in many shipping countries: To fill the increasing demands of container vessels with larger size and augmenting capacity, the draft of the terminals needs to be deepened, the terminal berths need to be expanded, and the terminal infrastructures and superstructures should be reformed. The size of container vessels has been enlarged to over 12500 TEUs. Moreover, according to the developing level of industry and technology, and the practical demand of some certain routes, it is not difficult from materials and crafts to design and build vessels with capacity of over 15500 TEUs, or even more, 18000TEUs (Triple-E vessels). (*Sustainability Progress Report 2010*, Maersk Line) The only problem all over the world today is that there are few container terminals which has a safe draft of over 16 to 21 meters and can serve mega container vessels with a length of more than 410 meters. All these brings steep requirement to terminal infrastructure.

1.6.2 Container terminals are taking great burdens on their infrastructures

Container transportation has irreplaceable advantages. Especially, it has fast transport speed, high economic benefits, and convenient transport network. Today, bananas, cereals, ores, cottons, even beverages, inebriants, oil, production rejects, ferrous wastes and garbage, which used to be recognised as bulk, are carried in containers. Before 2011 or 2015 the latest, the global cargo volume carried by containers will increase to 2 or 3 times as now, and the increasing rate in some routes will be larger. (Rongzhong Zhang, 2003) For example, the container volume in North America-China line will increase to 4 times. So there is a trend that nearly all terminals in the world have the ambitions to develop container transportation, and most of them declaim that they have the natural advantages to become core container terminals. However, the real successes to become the international container terminals are minority, and most terminals are disappointed. The reason is simple: the hub-and-spoke systems formed in north-south or east-west container shipping lines themselves have determined that the hub terminals are minority. The subordination is the correct position to most container terminals. Some natural conditions are hard to change in the process of struggling to get the core position in global hub-and-spoke system. The geographical position cannot be removed, changed or duplicated. So better geographical positions (like closer to north-south or east-west main container shipping lines, good waterway condition, enough berth draft for 12000+TEUs mega container vessels or close to hinterland industry centres) are most canonical and crucial in becoming international core container terminals. And this factor is exactly the reason why other terminals cannot get the international core position.

1.6.3 The development of hinterlands

Following the technology renovation and liberation of productive force, the “cake” of world economy becomes bigger and more attractive. The regional core container terminals raises accompanied with the transferring of the world economical centre and their throughputs increase rapidly. In the past, one regional centre of world economy only suited 1-2 core container terminals. The transport mode consisted of hub ports, main ports and sub ports. Anyway, this structure has changed today.

The hub container terminal can be classified into two types. One is international transferring terminal, and the other is hinterland oriented container terminal. The international transferring terminal is those don't have enough container volume from hinterland, and need to be fed by sub terminals. A necessity of this type of terminal is the vital geographical position. The hinterland oriented container terminal means the container volume from hinterland is enough to support the core position of the terminal. (Runxi Liu, 2009)

Make a general survey of the throughput international ranking of world core container terminal, those well known container terminals belonged under hinterland oriented ones, undergoing the transferring of the world economical centre, has waned these years. In the table below (Table 2), the container terminals like New York/New Jersey, Auckland, Liverpool, Tilbury, Belfast and Virginia, were very important when the world economy concentrated on America, Europe and Japan, and ranked in top 10 in 1971. These terminals generally focused on serving their hinterland and ignored the transferring functions. However, when the world economy moves to Asian and Pacific regions, these terminals have disappeared in 2007.

Table 1-2 1971-2007 The changes of ranking throughput of world's top 10 container terminals

Ranking	1971	1981	1991	2001	2007
1	New York/New Jersey	Rotterdam	Singapore	HongKong	Singapore
2	Auckland	New York/New Jersey	HongKong	Singapore	Shanghai
3	Rotterdam	HongKong	Kaohsiung	Busan	HongKong
4	Liverpool	Kaohsiung	Rotterdam	Kaohsiung	Shenzhen
5	Tilbury	Singapore	Busan	Shanghai	Busan
6	Bremen	Hamburg	Kobe	Rotterdam	Rotterdam
7	Yokohama	Charleston	Hamburg	Los Angeles	Dubai
8	Belfast	Yokohama	Keelong	Shenzhen	Kaohsiung
9	Seattle	Bremen	New York/New Jersey	Hamburg	Hamburg
10	Virginia	Kobe	Yokohama	Long Beach	Tsingtao

Source: The 38 Years History of Container Terminals

At present, following the rapid development of regional economics, the range of hinterland needed for the container volume to feed a main terminal is far smaller than that in 80s-90s in the last century, so that the number of hub port needed is relatively larger. On the other hand, if too many liner companies get congested in one terminal, the density of container flows is too high, and the over congestion of using a container terminal will lead to the overload of a city's infrastructure, and decrease the quality of service. Above all, under the condition of enough and secure supply of goods, some liner companies turn to exploit some relatively small terminals as regional main terminals. Few main terminals tend to develop into mass transferring ports.

1.6.4 Training of personnel for terminal operation and management is the thing put first

Well-trained employees and management talents are the biggest and most crucial key to any enterprise management. The last main challenge faced by international container terminal managers is the training of terminal operating and management personnel. The international container terminal enterprises have wild range of business and complicated global shipping networks. They should require that their personnel are hardworking, loyalty, responsible related. Besides, they also need a managing group with team spirit and vigorous. Without well-trained employees and management talents, any development planning and goals of international container terminal enterprises, including economic benefits, will become a piece of worthless paper. So, for an international container terminal enterprise, strategic employee training program and specific operation of the plan have the No.1 important meaning.

1.7 Research Methodology

Research questions

In this thesis, there are five research questions which I raised, and the objective of my dissertation is to analyze and answer these questions.

1. Research the performances and influences of large-scaled container vessels in current global container transportation market.
2. Analyze the economic effects and influences of large-scaled container vessels

   - Motivation
   - Economic advantages
   - Scale of economics

3. Analyze the coordination between terminals and large-scaled container vessels

   - The requirement of large-scaled container vessels on port infrastructure
   - The requirement of large-scaled container vessels on the quality of labour force and the impact on the cost of labour force.

4. Case study on YICT

   - Define the data needed for evaluate the capacity of the terminal.
   - Analyze the natural conditions and limits of YICT for serving the large-scaled container vessel.
   - Calculate terminal capacity (berth capacity, handling capacity and storage capacity, etc.) by using the current and predicted data. Make an assumption that Emma Maresk (current) and Triple-E (future) are under service, calculate their efficiencies.
   - Make the comparative analysis of current and future efficiencies

5. Make the conclusion that if YICT port can meet well with the impact of the development of large-scaled container vessels.

1.8 Process at a container terminal

The method I use in this thesis is introduced on Maritime Logistics course (2010-2011) from MEL. When we analyze the operating process of a container terminal, we can see the following stages which will take place:

- Berthing of container vessels at the quay.
- The discharge of the vessel and the handling of containers from the vessel to an internal transportation mode.
- Transport of containers to the stack.
- Unloading of the internal transportation mode, handling of container to the stack.
- Storage of containers.
- Internal shifting of containers in the stack.
- Transshipment of containers from the stack to a landside internal transportation mode.
- Transport to the transshipment point of the continental transportation mode.
- Handling to the continental transportation mode.

In all these stages, a terminal can be classified by a number of factors. Specifically,

- Quay capacity = Yard (Storage) Capacity / (1- 0.5 * Transhipment Ratio)
- Quay crane capacity = # quay cranes * average gross crane rate * max. Running hours * QC Reliability rate
- Yard Storage Capacity = (TGS x Maximum Stacking Height x Peak Utilization x Days in period) / (Separation Factor x Peaking Factor x Dwell Time)
- Yard Handling Capacity = Throughput * Maximum Handling Capacity of Yard Equipment / (Peak Landside Load + Peak Waterside Load)

In my thesis, I will use these formulas to analyze and compare the impacts of mega container vessels on Yantian International Container Terminal in 2009 and 2015. From the results, I will demonstrate if YICT is able to meet the trend of larger scale of container vessels.

1.9 Access to data

The data used in my thesis are mainly from the official website of YICT. Meanwhile, Chinese government has performed some research projects on the developments of China's coastal container terminals. The data and reports of these projects are also of great help to my research.

In addition, the research methodology and relative deducing process are from course book of Maritime Logistics edited by Professor Y.A.Saanen. And other useful data are from the following sources:

Official website of Yantian International Container Terminal: www.yict.com.cn

China shipping services: www.shippingchina.com

Database of Dalian Maritime University: www.dlmu.edu.cn

www.Portcontainer.cn

Chapter 2. The analysis of global container market and large scale container vessels

2.1 The analysis of the current container transport market

The container transport started at 1960s. In the past half century, the container transport market made a significant progress and enjoyed the greatly competitive supremacy in general cargo transport market. Since 1990s, following the rapid development of world trade and economy and the improvement of technology, the large scale tendency of container vessels strengthen the global container fleet, and improve the quality of service in container transportation.

2.2 The demand analysis of international container transportation

The demand of container shipping has a strong positive correlative relation with world economy. The relevant statistics shows that every percent growth of world economy (GDP) results in 1.6% increasing in global sea cargo transportation and more than 2% growth in world container volumes. The table (Table 3) below shows the correlation between world economy growth and the increase of container volumes from 1980 to 2010.

Table 2-1 The correlation between world economy growth and the increase of container volumes

Year	Container volumes (million TEU)	Compound average growth rate over previous period	Growth rate of GDP
1980	13.5	-	1.8%
1990	28.7	7.8%	3.2%
2000	68.7	9.1%	4.8%
2010	177.6	7.3%	4.6%

Source: IMF annual report & Chinese Shipping Gazette

In the past few years, despite of undergoing the Financial Crisis, the growth of international container shipping kept a generally increasing trend. In 2003, the world container volume was 84 million TEUs, increasing at a rate of 10.5% on a year-to-year basis. In the next year, the increase reached 14.3% with the amount of 96 millions. In 2005, world container volume broke through 100 millions.

According to the World Economic Outlook published by IMF, in 2006 and 2007, the world economy maintained a high growth rate of 5.1% and 4.9% respectively. Driven by the world economic growth, the international trade was expanding. Although Financial Crisis led to some negative effects on it, the global container volumes have recovered today. As the report of Jefferies 7th Global Shipping & Logistics

Conference (2010) shows, the increase in container volumes for 2010 was 10.9%, and the global container demand growth was 8.6% in 2010.

In 2011, world economy grows dramatically, but the influences of Financial Crisis still exist. At the same time, European Debt Crisis and political turmoil in Libya continue. All these bring uncertainty to world container shipping market. Anyway, China will play an important role in container shipping. According to the report from Chinese Academy of Sciences on July 1 2011, China has become the country with the highest demand for container shipping. These years, Chinese economy grows rapidly and has significant influence on world trade. The trade with China advances the shipping business of relative countries and regions. For example, the 50% of business growth in Port of Antwerp is from the market of Chinese mainland; one third of containers in Port of Hamburg are coming from or to China.

2.2.1 The supply analysis of international container transportation

In order to meet the rapid increase of demand for container shipping, the world container fleet came into a new expand expanding period. Claskson Research statistics shows that the scale of world container fleet reached 8.2 million TEUs, increasing at 13.1% which was much higher than the level in 2002 and 2003. Specifically, the transport capacity of Post-Panamax grew fastest at 2.4 million TEUs (22.1%), which took up 29.7% of the total container fleet. According to Clackson statistics for ship ordering, the end of 2007 was a peak time of ship delivery. The percentage of new coming capacity in world container fleet was 17% in 2006. In 2009, the capacity of global container capacity increased by 6%, and the rate was 10% in 2010. Now the total capacity of world container fleet reaches 13.6 million TEUs. And the capacity of the container vessels delivered in 2011 will be 1.4 million TEUs. At present, the large scale tendency of container vessels has not ended, and the biggest container vessel which has been put into use is CLCS STAR (14100TEUs).

2.3 The definition of the large scale container vessel

Today, the academic circle has been discussing about Very Large Container Ships (VLCS for short). However, there is no unified definition for this kind of container ships. The large scale container vessels in this thesis should meet the following conditions:

- The length over all is more than 300 m; the vessel has more than 18 40' bays
- The breadth moulded is more than 42.5 m; the vessel can take 17 or more rows and containers.
- The depth is more than 24 m; the stack height in holds is 9-10.
- The draft is more than 14-15 m; the deadweight is more than 920 thousand tonnages.
- The total capacity is more than 8000 TEUs.

2.4 The summary of Very Large Container Ships

2.4.1 The categorization of VLCS

According to the definition above, the VLCSs in the world are mainly built in 7 shipyards and can be categorized into the following types: (Yongping Qiu, 2008)

1) Maersk-S: This type of vessels is built by Odense shipyard in Demark and it is the oldest VLCS. The first container vessel in this type “Sovereign Maersk”, with a tonnage of 8050 TEUs, came out in September 1997. There are now five derived types based on its breadth moulded (42.8m) and draft (24.1m). The newest “G” series are the longest container vessels in the world with a LOA of 367m.
2) The three types from Hyundai Heavy Industries: 8200/8400 TEUs type, 8600 TEUs type and 9500TEUs type.
3) The three types from Samsung Heavy Industries: OOCL “SX” series, CSCL 8500TEUs, and 9200/9600 TEUs.
4) The 8000 TEU type from Hanjin Heavy Industries.
5) The 8400 TEU type from Daewoo Heavy Industries
6) The 8400 TEU type from Ishikawajima-Harima Heavy Industries (Japan).
7) The 8530 TEU type from CSSC (China).

The data for VLCSs advance very fast, and the following table (Table 1) shows some basic parameters and representative vessels for each type in 2007:

Table 2-2 The basic parameters of VLCS in the world

Ship type	**LOA/ m**	**Breadth/ m**	**Depth/ m**	**Draft/m**	**Deadweight/ t**	**TEUs**	**Representative vessel**
Maersk-S	346.98	42.8	24.1	14.5	104800	8050	Sovereign Maersk
Maersk-S II	346.98	42.8	24.1	14.5	104700	8372	Clifford Maersk
Maersk-S III	346.98	42.8	24.1	14.5	104700	8400	Cornelius Maersk
Maersk-S IV	352.00	42.8	24.1	15.0	109000	8650	Axel Maersk
Maersk-S V	367.00	42.8	24.1	15.0	115700	9120	Gudrun Maersk
Hyundai 8200	335.00	42.8	24.5	14.5	100400	8238	CMA CGM Hugo
Hyundai 8400	335.00	42.8	24.6	14.5	100800	8488	CMA CGM Tosca
Hyundai 8600	335.07	42.8	24.5	14.5	100400	8750	Colombo Express
Hyundai 9500	350.00	42.8	24.5	14.5	107500	9469	COSCO Guangzhou
Samsung 8000	323.00	42.8	24.6	14.5	99500	8063	OOCL Shenzhen
Samsung 8500	334.00	42.8	24.6	14.5	101600	8468	CSCL Aisa
Samsung 9200	336.70	45.6	27.2	15.0	108200	9580	MSC Pamela
Daewoo 8400	332.00	43.2	24.5	14.5	107000	8400	Savannah Express
Hanjin 8000	325.00	42.8	24.5	14.5	100800	8034	MSC Maeva
IHI 8400	335.00	42.8	24.4	14.0	97500	8450	Maersk Sana
CSSC	334.00	42.8	24.8	14.6	101000	8530	-

Source: Yongping Qiu, 2008

2.4.2 The analysis of VLCS orders

Table 5 shows the statistics of VLCS delivery in 2007-2010, from the table we can make some conclusions as follows:

Table 2-3 The VLCS delivery 2007-2010

Company name	2007	2008	2009	2010	Total number in 2010
Maersk line	-	16	-	-	52
MSC	2	-	16	-	51
CMA CGM	-	8	4	-	27
COSCO	-	7	1	-	16
CSCL	-	4	-	-	16
Hapag Lloyd	2	2	-	-	10
OOCL	-	-	2	2	16
Evergreen	-	-	-	-	8
Yangming	-	2	3	-	9
NYK line	5	3	-	-	12
K line	-	1	3	-	8
MOL	-	4	4	-	9
Hanjin	-	-	-	-	5
Hyundai	1	3	-	-	4
ZIM	-	-	9	-	9
Others	3	6	14	2	25
Total	13	48	60	8	277

Source: Maritime Literature and Information 2007.6

1) The number of orders is huge and the VLCS fleet is increasing.
2) The orders from 2007 to 2010 take nearly half of total VLCS fleet at the end of 2010, and the capacity of the fleet kept rising in recent years. 2008 and 2009 are the peak times, when more than 80% of the orders are delivered.
3) The leading forces of container lines fall over each other with joining the VLCS club.
4) K line and Yangming owned their first VLCS in 2006. NYK and MOL received the first VLCS in 2007, then Hyundai in 2008. From the table, we can see that the Top 15 liner companies take up more than 90% of the VLCSs in the world. Maersk line and CMA CGM keep their dominant positions in the list. However, the advantages they have are getting less clear than before.
5) China's proportion of VLCS in world container fleet is becoming more and more significant.
6) COSCO and CSCL had already started to develop VLCS in 2002. In 2010, they have already owned 32 VLCS. If we take OOCL into account, at the end of 2010, China has taken more than 16% shares in total fleet of VLCS.
7) Only a few countries and shipyards are able to build VLCS.
8) Because building VLCS is quite a difficult task, there are limited numbers of shipyards which can take this kind of orders. Korean shipyards have most orders; meanwhile Chinese shipyards begin to take up certain market shares. Odense shipyard in Demark had no orders after 2004. Among all the shipyards, Hyundai Heavy Industries has the most orders up to 2011 which

is 88. Samsung and Daewoo keep the second and third positions with 53 and 51 respectively.

9) The ship-size in orders is increasing and new type has emerged.
10) One thing should be mentioned is that the data in the table are only the basic parameters of each type. Today, orders for over 10000 TEUs container vessels become more common. According to Lloyd’s statistics, the first order for over 10000 TEUs container vessel was in 2004. Up to the first half of 2011, the world total orders for over 10000 TEUs container vessels are 227. 2006, 2007 and 2008 are the peak years for ordering, when 80% of orders happened. Most of these orders should be delivered in 2010-2012. Moreover, Maersk’s new order for a fleet of 10 Triple-E container vessels (18000 TEUs) will be delivered in 2013-2015.

2.4.3 Triple-E container vessels

In February 2011, Maersk has ordered a fleet of ten 18000 TEUs container vessels, each of which costs 190 million dollars. These vessels will be delivered in 2013-2015. “Triple-E” stands for Economy of scale, Energy efficiency and Environment improved. The Triple-E class vessel is 400 m long and 59 m wide. Triple-E is currently the biggest container vessel in the world, and its feature of environmental protection is also excellent. Although the highest speed of Triple-E is 2 Kn slower than Emma Maersk (23 Kn), its CO_2 emission is 20% lower than that of Emma, and 50% lower than the average emission of the container vessels serving in Europe-Asia lines. In addition, its fuel consumption per TEU is 35% lower than that of 13100 TEUs container vessels which are going to be put into use in Europe-Asia lines in the next few years. In order to reduce the influence of this type of vessels on the environment, all the construction materials used on the vessel are recorded on a “vessel passport”. This means when the vessels retire, the documents make sure all the materials will be reused, recycled or disposed in the most secure and effective ways.

At present, this type of container vessels can only serve in Europe-Asia lines, because only in this line are there enough cargo supply and proper port infrastructure. For example, in shipping lines across the Pacific there is sufficient cargo supply, but the port infrastructures in North American container terminals cannot serve such mega vessels. Assumed from the current terminal capacity in North America, the discharging of Triple-E vessels at Port of Los Angeles may takes 5 days, even with the assistance of AP Moller, Maersk Group. (Skibsteknisk Selskab, 2011)

Wherever these Triple-E vessels are put into use, the global service network of Maersk Line will be remoulded. In addition, the operating costs of Triple-E is much lower than that of other types of vessels, so Triple-E vessels are more likely to be stowed even if the demand in global container market diminishes. If the demand for container shipping reduces, other vessels could be forced to quit and divert into other lines and even be laid up in a worse situation. So, the Triple-E class container vessels influence not only the Europe-Asia line, but also the shipping lines all over the world through a chain reaction. When these 18000 TEUs class container vessels come into service, all container shipping companies, whether large or small, global or regional, will be influenced in some forms and degrees, and many of them should reconsider their business plans.

2.5 The effects and applications of large scale container vessels

The large scale container vessel comes out for no more than 10 years, but its appearance and development have made great impacts on liner transportation. These impacts can be listed from the following aspects:

2.5.1 Deeply changing patterns of competition in world liner market

The liner transportation has step in the times of container vessels upsizing. More and more container shipping companies start to own large scale container vessels. The economy of scale has become the core competitiveness in container shipping market, and the competitions in this market has upgraded to the big race of large scale container vessels. In order to keep the shares, each magnates in liner market speed up to expand their routes armed by large scale container vessels. For example, Maersk Line keeps promoting new classes of container vessels these years to maintain its leading position in development of ship-size. Large scale container vessels are pushing the further evolutions in world liner market.

2.5.2 Influencing the fleet deployment in global container shipping lines

As the fleet of large scale container vessels is expanding, the Post-Panamax container vessels with 5600-6000 TEUs begin to quit from core routes and turn to feeder routes in Europe-Asia lines and Pacific lines. And 6600 TEUs container vessels have appeared in Atlantic lines. This downward chain reaction then influences 4000 TEUs vessels. The fleet deployment in global container shipping lines has upgraded totally.

2.5.3 Pushing the development of world shipbuilding industry

The technology involved in building large scale container vessels is another milestone in world's shipbuilding industry, and much higher than that in VLCC and VLOC. The tendency of larger size and higher speed directly push the regeneration of marine diesels. As the ship-size is enlarged, the parameters of marine diesels are also breaking the record. Today, the power rating of main engines equipped on large scale container vessels has reached 70 thousand kW. The world shipbuilding technology has been pushed by large scale container vessels.

2.5.4 Causing the reform of infrastructures in container terminals.

Large scale container vessels have not only the huge size, but also the new requirements on water depth, berth length and reaches of quay cranes. And these need the main container terminals in the world expand and upgrade their infrastructures. What is more important is that the new technology improving the loading and discharging efficiency emerges because of the huge load of loading and discharging. The traditional container terminals and their operation types, processes, efficiencies and effectiveness face great changes and challenges when the time of large scale container vessels comes.

2.5.5 Having deep influences on enterprise management and operating.

Concerning management and operating, to manage shipping lines for large scale container vessels, liner companies need to promote completely the cargo canvassing capacity to expand the supply of cargo. And this may even lead to re-division of terminals' hinterland and change the course of some major projects on inland collecting and distributing. These deep influences refer to both macro and micro managing aspects. So the management and operation of large scale container vessels need to start with changing the management principles, and then implement management with higher requirement, like globalized management, highly efficient management, dynamic management, vision and risk management.

2.6 The motivation of large scale container vessels

As mentioned in the last chapter, the main background of large scale container vessels is from the following aspects: the tendency of world economy; the stable development of global trades. Besides, the producing and operating activities of multinational corporations have become one of the leading forces of world economy. The continuing expansion of the businesses in multinational corporations has brought great influences on global shipping market, cargo structures and flows.

The international shipping industry has an increasing demand for large scale container vessels because of its attractive cost-effectiveness. At present, the container shipping market is facing fierce competitions, and each container company is working at reducing the operating cost and increasing the economic benefits. Large scale container vessels, as a solution, can significantly reduce the cost for cargos per ton or per unit so that its operating cost goes down relatively. We have discussed before that the orders for large scale container vessels never stop, and the ship size also keeps increasing. In theory, the most important advantage brought by single large scale container vessel is economy of scale. Specifically, in every single voyage, the container volume is high, and the number of port calls decreases. The cost and expense for one TEU on that vessel is about 10%-12% lower than that on a container vessel with a capacity of 5000-6000 TEUs, and 30% lower than that of 4000 TEUs, then more benefits come to ship operators. Anyway, one premise for such conclusion is that the large scale container vessel must be fully loaded, or the advantage does not exist. In practice, Drewry Shipping Consultants in London has done a research on over 6000 TEUs Post- Panamax container vessels in 2007. In their report, they compare the unit cost for per TEU with that for Panamax. The cost and expenses are saved from the following aspects: crew (30%), fuel (20%), insurance (10%), port fees (15%) and maintenance (25%). In addition, the cost reduces by US$ 200 per TEU on 5000 TEUs Post-Panamax container vessel compared with that of the largest Panamax container vessel.

Driven by these significant benefits of scales, liner companies and ship owners are scrambling to build large scale container vessels. From the perspective of practical operating, the tendency of large scale container vessel is an irreversible trend. The following data can support this issue.

Table 2-4 The increasing size of container vessels

Year	Average size (TEU)	Maximum size (TEU)
1980	975	3057
1990	1355	4409
2000	1741	7200
2004	1999	8063

Source: Database of DMU

2.7 The advantages of large scale container vessels

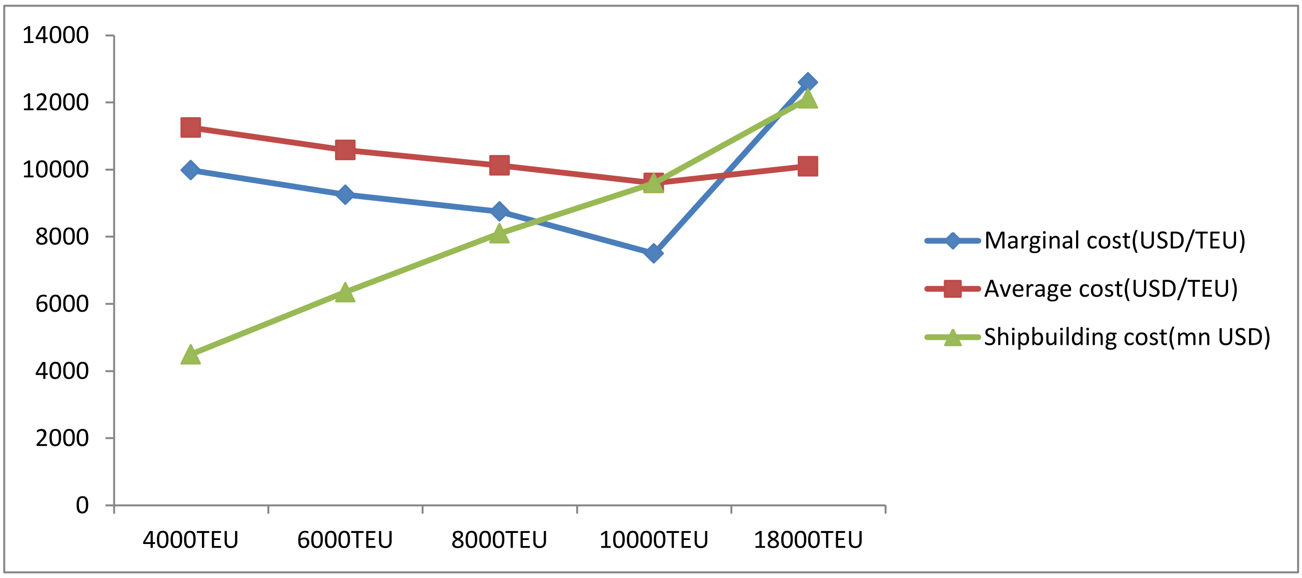
2.7.1 The economy of scale in container shipping

The prime movers behind tendency of large scale container vessels are the lower operating and building costs of container vessels. Generally speaking, economy of scale is based on large economic scales. According to Gregory Mankiw's Principles of Economics, economies of scale, in microeconomics, refers to the cost advantages that a business obtains due to expansion. There are factors that cause a producer's average cost per unit to fall as the scale of output is increased. "Economies of scale" is a long run concept and refers to reductions in unit cost as the size of a facility and the usage levels of other inputs increase. In shipping market, economy of scale refers to the phenomenon in which the unit costs are reduced as ship size increase. This reduction is more pronounced particular in the case of shipbuilding costs, manning costs (Emma Maersk has a crew of 13!) and fuel costs. Today, it is hardly that a shipping company will doubt the advantage on costs brought by large scale container vessels. Because of the economy of scale, the average unit costs decrease gradually as the ship size of container vessels increases. This can be explained by the Marginal cost pricing theory. The figure and table below shows the economy of scale in operating costs in container shipping market.

As can be seen, when the container vessels advance from 4000 TEUs to 10000 TEUs, the marginal cost and average cost show a downward trend, and touch the bottom at 10000 TEUs. But when the ship size breaks out 10000 TEUs, the marginal cost begin to increase, and the curve shows a 'U' shape.

Table 2-5 Cost changing with ship size increasing

Ship size	4000TEU	6000TEU	8000TEU	10000TEU	18000TEU
Marginal cost(USD/TEU)	9980	9250	8750	7500	12600
Average cost(USD/TEU)	11250	10583	10125	9600	10100
Shipbuilding cost(mn USD)	4500	6350	8100	9600	12120



Source: DMU database

Table 2-6 Costs in detail per TEU per year

Ship size	4000TEU		6000TEU		10000TEU		12000TEU	
Salary/ Welfare	233	10.13%	133	6.82%	83	5.79%	83	5.87%
Insurance	200	8.69%	167	8.56%	183	12.77%	167	11.82%
Ship management	34	1.48%	33	1.69%	33	2.30%	17	1.20%
Port fees	500	21.73%	450	23.08%	300	20.94%	283	20.03%
M&R	217	9.43%	167	8.56%	100	6.98%	133	9.41%
Storage	50	2.17%	50	2.56%	17	1.19%	30	2.12%
Fuel	1067	46.37%	950	48.72%	717	50.03%	700	49.54%
Total	2301	100.00%	1950	100.00%	1433	100.00%	1413	100.00%

Source: Drewry Shipping Consultants 2003

2.7.2 The cost advantages of large scale container vessels

In order to analyse the cost advantages of large scale container vessel, I will focus on three costs in shipping industry including capital cost, operating cost and voyage cost, and their definitions are in accordance with Martin Stopford's Maritime Economics.

1) Capital cost

Capital costs depend on the way the ship has been financed. They may take the form of dividends to equity, which are discretionary, or interest and capital payments on debt finance, which are not. The capital cost take up the most proportion in total cost of container shipping, with more than 46.2%. (Stopford, 2009) The capital costs of container vessels will increase as the ship size goes up. However, in the past few years, the ordering cost of large scale container vessels decreases dramatically with a rate of as much as 25%. Comparing the sixth generation of container vessels with the fourth, the capital cost of later fluctuate between USD 6000-6700 millions and the average capital cost is USD 1.37-1.56 million. Anyway, the capital cost of the sixth generation is between USD 9500-12500 millions, and the average capital cost is mainly around USD 1.13-1.34 millions. From the capital cost per TEU, that of the sixth generation is lower.

2) Operating cost

This cost constitute the expenses involved in the day-to-day running of the ship – essentially those costs such as crew, stores and maintenance that will be incurred whatever trade the ship is engaged in. (Stopford, 2009) This cost takes up 16.1% of total cost of container shipping. Seen from each aspect of operating cost, it will increase as the ship size goes up, but the increasing rate is far less than that of ship size. From table 2, as the ship size increases from 4000 TEUs to 12000 TEUs, the operating cost per unit decrease from USD 2301 to USD 1413. That is to say, the operating cost reflects the economy of scale more directly in container shipping.

3) Voyage cost

Voyage costs are variable costs associated with a specific voyage and include such items as fuel, port charges and canal dues. (Stopford, 2009) This cost takes up about 37.4% of total container shipping cost. According to Table 2, the voyage costs of 4000 TEUs, 6000 TEUs, 10000 TEUs and 12000 TEUs are USD 1567, 1400, 1020 and 983 respectively. The data shows a downward trend as the ship size increases.

2.7.3 The limits on economy of scale

The analysis of economy of scale above take no external factors into account. In fact, there are a lot of limits on the economy of scale in container shipping which will decrease its effects.

1) The limits of cargo supply

In order to make sure the economy of scale in container shipping, there must be sufficient cargo supplies. As the tendency of large scale container vessels goes, the external requirements for matchable cargo supplies increase. If there are no enough cargo supplies, the large scale container vessels cannot make the most of its advantages on low unit costs. Because of the geographical and political limitations, most of large scale container vessels are put into the Europe-Asia and North America- Asia lines. This may lead to the over competition, and eliminate the utility of vessels. So if the cargo supplies are scarce, the lost will be more serious as the ship is bigger. Then the economy of scale in container shipping loses its means.

2) The limits of terminals

Today, more large scale container vessels are put into global lines, but the developing speed of some container terminals doesn't catch up. Once congestions happen, the advantages of large scale container vessels will face challenges. Even one day delay may lead to great economic loss to a company.

The tendency of large scale container vessels request the matchable port natural conditions and operating efficiency. More container terminals in the world are expanding their port areas and improve the port existing conditions in order to meet the new challenges and opportunities brought by the rapid developing shipping industry. However, from the current situation all over the world, only a few terminals (like Rotterdam, Hamburg and Hong Kong) have water depth over -15 meters. Just because of the limits like water depth, the large scale container vessels tend to eliminate the direct calls in route planning and use Hub-Spoke system. The economy of scale in container shipping is embodied in sea moving instead of port calls. One of the benefits of Hub-Spoke system is that it reduces the numbers and times of calls, which can turn the economy of scale to best account.

3) The limits of inland activities

The inland transportation is other factor that influences competitiveness of economy of scale in container vessels. As the number of terminal that can serve a large scale container vessel is few, the tendency of large scale container vessels makes the cargos which used be handled in small terminals closer to the hinterland now tend to be consolidated in main container terminals by rail, road and inland shipping. This means the distances of inland transportation rise and the costs increase while the shipping costs are saved. The total costs will increase so that the competitive status of container shipping may be weakened. According to the report from Port of Shanghai, after Yangshan deep-sea container terminal was completed, the cost of inland transport for local container cargos increased by 600 RMB per TEU.

In addition, the tendency of large scale container vessels makes the inland transportation more congested. For example, a 10000 TEUs container vessel serving in North America-Far East line has approximately 6000-7000 TEUs which should be discharged in western coastal terminals and half of these cargos have to be transported to destinations by rail. Here we assume that a train can load 90 TEUs. In order to bring the containers from this vessel to inland areas, more than 50 this kind of trains will be needed. So the transport capacity of inland systems will influence the advantages of economy of scale in container shipping.

Chapter 3. The development of container terminals under the tendency of large scale container vessels

3.1 The history and current situation of container terminals

The history of container terminals is not a long story. However, during the 6o years after World War II, container terminals grew out of nothing and gradually became an important part in international shipping industry. Meanwhile, the core area of container shipping underwent continuous changes. Some major ports stepped down, and some new forces came into our sights.

After World War II, the western countries came into the time of heavy-industrialization. Most industrial companies which depended on maritime transportation got together in coastal regions. Raw materials and energy products took up a great proportion in the throughputs of terminals. At the same time the value-adding activities like packaging and labelling began to appear in port areas. The port function developed from loading and discharging to industrial and commercial sectors. In this period, the international container transportation started. Ports gradually became a crucial link in multimodal transport. They were actually junctions in transportation and the base for industrial activities.

As the modern logistics and container transport developed in the next dozens of years, after 1980s, some ports, relaying on their geographical and natural advantages, the wide hinterland, completed collecting and distributing system and the large cities behind them, became the international logistical centres. They were not just the transportation junctions and the base for industrial activities, but also can provide high value services like international trade information and logistics distribution. The diversified development made ports the most active area in coastal regions. At this time, the world's most important container terminals converged in Europe, America and Japan. At that time, the world's biggest container terminal was in New York.

When time came into 1990s, the speed of economic development in the Far East and Southeast Asia was almost as twice as the world average level. In spite of the Southeast Asian financial crisis in 1998, the proportion of trade volumes in the Far East and Southeast Asia in the total world trade rose from 15% in 1970 to 32% in 1998. This made the area became the original place of goods for global container shipping. The container throughput in the Far East and Southeast Asia was 25% of world volumes in 1980, and the percentage jumped to 42% in 1998. (Hua Shi, 2008) In the end of 2010, China has become the world's most important container shipping country and Port of Shanghai owns the world's biggest container terminal. The container centre has transferred unbelievably. Table 7-10 show the changing ranks of world's top 10 and 20 container terminals from 1980 to 2011.

Table 3-1 1980 Top 10 container terminals

Port Name	Throughput (10000 TEUs)	Country
New York	194.7	USA
Rotterdam	190.1	the Netherland
Kobe	147.1	Japan
Hong Kong	146.5	UK
Kaohsiung	97.9	China Taiwan
Singapore	91.7	Singapore
San Juan	85.2	USA
Hamburg	78.3	Germany
Oakland	78.2	USA
Seattle	78.1	USA

Source: The 38 Years History of Container Terminals

Table 3-2 1990 Top 10 container terminals

Port Name	Throughput (10000 TEUs)	Country
Singapore	522.4	Singapore
Hong Kong	510.1	UK
Rotterdam	366.7	the Netherland
Kaohsiung	349.5	China Taiwan
Kobe	259.6	Japan
Busan	234.8	Korea
Los Angeles	211.6	USA
Hamburg	196.9	Germany
New York	187.2	USA
Keelung	182.8	China Taiwan

Source: The 38 Years History of Container Terminals

Table 3-3 2000 Top 10 container terminals

Port Name	Throughput (10000 TEUs)	Country
Hong Kong	1810	China
Singapore	1704.4	Singapore
Busan	754	Korea
Kaohsiung	742.6	China Taiwan
Rotterdam	627.5	the Netherland
Shanghai	561.2	China
Los Angeles	487.9	USA
Long Beach	460.1	USA
Hamburg	424.8	Germany
Antwerp	408.2	Belgium

Source: The 38 Years History of Container Terminals

Table 3-4 2011 The prediction of Top 20 Container terminals in the world

2011	2010	Port	Country	Predicted throughput (million TEUs)	Increase by %
1	1	Port of Shanghai	China	3213-3254	10.6-12.0
2	2	Port of Singapore	Singapore	2934-2988	3.2-5.0
3	3	Port of Hong Kong	China	2438-2484	2.9-4.8
4	4	Port of Shenzhen	China	2321-2366	3.1-5.1
5	5	Port of Busan	Korea	1615-1641	13.9-15.7
6	6	Port of Ningbo-Zhoushan	China	1497-1520	14.6-16.4
7	8	Port of Qingdao	China	1374-1396	14.4-16.2
8	7	Port of Guangzhou	China	1332-1356	7.2-9.1
9	9	Port of Dubai	UAE	1186-1205	3.1-4.8
10	10	Port of Rotterdam	the Netherlands	1180-1201	5.8-7.7
11	11	Port of Tianjin	China	1171-1188	15.9-17.6
12	12	Port of Kaohsiung	China Taiwan	970-986	5.7-7.4
13	13	Port of Kelang	Malaysia	965-982	8.8-10.7
14	14	Port of Antwerp	Belgium	890-905	5.0-6.7
15	15	Port of Hamburg	Germany	860-875	8.9-10.8
16	16	Port of Los Angeles	USA	847-862	8.2-10.1
17	17	Port of Tanjung Pelepas	Malaysia	739-751	13.7-15.5
18	18	Port of Long Beach	USA	669-677	6.9-8.1
19	19	Port of Xiamen	China	613-624	5.3-7.2
20	21	Port of Dalian	China	595-605	13.2-15.1

Source: Chinese Academy of Sciences

3.2 The overview of container terminals

3.2.1 The definition of container terminal

According to Saanen and Reijsenbrij, “A terminal is an organization offering a total package of activities and services to handle, store and control cargo to and from transportation modes with a balance in handling and services to the transportation modes against the minimised costs.”

The cargo we discuss in this thesis is the container. So a container terminal is a place where containers arriving are transferred in general. From this perspective, a container terminal provides transhipment service and storage service.

There are two similar definitions of a container terminal relating to these functions. The first one (Tonguc & Hacı Murat) gives the following description:

A container terminal is considered that has a quay side where ships are loaded/ unloaded and a yard side where containers are kept until they leave the terminal by departing ships or other mode s of transportation.

Gronalt (2007) gives a more general definition from the view of the whole container transport system:

Container terminals are important hubs in modern logistic-networks that ensure efficient and frictionless intermodal (rail, truck, ship) container turnover which should be planned and coordinated.

From these definitions above we can conclude some important elements of a container terminal.

- A container handling system
- Fulfils storage function between different modes of transportation
- Provides fast handling facilities and equipments
- Provides other services to make sure the container transport process regular and coordinated

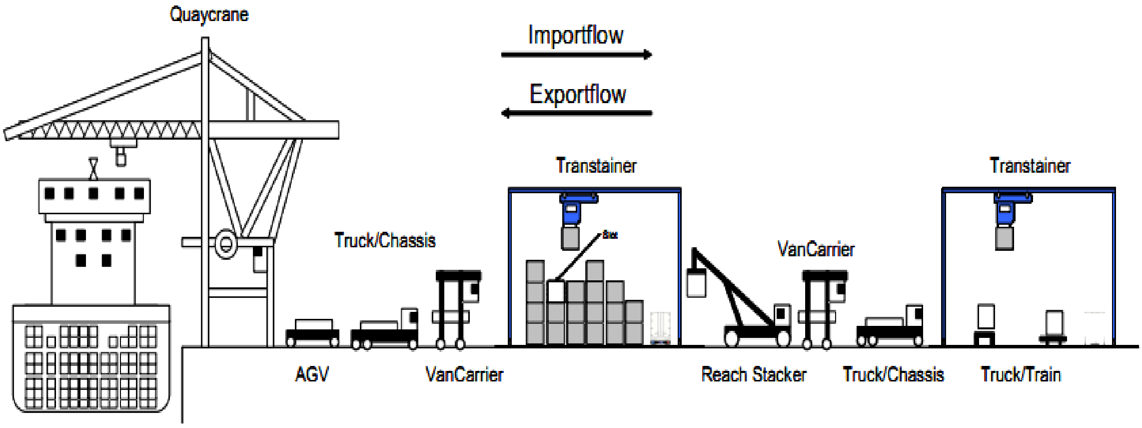


Figure 3-1 The vertical plan view of a container terminal
Source: Manfred Gronalt, Simulation of Hinterland Container Terminal Operations

Figure 3-1 shows the vertical plan view of a typical container terminal. At the left end, there is a large container calling at the berth. The right side is one end of the inland transport system, and containers are loaded or discharged from trucks and trains. We can see clearly that through a series of terminal activities, containers are transferred between the quay side of terminal and the inland. Meanwhile, we should notice the terminal activities include complicated equipments and wide operation areas.

3.2.2 The operating process of container terminal

The following figure shows the operating process of a container terminal. We conclude the following processes when the container flows take place in the terminal area (Saanen, 2011):

- Berthing of vessels at the quay
- The discharging process of the vessel, and the handling of containers from the vessel to an internal transportation mode.
- Transport of containers to the stock area,
- Unloading of the internal transportation mode, handling of containers to the stock area.
- Storage of containers
- Internal shifting of containers in the stock area.
- Transhipment of containers from the stock area to a landside internal transportation mode.
- Transport to the transhipment point of the continental transportation mode.
- Handling to the continental transportation mode.

This sequence of processes also takes place in the opposite direction.

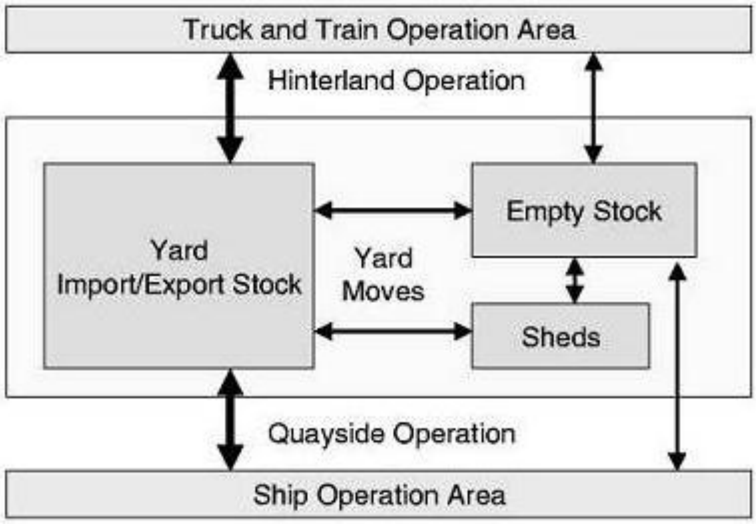


Figure 3-2 The process in a container terminal
Source: Compiled by author

3.3 The relation between container vessels and terminals in the time of large scale container vessels

1) Correlative dependence

Today, container vessels travel throughout the world, and container shipping lines spread over all the lands that people live on. Accompanied with the development of technology and the increasing frequency of international exchange, more economic activities concentrate around the port areas. The correlative dependence between container terminals and shipping lines/ container vessels and terminals become more obvious.

2) Correlative development

In order to adapt to the trend of large scale container vessels, the construction and reconstruction of container terminals are imperative under this circumstance. Although these activities increase the market risks and investing risks, there are more opportunities for terminal operators and liner companies. Because of the competition diversification and investment globalization occurred in the development of global container market, the global container terminals shows a booming trend which has never been seen. (Yongping Qiu, 2008) The major liner companies have invested on and joined in the management of container terminals, or rent terminals from port authorities for their own businesses. These are of great help in pushing the tendency of large scale container vessels and improving the adaptability of container terminals. In addition, the terminal operators should realize that the development of container terminals should be advanced compared with that of container vessels. Making a general look at the container terminals in the Far East, the advanced development of container terminals has become a major trend. Hong Kong, Singapore, Japan, China Taiwan and Korea have already executive the advanced container terminal developing strategies.

3.4 The transport network optimisation

On the sea, container transport forms a transport system which consists of container hub ports and feeder ports. The main lines between hub ports are linked with large scale container vessels, and the sub routes between hub ports and feeder ports are connected by medium and small size container vessels. And that is the container shipping system with hub/feeder ports and main/sub lines.

3.4.1 The Hub and Spoke system

The Hub and Spoke system is a transport mode relative to Point to Point system. (V.Chawla, 2008) Using large scale container vessels between hub ports with longer distances makes the hub ports become the global or regional container collection and distribution centre and build convenient shipping connection with other hub ports. Between hub ports and spoke ports and between spoke ports, medium and small size container vessels can play a part. At the same time, concerning the container flows in the hinterland, the multimodal transportation absorbs rail/ road network and inland shipping both as a part of the main container transport system. In this system, a hub port, together with a cluster of spoke ports around it, become one end in Hub and Spoke system. Through this subordinate relationship between hub and spoke ports, the container shipping achieves the expansion of the general container shipping market and the concentration of the regional container flows. This organization modal takes the hub ports as a core, links the hub port and spoke ports with a certain number of vessels stimulate and channelize the container flows and improve the covering surface and reaching ability of container shipping network.

Figure 3-3 Hub and spoke system
Source: Transport Canada

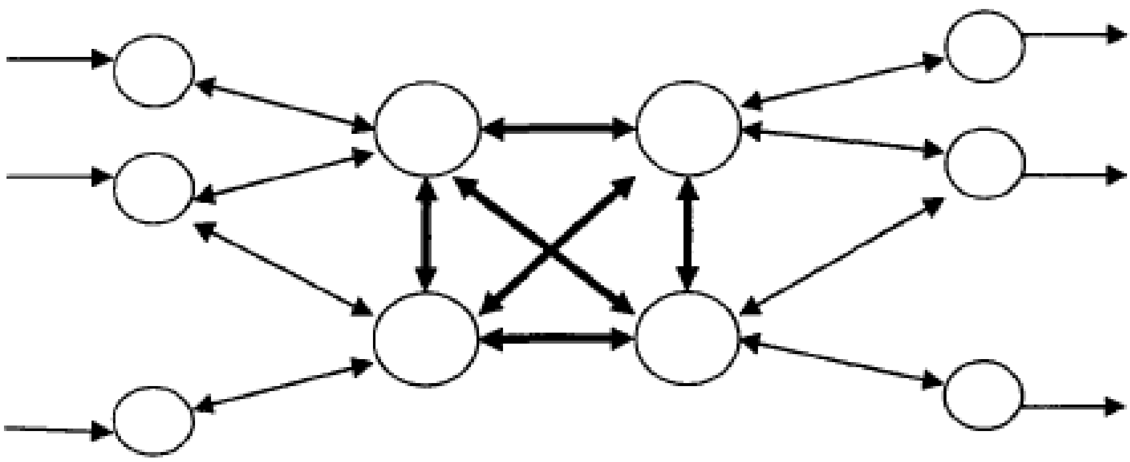


Figure 3-4 Network system of container shipping market
Source: Compiled by author

3.4.2 The requirement for feeder transportation in hub and spoke system

As the large scale container vessels continue emerging, the demand in the Hub and Spoke system for the transportation in feeder lines increases. The feeder transportation as a special transport modal has its natural advantages and provides extensive support to hub ports and main lines.

3.4.3 The demand of entire transport network for feeder transportation

As the globalization of world economy speeds up, the multinational trade has become the theme of current world economic development. The suppliers and consumers all over the world raise more claims for highly qualified transportation. The international shipping companies, playing the role of carries, are ask to have wider covering surface of shipping lines and denser vessels at the service. Meanwhile, at the two sides of the shipping lines, the “Door to Door” multimodal transportation and the combined logistic service which has high added value are needed.

However, the major trend of container shipping at present has turned to large scale container vessels and large size vessel can only call at deepwater ports. So the transport demand from all industries can hardly be met with only large scale container vessels. The containers on these vessels require another transport mode to do the spider-web transhipment and distribution. The feeder transportation exists because of this requirement. Feeder transportation links the scattered cargo supplies with the container terminals very well, whose wide covering ability guarantees that most cargo suppliers are able to enjoy the “Door to Door” service.

In addition, the shallow draught nature of feeder vessels and the fleet capacity make sure that they make full advantages of wide inland channels. And the lower requirement of feeder vessels on handling equipment makes the handling work at inland container terminals possible and adaptable. All pervasive feeder transport network and rational feeder routes make the suppliers run international import and export trades in front of their desks. (Yongping Qiu, 2008)

3.4.4 The demand of cargo suppliers and slots utilization rate for feeder transportation

As mentioned in the previous chapter, the tendency of large scale container vessels needs the premise that there are sufficient suppliers for the shipping lines and the ship slots are made as fully use as possible. If the premises above cannot be met, the advantage of large scale container vessels (the economy of scale) will no more exist. Following the development of large scale container vessels, there must emerge new global container terminal network in which some main international terminals work as hub ports and cover many spoke terminals and a wide hinterland. To make sure the utilization of large scale container vessels calling at these terminals, a huge feeder transport system is needed.

In the next 10 to 20 years, European and Asian container terminals will take the leading place in the new terminal network. They will become the core of global shipping system. In addition, there is enormous quantity of regional feeder ports existing in the global shipping network. Their main function is to transport global trading cargos in/out of the international container terminals in this region. So the feeder transportation has become an important assistant between hub and spoke terminals. It is also a guarantee of sufficient supply and high utilization of containers. This is embodied not only in distribution and transhipment in the hub ports and their hinterlands, but also in the connection of medium and small scale container vessels between hub ports and feeder ports. (Tengfei Guan, 2009)

3.4.5 The demand of shipping schedules for feeder transportation

The exact shipping schedule is the basic in the liner shipping operation, and it even relates to the reliability of the enterprise. As the vessels are big, the limits it may meet are wide. The volume for one single vessel is huge; meanwhile the vessel should run under the strict shipping schedule. So the large scale container vessels must depend on the smaller and agiler feeder vessels. So the rational plans for feeder transportation can bring the liner companies the efficient and regular business operation, lower operating cost and build the companies' reliability among customers. At the same time, these feeder transport plans also benefit container terminals. It reduces the waste of port resources in container yards and berths, and generally improves the handling efficiency. (Yongping Qiu, 2008)

3.4.6 The demand of empty containers for feeder transportation

The empty container issue is always a challenge faced by container shipping companies and terminals. In China, a liner company commonly need 20% of its capacity to deal with the empty container problem. (Jun Nie, Xiaojian Gao, 2004) As more 8000+ TEUs container vessels are put into use, the empty container problem becomes more obvious. Anyway, feeder transportation has an advantageous position in collect and distributes empty containers.

First, the operating range of feeder transportation is relatively small and concentrated. The partial shipping network and reaching ability of shipping companies in spoke ports are better than that in hub ports. So the hub ports probably turn to spoke ports for help in handling empty containers because the later are more agile. Second, large scale container vessels always have fixed calling ports and fixed slot allocation plans. The empty containers will influence the effective transport of cargos and reduce the economic effect of large size. The feeder vessels are different: the routes are shorter and the operation of feeder vessels is more agile than large size vessels. The slot allocation has more planning space. In addition, in the regional distribution of empty containers, feeder vessels don't need complicated custom clearance and import /export declaration. And this saves a lot of time and unnecessary works. Above all these factors, the feeder transportation has obvious advantages in empty container collection and distribution.

3.5 The developing trend of those container terminals able to serve large scale container vessels

3.5.1 The construction of container terminal infrastructures

Under the tendency of large scale container vessels, there is no doubt that the terminals have been investing heavily on their infrastructures. Many projects of development and construction focus on large scale container vessels are implemented successively. The port authority of Rotterdam and the Netherland government has capitalized 4 billion Euros on “Maasvlakte 2” project, aiming at expanding the current terminal area and improve the terminal capacity of providing high qualified service. In addition, the port authority of Rotterdam invested USD 12.1 billion specialized on the upgrade the rail system and the facilities serving for the container terminals. Port of Singapore financed USD 245 million in 2008 to purchase 12 mono-girder cranes from ZMPC which can serve container vessels of over 9000 TEUs capacity, aiming at renewing the handling equipments and improving the operating efficiency. Long Beach put USD 202 million to build new deepwater container terminals and 65 million to expanding container stacking area. Port of Los Angeles dredged the waterways in the port area in 2007. The depth increased from 13.7 m to 16.2 m. Table 5 below shows some recent details of main container terminals in Europe and Asia.

Table 3-5 The statistics of container terminals in the world's main ports

Port name	Terminal name	Num. of Berths	Max. Depth	Num. of Quay cranes	Stacking areas	Max. container stacking
Singapore	Brani	9	-15.0	29	79 ha	15424
	Keppel	14	-14.6	36	96 ha	20248
	Tanjong pagar	8	-14.6	27	80 ha	16532
	Pasir anjang	6	-15.0	22	84 ha	14260
Hong Kong	Kwai Tsing	24	-15.5	92	143 ha	
Shanghai	Yangshan I	5	-16.0	15	86 ha	25386
	Yangshan II	4	-16.0	16	89 ha	21037
Shenzhen	Yantian	9	-16.0	41	208 ha	
Qingdao	QQCT	7	-15.0	26	225 ha	
Kaohsiung	No.1	4	-14.0	3	10 ha	2500
	No.2	4	-14.0	8	45 ha	12000
	No.3	3	-14.0	10	60 ha	17000
	No.4	7	-14.0	13	92 ha	36000
Rotterdam	ECT Delta		-16.6	36	265 ha	
	Euromax		-16.8	12	84 ha	
Hamburg	Eurogate	6	-15.5	21	140 ha	
	Altenwerder	4	-16.7	26	110 ha	
	Burchardkai	8	-16.5	22	140 ha	
	Tollerort	4	-15.2	8	40 ha	
Antwerp	Deurganck		-15.6		156 ha	
	Delwaide		-15.0		141 ha	

Source: Offical website of each port

3.5.2 The through transportation of container terminals

At the same time with developing the terminal infrastructures, many container terminals are developing the logistics services. Through transportation has become the core service of container terminals. Container terminals live by providing service to ocean carriers, and its main incomes are from the container throughput volumes. To some transhipping terminals like Singapore and Hong Kong, providing further service like through transportation is the way that they can survive in the competitive circumstance. Taking Hong Kong an example, before 2000, millions TEUs came to China mainland transhipped in Hong Kong every year. However, the through transportation directly to the mainland appeared and took this market share. After 2005, the annual increasing rate of container volumes is around 4%, while that in

China mainland is 30%. (Shipping Exchange Bulletin, 2009) At present, the container terminals focusing on providing through transportation includes Busan, Kaohsiung, Antwerp, Hamburg, Bremen and many other terminals. Hong Kong is now taking strategies to make better market image and improve its competitiveness.

Chapter 4. Case study: The impact of Triple-E class container vessels on Yantian International Container Vessels

4.1 The current situation of container terminals in China

According to the China Container Port Industry Report, 2011, accompanied with the recovery of global trade in 2010, the international container shipping market became booming. The increasing rates in traditional Europe- Asia, Pacific and Atlantic lines all exceeded 8%. In 2010, Chinese container terminals completed a container volume of 146 million TEUs, 19.4% more than that in 2009. Compared with 2007 and 2008 before the economic crisis, this figure is 27.7% and 13.9% higher respectively. Specifically, the coastal terminals completed 131 million TEUs, 19.3% higher than last year, and the inland terminals completed 14.68 million TEUs, 20.3% higher than last year.

4.2 Introduction of Yantian International container terminal

4.2.1 The current situation of YICT

Yantian International Container Terminal (YICT) is a Chinese container terminal located in Dapeng Bay of Shenzhen city. YICT is a joint venture of Hutchison China Trade Holdings and Port Authority of Yantian. YICT consists of eastern terminal, western terminal and central terminal. Specifically, the central terminal is constructed as in Phases I-III, and the western terminal is constructed in Phases I and II. The eastern terminal has not been constructed yet. In October 1993, the port authority of Yantian and Hutchison China Trade Holdings together built Yantian International Container Terminal, invested 6 billion RMB and operated the Phase I and II container terminals. Thereamong. The Port Authority of Yantian held 27% of shares; Hutchison China Trade Holdings took 50%. The other 23% was equally split into COSCO and Maersk. From this we can see the predominant natural conditions and strategic geographical position has already been recognized by each side.

YICT is the most important component of Port of Shenzhen. YICT is located in the east of Shenzhen city. It is a unique port with perfect natural water depth condition and covering condition, so it can serve the fifth and sixth generations of large scale container vessels. YICT has a very high status in Shenzhen. Since 2000, the container capacity of YICT has taken around 50% of the total container volumes in Shenzhen every year. Having becoming the strategic centre of modern logistics in Shenzhen, YICT, depending on the natural advantages and huge port business, is developing into an international deep water container terminal and a hub port in south part of China. The graph below shows a panoramic view of YICT.

Figure 4-1 Layout of YICT
Source: YICT official website

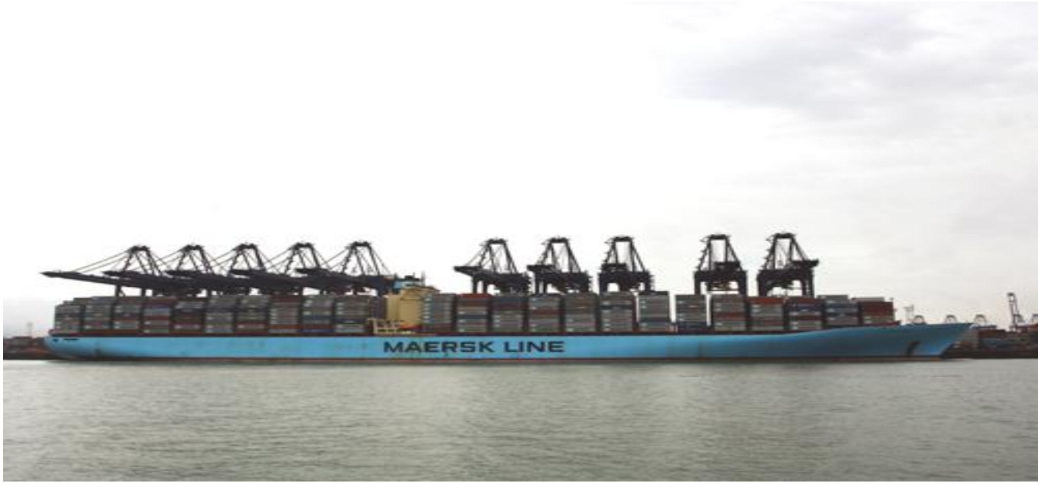
YICT is the preferred option in the south part of China for large scale container vessels. Since the terminal was open, it has frequently served mega vessels. In order to serve these calls, YICT is equipped with the world's leading port operation facilities -Post-Panamax quay cranes. These cranes, which are the first ones in south of China, are capable of handling the largest container vessels with 9 floors high above the deck. From 2003 on, YICT, due to its advantageous handling efficiency, has won "Excellent Container Terminal in China in terms of Quay Crane Rate and Vessel Productivity" for consecutive years.

Specifically, the following data for YICT's infrastructure are given from its official website.

Table 4-1 The general description of YICT

Terminal physical		Equipments	
berth number	16	Quay crane#	74
berth length	6743m	Average gross productivity of the quay cranes	35 mph
Draft alongside	14-16.5m	Gantry crane#	200
Terminal area	373	Ground slot	2000
Approach depth	16-17.4m	Height	6

Source: CICC report, YICT offical website



On June 10th 2010, the 15000 TEU class Ebba Maersk, one of the world's biggest container vessels called at YICT with a full load for the first time. Until now, YICT is the only terminal which can serve this class of container vessels in south part of China.

The table below shows YICT's operation of mega vessels in these two years.

	9 April 2011 Grand China Shipping's "Red Strength"		11 April 2011 "Hanjin Netherlands"
	24 September 2010 Evergreen's "Ever Apex"		14 September 2010 Matson's"kaimoku"
	10 June 2010 Maersk's "Ebba Maersk"		25 March 2010 "TS Taichung"

Figure 4-2 The calls of mega vessels to YICT
Source: YICT official website

As mentioned above, the throughput of YICT takes around a half of the total throughput of Port of Shenzhen. From the data for the last three years, YICT has completed the container throughputs of 968 million TEUs, 858 million TEUs and 1013 TEUs between 2008 and 2010. The proportions of these throughputs in the total amount of Port of Shenzhen were 45%, 47% and 45% respectively.

In addition, YICT has a rational and effective container structure. According to SWS research in Shanghai, 90% of the containers in YICT are used in Europe-Asia line and America-Asia line. There among, the containers for America reach a percentage of 50% and the containers for Europe takes 40%. These proportions are higher than any container terminals which have similar conditions. So under the atmosphere that the development of European and American economies is optimistic, YICT is the container terminal which will benefit most directly from the economic recovery in Europe and America. However, the risk that the economic recovery may be lower than expected should be taken into account. According to the current situation, American Federal Reserve committee and IMF has raised the economic rate of developed economies in Europe and America in 2011 repeatedly, but other factors like regional conflicts and price rising of bulk commodity will interrupt the recovering process.

From the perspective of freight rate, YICT possibly have less competitiveness because it has the highest freight rate in China mainland. In fact, the terminal charges of YICT are the price mark post for the nearby container terminals. Actually the high pricing rate in YICT comes from its overall advantages. First of all, YICT has a high handling efficiency. The current handling capacity of quay cranes in YICT is 35 moves per hour, which is higher than the average 20 moves per hour in Europe. Second, YICT has high qualified infrastructures so that the repair and maintenance costs are lower. The constructing standard of YICT is from Britain, which aims at no main repairs in 50 years. In addition, according to the annual report of YICT, in recent years, YICT presents sufficient berth capacity. So it can save many waiting time for container vessels coming. Another advantage is the high dense of the container shipping lines. Anyway, if the container volume goes down, the container handling charges will face pressures. But the general situation should be stable. Firstly, the demand for container shipping is rigid which means the demand is not sensitive to price. The price reduction does not necessarily bring more container volumes. Secondly, the main operators in YICT like Hutchison China Trade Holdings and China Merchants mostly have terminals in nearby ports like Hong Kong, price war may damage their terminals there more. (Chinese economy and shipping, 2011)

4.2.2 China in Europe – Asia container shipping lines

As the second biggest economic force in the world, China is keeping a flourishing development in global trade. Triple-E class container vessels will help Maersk line to adapt to this development in a more efficient way.

Maersk line owns the most market share in Europe – Asia container lines among the major container shipping companies. From Asia to Europe, 18% of the container volumes are carried by Maersk line. From Europe to Asia, the proportion is 15%. After Triple-E class container vessels are delivered, they will cover 5 container ports in China (Shanghai, Ningbo, Xiamen, Yantian and Hong Kong). The container capacity in Europe – Asia lines will increase in a large scale, and the leading position of Maersk line in container market will be more highlighted.

Today, the centre of world economic development has transferred from west to east, from north to south. China has a population of 1.3 billion and its GDP is predicted to increase with a rate of over 10% per year. So China is playing the most crucial role in the new industrialized economies. The Chinese container shipping demand is showing a very strong increasing tendency. In the next 5 years, the new industrialized economies including China, India, Latin America, Africa and South America may keep an increasing rate which is several times higher than that in mature market. From the aspect of trade, the huge number of container volumes in Chinese shipping market can make much more outstanding scale of economy than any other countries and regions.

The developing pattern in China has transferred from the labour intensive manufacturing to high-tech industries. Chinese government has emphasized more than once that the future developmental direction of Chinese economy is stimulating the domestic consumption. These indicate that there will be more business from import aspect in Chinese ports. At the same time, the “Development of West Regions” strategic policy also brings many opportunities. Most overseas-funded shipping companies in China manage not only the ocean shipping business, but also logistic and other services. The biggest working place of Damco Logistics which belongs to Maersk Line is in Chengdu.

4.2.3 Chinese container terminals in the tendency of large scale container vessels

The tendency of large scale container vessels brings many benefits to the current container shipping market in China, as well as a lot of new challenging requirements. At present, the great achievements that the international container shipping enterprises get are impressing, and its development prospects are glorious. At the same time, however, these container shipping enterprises are facing enormous pressure.

Today, shipping companies tend to invest on large container vessels which bring scale of economy – using large vessels instead of small ones. In Europe – Asia lines 62% of the container capacity is taken by Post- Panamax container vessels. More than half of the container volumes are carried by large scale container vessels with a capacity of more than 10000 TEUs. (Chinese economy and shipping, 2011) However, there are still a limited number of container terminals all around the globe which can serve this kind of vessels. This means terminal operating companies need to invest much capital into constructing the terminal infrastructures. Terminal operating companies should adjust to the tendency of large scale container vessels. Beside expanding terminal areas and increasing the number of handling equipments, the terminal operating companies need also work hard on planning the whole operating process and improving the handling efficiency.

Now, the achievements that Chinese terminal operating companies invest on building and improving container terminals are obvious to the world. Ports such as Dalian, Tianjin, Qingdao, Shanghai, Lianyungang, Ningbo, Xiamen, Shenzhen, and Hong Kong are now able to serve large scale container vessels. Some experts believe that the terminal throughput capacities of container terminals in Delta Regions of Pearl River in south part of China have already been surplus. But the capacities in Yangtze River Delta Area still have climbing space. Anyway, other factors like high cross-province transport cost in Chinese road transportation have negative influence on Chinese terminal operating companies.

The graph below shows the top 10 container terminal throughputs in December 2010 and the whole year.

Table 4-2 The top 10 container port in China (2010)

Rank	Port name	Dec 2010(mln TEU)	Total in 2010(mln TEU)
1	Shanghai	2.49	29.07
2	Shenzhen	1.80	22.51
3	Ningbo-Zhoushan	1.00	13.14
4	Guangzhou	1.24	12.55
5	Qingdao	1.03	12.01
6	Tianjin	0.92	10.08
7	Xiamen	0.54	5.82
8	Dalian	0.45	5.24
9	Lianyungang	0.26	3.87
10	Yingkou	0.24	3.34

Source: Portcontainer.cn

The container terminal group in Delta Regions of Pearl River, consisting of Guangzhou, Shenzhen, Zhuhai and Shantou, takes the south and west south parts of China as hinterland. Specifically, Shenzhen takes container shipping as a main business. In 2010, it completed 22.51 million TEUs, ranking No.2 in China and No.4 in the world. Guangzhou completed 12.55 TEUs, ranking No.4 in China.

At this time, an important direction of Chinese container terminal construction and development is transferring the traditional container terminals into logistic zone or logistic centre. The logistic container terminal is not only with container handling functions but also the logistic hub, modern communicating technology, automatic in-port transportation system and warehousing function. This can dramatically improve the process and quality of terminal operation and the redistribution of logistic design.

4.2.4 YICT's status among Chinese coastal container terminals

As the container terminal with the highest container throughput in China, Yantian International Container Terminal has joined in 115 container shipping lines in the world in 2010. This has made the record of container lines since the terminal opened.

Yantian International Container Terminal is one of the four international container transfer ports in China which is praised as “The Pearl in south China”. It is nearby the International financial, trade and container shipping centre – Hong Kong. And its hinterland is the biggest export processing centre - Delta Regions of Pearl River. With the advantageous geographical location and the strong supports of Chinese government, YICT has become the container hub in south part of China.

Because of the large number of global container shipping lines, high dense of calling container ships and completed infrastructures and superstructures, YICT keeps stable increasing trend in International container shipping business.

At present, Maersk Lines, Evergreen, Hanjin, COSCO and other 35 world – famous container shipping companies have used YICT in their lines. Among them there are 38 lines in North American market, 38 lines in European market, 16 lines in Asia, 5 in Middle East, 4 in South America, 4 in Africa, 3 in Australia and 1 in Central America. Besides, there are 6 lines serving China mainland.

The table below shows the major lines YICT joins in each container market in the world. We can see that almost all large scale container vessels calling at Yantian International Container Terminal are serving in Europe – Asia lines and America – Asia lines. Next, I will concentrate on YICT's service quality for large scale container vessels by simulating the process in European lines.

Table 4-3 Examples of shipping lines where Yantian International Container Terminal takes an important part

Line name	Operating company	Ship class	Ports of call
European lines			
AE10E	Maersk lines	8700 TEUs	Felixstowe, Zebulehe, Dunkirk, Malaga, Valencia, Salalah, Colombo, Yantian, Shanghai
AE7E	Maersk lines	11000 TEUs	Rotterdam, Bremen, Algeciras, Tanjung Pelepas, Yantian, Hong Kong, Ningbo, Xiamen
Dragon	MSC	8000 TEUs and above	Singapore, Chiwan, Hong Kong , Dalian, Tianjin, Bussan, Ningbo, Shanghai, Fuzhou, Yantian, Hong Kong, Salalah, Gioia Tauro, Naples, Laspezia, Fos, Barcelona, Valencia, Jeddah
FAL1E	CMA-CGM	10000 TEUs	Khor Fakkan , Yantian, Dalian, Tianjin, Shanghai, Xiamen, Hong Kong, Singapore , Klang, Suez Canal , Tangier, Southampton , Hamburg
American lines			
AAE1	CSCL	4000 TEUs and above	Shanghai, Hong Kong, Yantian, New York, Norfolk, Savannah, Miami
UAEE	Evergreen	7000 TEUs	Rotterdam, Hamburg, Thamesport, Zebulehe, Said, Colombo, Tanjung Pelepas, Yantian, Hong Kong, Kaohsiung, Los Angeles, Oakland
ASIA	Maersk lines, HBS	5560 TEUs	Bussan, Shanghai, Ningbo, Yantian, Hong Kong, Tanjung Pelepas, Singapore , Durban, Itaguai, Puerto Santos , Buenos Aires, Rio Grande, Navegantes, Paranagua
Asia lines			
JSTN	TSL	1200-1800 TEUs	Penang, Klang, Singapore, Pasir Gudang, Yantian, Hong Kong, Kaohsiung, Taichang, Keelung, Tokyo
CPG1	COSCO	3400 TEUs	Shanghai, Ningbo, Yantian, Singapore, Abbas, Karachi
CPG2	Evergreen	3400 TEUs	Qingdao, Shanghai, Ningbo, Yantian, Hong Kong, Tanjung Pelepas, Dammam, Nhava Sheva, Singapore, Kaohsiung
Middle East lines			
FMX	Hanjin	-	Qingdao, Yangon, Bussan, Shanghai, Ningbo, Kaohsiung, Yantian, Singapore, Abbas, Khor Fakkan, Karachi, Klang
APG	Evergreen	2000 TEUs	Kaohsiung, Taichang, Yantian, Tanjung Pelepas, Colombo, Dubai, Abbas, Laem Chabang, Hong Kong

Source: YICT official website

4.3 Introduction of Triple-E class container vessels

At the beginning of this year, Maersk Line has announced its order of ten 18000 TEUs class Triple – E mega container vessels. The delivery will be made in 2013-2015. At that time, these vessels will become the world No.1 container carriers. In the previous chapter, I have introduced the scale of economy brought by this type of container vessels. But that is only one aspect of the influences comes from these vessel. While offering new container capacity to the market, these 18000 TEUs container vessels also bring great challenges to container terminals all over the world.

At present, it is still an open question that where these mega container vessels should be put into use. Anyway, most specialists on container shipping market believe that they will serve in Europe – Asia lines, because the market and terminal service quality are more likely to meet the capacity and profits of these mega vessels. In America lines, the long voyage time across the Pacific and the relatively low terminal handling efficiency may have impacts on the profitability of Triple-E container vessels.

The new Triple-E class container vessels are 400 metres in length, 59 metres in width and 73 metres high. Compared with the present biggest container vessel "Emma Maersk", Triple-E class vessels are 4 metres longer and 3 metres wider, which doesn't look so significant. Anyway, the carrying capacity of Triple-E is 2500 TEUs more than Emma, reaching 18000 TEUs. The expanding proportion is 16%. This is mainly due to the different ship form design. Emma Maersk has a "V" shape ship form and Triple-E is more like a "U" which allow it for one more row of containers. So Triple-E can carry 23 rows of containers in cross section. The wide ship body and the one more row offer a carrying capacity of 1500 TEUs. The double – island design of Triple-E makes the bridge and crew space moving forward 5 slots, so the containers can be stacked higher (250 more TEUs). Meanwhile engines and chimney are moved backward 6 slots which save the space on the deck for 750 more TEUs. (Jun Liu, 2011)

In spite of the huge ship body, Triple-E class container vessels are the most efficient in CO2 emission. Compared with Emma, the reduction of CO2 emission for carrying one container on Triple-E is 20%. And this figure is 50% lower than the average level of the container vessels sailing in Europe – Asia lines. The CO2 emission of Triple-E class container vessels even 35% lower than that of the 13100 TEU class mega container vessels which will be put into use in the next few years. (Jun Liu, 2011) All these are based on three main reasons: First, as we mentioned in the previous chapter, the scale of economy reduces the CO2 emission. Second, Triple-E class container vessels choose smaller engines. Third, Triple-E vessels are equipped with the expansive heat recycling system which uses the afterheat of engines to generate the extra propulsion.

4.4 The simulation that Triple-E class container vessels calling at YICT

Now, I will make a general research on the service capability of Yantian International Container Terminal to Triple-E container vessels with the actual situation of the terminal and the known parameter of the type of container vessels. The research subjects includes the efficiency of custom clearance, the requirement of Triple-E container vessels on the terminal infrastructures and berth capacity, yard storage capacity and the handling capacity in the simulation that Triple-E class container vessels actually call at YICT.

4.4.1 The requirement of large scale container vessels on the efficiency of custom clearance

The efficiency of custom clearance in a container terminal has an extremely important realistic meaning on the operation of large scale container vessels and the development of container terminal itself. The high efficient custom clearance can reduce the operation costs of vessels and attract more container shipping companies and other clients. It is a very important index of the container terminal's soft power. As the best model of following the scale of economy, Triple-E class container vessels certainly pay more attention to these details in operation. Here, I make a short research on the efficiency of custom clearance of Yantian International Container Terminal.

The custom clearance of Yantian International Container Terminal is very convenient and swift. YICT authority keeps cutting red tapes and improves the effectiveness in custom clearance. Dapeng customs implement the mode of supervision and administration that allows prior registration of import containers, so the containers can be delivered immediately after discharging from ships. Meanwhile, the authority takes the lead in China to use electronic custom clearance. Companies can apply to customs from the online system, which makes the whole process only for 15 minutes. China Inspection and Quarantine has start to use Radio Data System and 24 hours on-site inspection and checking work system without holiday. The fact that the container shipping lines which Yantian International Container Terminal serves can break 100, to some extent, profits from the customs operation reforms and expedient measures of CIQ to help the terminal facing the economic crisis and advance YICT's developments. In addition, the rigorous and efficient service offered by the custom powerfully guarantees the proper running of the container shipping lines and brings convenience to the container shipping companies in importing and exporting.

As the YICT container shipping lines break 100, the imported/exported containers and the container vessels entering and leaving the border make new records. According to the statistic report of Dapeng Custom, in the first quarter of 2011, the number of containers imported/exported through Yantian International Container Terminal under its supervision reached 3 million TEUs and the container vessels through the custom reach 5542 ship/time. The figures increased by 5.5% and 24% respectively on year-on-year basis. (Work report of Shenzhen Government, 2010)

By ensuring the efficiency and improving the environment of custom clearance, Yantian International Container Terminal attracts numerous world-famous shipping companies to open shipping lines there and makes more enterprise to import and export cargos from it. In recent years, Dapeng Custom takes the first in China to implement reforms in customs clearance. To the low risk clearance from honesty and trusted companies, Dapeng Custom takes "Automatic inspection and automatic approval" on computer systems. (Work report of Shenzhen Government, 2010) Compared with the traditional manual inspection of paper documents, the custom inspection process of Dapeng Custom saves half of time. The average time that the process costs is 3 to 4 minutes which dramatically increase the speed of custom clearance and reduce the cost of applying companies. Besides, Dapeng Custom also expands the practical range of ocean rail transportation and customs transferring, and keeps enhancing the radiate to drive power of YICT to surrounding cities. At present, YICT has built many railways directly to inland regions of China and advances transferring business with nearby cities like Guangzhou. (Work report of Shenzhen Government, 2010)

To sum up, the custom capability of YICT is sufficient to serve large scale container vessels like Triple-E class. At the same time, the custom service of YICT can cover most parts of south China. Under the scale of economy concept of large scale container vessels, the custom capability of YICT can play a more important role.

4.4.2 The requirement of Triple-E class container vessels on the natural condition and infrastructure of container terminals

As the biggest container vessels in the future container market, Triple-E class container vessels bring a tough challenge to container terminals all over the world. There are already a limited number of terminals that can serve this type of vessels from natural conditions. Anyway, natural condition is not the only standard to evaluate these terminals. Triple-E class container vessels will test a container terminal from all aspects. Now, let us see if Yantian International Container Terminal can stand the test of Triple-E.

1) Waterway and berth depth

The table below describes some basic parameters of Triple-E class container vessels.

Table 4-4 Ship parameter of Triple-E class container vessels

Length over all	400 m	Max. capacity	18000 TEUs	Normal speed	19 knots
Breadth	59 m	Reefer slot	600 TEUs	Max. speed	24 knots
Draught design	14.5m	Deadweight	165000 t	Propeller power	65-70 MW

Source: China shipping services

From the data of this being built container vessel, the maximum draught of Triple-E will be around 14.5 metres. If it wants to enter and leave the terminal on 24 hours and all weathers, the waterway depth should be more than 16 metres. Assuming the actual stowing rate is 80%, the practical draught of Triple-E when sailing in the waterway should be around 14 metres and the depth of berth should be above 15 metres. From the table in the beginning of this chapter we can see that after Phase

III construction, the maximum waterway depth of YICT is 17.4 metres and the maximum depth on berth can reach 16 metres. Basically, the depth of YICT area can meet the requirement of Triple-E class container vessels.

2) Berth handling equipments

Compared with any other large scale container vessels, the length over all and breadth are both larger. In order to meet the increasing part of ship breadth and container slots, the berth should be equipped by container quay cranes with larger reaching range and higher loading capacity. The breadth of Triple-E class container vessel is 59 metres. And the row number is 23 from the cross section. So the maximum outreach of quay cranes should be more than 60 metres. At present, YICT owns the quay cranes with the longest outreach in the world. The outreach length can reach 65 metres which means the cranes are completely capable of finishing the handling work of container vessels with 23 rows.

In order to see how many cranes should be prepared for Triple-E class container vessels, CLCS star container vessels can be used as a reference. In the beginning of this year, the 14100 TEUs class container vessel CLCS star called at Yantian International Container Terminal, YICT offered 10 post Panamax quay cranes for the handling work. So in the following research and simulation I will use this as a basis to assume that there will be 10 – 12 same type of quay cranes serving for Triple-E class container vessels.

3) Container yards

When Triple-E class container vessels are put into use, they can only sailing on main lines. Because the ports they can call at is limited, the handling capacity for one time should be enormous, which requires for the container terminals have the sufficient space in container yards. The area of container yard in Yantian International Container Terminal is about 12.5 ha, which allows for around 12000 TEUs. Estimating from the current data, under the premise that the loading volume equals to discharging one, YICT is able for handling 33% of the total container volume of Triple-E container vessel. If we assume the dwell time is 3 – 4 days, then Triple-E class container vessels will bring huge pressure on the container yard of YICT. The specific impacts will be discussed in the following modal.

4.4.3 The research on terminal capability of YICT

In the following section, I will simulate the actual situation in which Triple-E class container vessels calling at Yantian International Container Terminal in a simple modal. The major research subject is the berth capacity, berth occupancy and the yard storage capacity of YICT. From this modal, the subject is to demonstrate the feasibility that Triple-E class container vessels calling at Yantian International Container Terminal and find out the benefits and challenges that Triple-E class container vessels bring to YICT when they are calling.

At present, the Phase III of YICT deepwater container berth is the first option for large scale container vessels. The water depth of quay apron here is 16 metres and the length of the berth is 1261 metres. The berth is now equipped with 14 quay cranes, among which there are 11 world' leading dual hoist cranes. The berth is advanced enough for berthing the world's biggest container vessel. (See the table below). As discussed before, there should not be any problem for Triple-E class container vessels to call at the Phase III of YICT. Now let us research the operating efficiency of this berth.

Table 4-5 Basic parameters of Phase III

Quay Length in meters	1261 m	Ground slot	2000
Number of Quay Cranes	14	Stacking height	6
Average gross productivity of the quay cranes	35mph	TEU Ratio	1.3
		Area of Yard in Hectares	12.5 ha

Source: YICT offical website

Assumed condition

In order to simulate the situation that Triple-E class container vessels calling at YICT, I first make the following assumptions:

1. Triple-E class container vessels are calling at YICT on a weekly basis. In other words, only one Triple-E class container vessel will be at YICT per week.
2. Every time that Triple-E class container vessels call at YICT, the terminal will offer 10 dual hoist cranes to serve the vessels.
3. Assume that the annual average TEU ratio in YICT is 1.3

- **Berth capacity**

The operation of large scale container vessels specially focuses on efficiency. Every shipping company wants to reduce the time that their vessels are at port and decrease the operation cost. Berth capacity is an index which directly relates to the porting time of container vessels. "The berth capacity is the maximum volume (through vessels and their exchange size) handled without causing unacceptable waiting time for berthing for the customers." (Saanen, 2011)

In formula, berth capacity is:

Berth capacity = Min. (Quay capacity, quay crane capacity)

And:

Quay crane capacity = crane productivity * number of quay cranes * max. working hours of the crane

In this simulation, I will use the service time that Triple-E class container vessels berthing at Yantian International Container Terminal as the index mark of measuring the berth capacity of it because I make this research on the working efficiency of the terminal to one single Triple-E class container vessel. So from the formula above:

The working hours = container volume handled / (crane productivity * number of quay cranes)

And:

Container volume handled = numbers of TEU / TEU factor

Yantian International Container Terminal is the only terminal that can serve Triple-E class container vessels in the south part of China. So a prediction that an 8000 – 10000 TEUs container handling volume for one call in the calculation is made here. According to the assumed condition, there will be 10 dual hoist cranes serving the Triple-E class container vessel when it calls. From the data in the table above, the practical productivity of each crane is 35 moves per hour. Due to the “dual hoist” function (allowing two containers for one time), the actual productivity is 70 boxes per hour. In the simulating situation, the handling volume is 8000 to 10000 TEUs for one time. So:

The minimum working hours = 8000 / (1.3 * 70 * 10) = 8.8 hours

The maximum working hours = 10000 / (1.3 * 70 * 10) = 11 hours

That is to say, the time for YICY to handling a half of the total container volume on a Triple-E class container vessel is only 9 to 11 hours.

To the container vessel itself, the huge amount of containers can be handling in such few hours. As a result, YICT has passed test in the term of berth capacity.

Another changing parameter from this aspect which should be taken into account is the berth occupancy. The new business from Triple-E class container vessels when they are delivered will increase the berth occupancy of YICT. “Berth occupancy is a percentage to measure if the berth is free or occupied.” (Saanen, 2011) In formula, the berth occupancy is:

Berth occupancy = ($\sum_{k=0}^{n}$ vessel length i * vessel service time i) / (quay length * measurement period)

Here we only consider the berth occupancy of Triple-E class container vessels to YICT. Calculating with 10 hours per week, the berth occupancy is:

Berth occupancy = 400 * 10 * 50 / (1261 * 8640) = 2%

The business from one type of vessels can bring 2% more berth occupancy. From this we can see that the coming of Triple-E class container vessels will be a great push to the development of YICT.

Which should be pointed out is that in practice, although the container terminal pays attention to the improvement of berth occupancy, this improvement includes two aspects of meaning (increasing and decreasing). Increasing the berth occupancy will release the working pressure of container terminals and lower the utilization, maintenance and investments on berth equipments. In the other side, decreasing the berth occupancy means increasing the operating efficiency and allowing more flexibility for the coming container vessels. Anyway, from the research subjects of this simulation, reducing the number of berth equipments offered to Triple-E class container vessels is meaningless to increase the berth occupancy, but to influence badly on the work time. So in my opinion, YICT has no necessity to plot against the berth occupancy since the current container shipping market is of great prospect and the hinterland for YICT is sufficient.

- **Yard storage capacity**

The international container shipping business of YICT keeps a good tendency of stably increasing thanks to its number of international shipping lines, high dense of sailing ships and enormous potential on infrastructure and superstructure. In the first quarter of 2011, Yantian International Container Terminal has completed a throughput of 3 million TEUs. The rapid growth of container volumes leads to the increasing demand for stacking space in container yards. The container yard has become more and more a bottleneck for the development of container terminals. In my opinion, the yard storage capacity is the most challenging problem that YICT is facing in serving Triple-E class container vessels. Now, the total area of container yard in Phase III of YICT is 12.5 Hectares with 2000 TEU ground slots. The stacking height in container yard is 6. So we can calculate that the container yard of the Phase III of YICT can hold 12000 TEUs in total. Such a storage space is probably not sufficient for a container terminal to serve large scale container vessels. Here I will calculate the actual storage capacity of the Phase III container terminal of YICT. In order to find out the impacts of Triple-E class container vessels on the container yard, I first assume that the whole container yard serves only Triple-E class.

“Yard storage capacity is measured as the number of yard (TEU) visits that the yard can handle.” Yard storage capacity is determined by the TGS (TEU Ground Slot), stacking height in the yard, days in period, separation factor and dwell time. In formula, yard storage capacity is:

Yard (Storage) Capacity = (TGS * Maximum Stacking Height * Peak Utilization * Days in period) / (Separation Factor * Peaking Factor * Dwell Time)

Each parameter in the formula has its characteristics which should be paid attention:

TGS

TGS is short for TEU ground slot and it is the basis number of container storage volume on the ground. In the table above, the TGS of the Phase III of YICT is 2000. The number of TGS is the direct reflection on the area of container yard. The only way to increase it is to expand the area of yard.

Maximum stacking height

The maximum stacking height is the top limit in vertical that a container yard can stack containers. This parameter is mainly influenced by the productivity of gantry cranes that a container terminal uses. Among the given data, the maximum stacking height of container yard in the Phase III of YICT is 6 (1 over 5). However, maximum stacking height is only an index. In practical operation, we often need to find an optimal stacking height which can effectively avoid the reduced accessibility and increased levels of equipment to handle the unproductive moves, thus eliminate the possibility of decrease in overall productivity in a congested yard. In this simulation, I assume the average stacking height as a percentage of the maximum stacking height is 85%.

Days in period

Because the Triple-E class container vessels will call at the container terminal on a weekly basis in this simulation. So the days in period which is taken into account here is 7 days. If only the container storage capacity of YICT can meet the long term requirement of Triple-E class container vessels, the terminal can become the stabilized service provider of this type of vessels.

Separation factor

In practice, optimal stacking height is not enough in the calculation of yard storage capacity. If nearly all slots in container yard are used, the operating process will become tougher and more complicated, because many containers which are not engaged in the business may need to be shifted and lifted if a certain container is needed. As the container vessels become bigger and the transferring works get more frequent, container yard needs some empty space to simplify the handling process. According to the situation of terminal infrastructure I learnt from Maritime Logistics course and the actual examples I met with in the assignment, here I assume the separation factor in 1.05.

Dwell time

"The dwell time refers to the period a container is in the container yard from when is placed into stack until it leaves the terminal." (Saanen, 2011) The average dwell time of containers in the yard can reflect the length of operational cycle in the container yard. Yantian International Container Terminal is the biggest container hub and transferring centre. Due to its advanced rail and road system and the complete inland transportation in Delta Regions of Pearl River, the dwell time of containers staying in container yard should not be too long. In this calculation, I assume the average dwell time in container yard is 4 days.

In addition, I take peak day in the peak week as the peak factor which is assumed to be 1.2. (According to Maritime Logistics Reader, it is 20% - 25% of weekly volume).

Now, the calculation for yard storage capacity of YICT is as follows:

Yard storage capacity of YICT = (2000 * 6 * 85% * 7) / (1.05 * 1.2 *4) = 14167

In other words, if the Phase III of YICT uses its all container storage capacity to serve Triple-E class container vessels, its stacking productivity can reach 14167 containers per week. This result looks comfort if the service ability of YICT as a hub to Triple-E class container vessels. But we should remember that the prerequisite of the calculation is that the whole container yard of the Phase III is used for only Triple-E class. In practical operation, this is unreachable. Yantian International Container Terminal has more than one hundred container shipping lines in the world and keeps business with dozens of container shipping companies. It is not rational and logical to put all its capacity to one company and one type of vessels. So, in fact, the coming of Triple-E will indeed bring great pressures on the container yard of YICT.

Considering the current situation of YICT, there is no denying that YICT can use the container yards of other terminals to release the pressure of the Phase III if Triple-E class container vessels are coming or even ask the whole Port of Shenzhen for more storage space. However, these measures will inevitably increase the operation cost of containers at the terminal and are not long term plans. In my opinion, there are commonly two solutions to this problem.

The first solution is to expand the area of container yard. Expanding the area of container yard can increase the container storage volumes. It is the direct way to release the pressure of container yard. Yantian International Container Terminal can increase the number of TGS in container yard or purchase the new gantry cranes which can handle more layers in operation. To the former, actually YICT has begun to pay attention to the construction of container yards in the recent extension projects. In May of this year, the new container yards – FS58 and FS61 in the Phase III of YICT have been completed and will be put into use soon. These two container yards take 5.68 hectares. The storage capacity design of these yards in total is 6200 TEUs. I believe in the future. The conflict between the huge terminal throughput and limited container storage space will be dealt with completely. Anyway, to the latter, in the range of the world, the maximum stacking height of common gantry cranes in container yard is 7 to 8. It is not cost effective if the new gantry cranes with high cost can only improve the storage capacity by 2000 – 4000. So this way is not recommended.

Another solution is to improve management of container yard in the view of current situation. At present, planning for empty containers is a problem that the terminal faces. Combined with the custom clearance efficiency we discussed before, we can find that increasing the custom clearance speed, enhancing the supervision and management of empty containers can ensure the efficiency of their distribution and turnover. This solution will not change the current operation capacity and range, but speed up the operating process of empty containers and reduce the time that empty containers cost at container yard, thereby save the area in the yard. The effectiveness of releasing the container yard’s pressure in this way may be limited, but it is the most cheap and simple solution.

4.5 Summary

Overall, in this chapter we learn the current developing situation of Chinese container terminals using Yantian International Container Terminal as an example. Through the assumption and simulation that the world's biggest container vessel – Triple-E class container vessels calling at YICT, I find out some general advantages and weaknesses of YICT to handle the large scale container vessels. In the last chapter, I will give my own opinion on the application of large scale container vessel in Chinese shipping market and the strategies with which YICT is able to serve the even bigger container vessel in the future.

Chapter 5. Conclusion

In the first ten years of the new century, a significant characteristic of container shipping is the tendency of large scale container vessels. The operation of large scale container vessels and the achievement of its scale of economy is a complicated process. This tendency will keep influencing the development of container terminals all over the world in the future.

In this thesis, I analyze the current situation, historical development and impacts of large scale container vessels. This type of container vessels has outstanding cost advantages and scale of economy. Anyway, the achievement of scale of economy has its prerequisites including cargo supply factor, terminal factor and hinterland factor. In order to get its scale of economy, large scale container vessels need sufficient cargos, rational organization of shipping lines and calling ports, well equipped container terminals and wide hinterlands. Among these, the service ability of container terminals is most important because the service quality of container terminals which are able to serve large scale container vessels determines the options of shipping companies to other factors above.

In addition, through the research about the impacts of large scale container vessels on container terminals and the simulation that Triple-E class container vessels call at Yantian International Container Terminal, I think that container terminals are facing great challenge of development and construction. Some container terminals in the world have already been capable of serving large scale container vessels, but terminals must improve their conditions to provide better service to large scale container vessels as the tendency of larger ships speeds up.

Taking Chinese coastal container vessels as an example, here I give some suggestions and recommendations on the development of container terminals:

1. Improve the terminal handing capacity and update the level of technology and automation.

If the handling efficiency of container terminal is low, the container vessels which cannot be handled in time need to wait at the terminal. This will lead to congestions in port area and an increasing operation cost of ship companies. If container vessels choose other ports, the container terminal will lose its clients and benefits. Concerning the handling capacity, YICT take the leading position in the world. Just because of this, YICT cannot represent the current level of many other terminals. In order to face the challenge brought by the tendency of large scale container vessels, container terminals should still recognize the increasing of handling efficiency as a long term task, so that they can provide better service to large scale container vessels.

At the same time, container terminals should also update their technological and automatic service level to provide overall service to large scale container vessels. To achieve this goal, container terminals need not only use the high speed and automatic system to serve the ship in and outbound the terminal as well as the handling process, but also to establish the forecasting system to simulate the time and condition that each kind of transportation needs in the process of information exchange. In addition, a diversified processing system is also needed in dealing with the shipping lines, terminal infrastructure and the natural information. Then container terminal can run without the influence of weathers and time so that they can meet with the requirement of container vessels at any time.

2. Carry out the dredging project and improve the safe depth in the port area.

In the simulation of Yantian International Container Terminal, YICT generally meet the requirement of Triple-E class container vessels on the water depth. Anyway, the terminal should not be satisfied with the current situation. As the new types of large scale container vessels spring up in the future, the requirement of shipping companies on water depth will be caustic. So deepening the depth of berths and channels at the terminal in order to serve large scale container vessels will be the core competitive factor in the future construction of container terminals. Now the major container terminals in the world are all applying themselves to the construction of deepwater berths which are aiming at 20 metres or even more. Container terminals need to push the process of dredging project in order to strengthen the competitiveness in the time of large scale container vessels.

3. Construct the smooth system of freight collection, distribution and transportation

The tendency of large scale container vessels increases the berthing time and handling volumes of vessels. As shipping companies are taking their own scale of economy into account, they also increase burdens on container terminals. A sharp contradiction in the system of freight collection, distribution and transportation is the congestion at the terminal. In the YICT's case study, we can see the insufficient storage capacity is an important potential problem when Triple-E class container vessels calling at YICT. So we can see the congestion is one of the worst bottlenecks in the scale of economy for large scale container vessels. The construction of system of freight collection, distribution and transportation is not only the challenge to container terminals. It also includes the improvement of rail and road systems as well as the extension and efficiency increase of container yards. To construct a complete system of freight collection, distribution and transportation, the strengths of many sections in the society (such as transport, logistics, finance and banking) are needed.

There is no denying that this thesis has many drawbacks. In consideration of my research ability and limitation of terminal data I get, I think there may be many omissions in details which I have not taken into account. In the simulation of case study, I research the subjects in Chinese container shipping market. Anyway, it may be better if I consider the subjects as parts of the whole Europe – Asia lines.

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