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WORLD MARITIME UNIVERSITY

Shanghai, China



Impact of Panama Canal Expansion on Container Liner Shipping Industry

BY

XUE RONGRONG

China

A research paper submitted to the World Maritime University in partial fulfillment of
the requirements for the award the degree of

MASTER OF SCIENCE

ITL

2017

Declaration

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

The contents of this research paper reflect my own personal views, and are not necessarily endorsed by the University.

2017-07-24

Supervised by

Professor Yin Ming

World Maritime University

Acknowledgments

First and foremost, I would like to show my deepest gratitude to my supervisor Professor Yin Ming who gave me valuable instructions. His effective advice and comments have kept the paper in the right direction. Without his enlightening instructions, impressive kindness and patience, I could not have completed my paper.

Then I am very grateful to my parents, friends and colleagues who support and encourage me during my writing of the paper.

Abstract

As one of the main canal in the world, the ‘World Bridge’ Panama Canal has large impact on world shipping industry. With development of global economy, adapting to tendency of maximization of vessels, In order to accommodate mega-ship trend and the increasingly trade demand, the expansion projection of the Panama Canal, which connects the Atlantic Ocean to the Pacific Ocean, is estimated to have an impact on the global shipping industry after the its expansion. The expansion has impact on demolitions, and deployment on trade lanes from Asia to USEC and USWC to some extent.

This dissertation summarizes the background of the Panama Canal expansion by introducing main vessel type and the principal cargo shipped through the Panama Canal. What’s more, the development of capacity distribution and Asia-US East Coast route will be concluded. Cargo flow from Asia to USEC via the Suez Canal, from Asia to USWC, cargo flow from Asia to Europe and operational costs of container liner companies will be analyzed. Through analysis of current container market with effects such as global economy and trade, phenomenon of unbalance between demand and supply, recommendations can be made to container liners for reference.

Key words: Panama Canal, Container liner shipping market

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List of Abbreviation

USEC	East Coast of the United States
USWC	West Coast of the United States
TEU	Twentyfoot Equivalent Unit
OOCL	Orient Overseas Container Line
IEX	India East Coast Express
SCFI	Shanghai Containerized Freight Index
PC/UMS	Panama Canal Universal Measurement System
SEAP	South East Asia Pendulum
FY	Fiscal Year
FEU	Forty-foot Equivalent Unit
BDI	Baltic Dry Index
IMF	International Monetary Fund
LNG	Liquefied Natural Gas

Chapter 1 Introduction

1.1 Background

Panama Canal is one of the main canals throughout the world, and it is one of seven engineering wonders of the world. It plays an important role in global container shipping. Panama Canal is located in a Central American country, Panama. It crosses Isthmus of Panama and connects Pacific and Atlantic, which shortens travelling time between east coast and west coast of America greatly. Otherwise the vessel has to round to Cape Horn, travels 15000 kilometers more than travels through Panama Canal. (Li, 2010) Statistics showed that about 5% quantity of shipment around the world was created through the canal. In this 5%, about 88% was cargo from U.S.A and Asia. The canal was completed in 1914, opened to navigation in 1915. From 1920, Panama Canal turned into an international channel. Before expansion, its total length was 81.3 kilometers, width was from 105 meters to 304 meters and its depth was from 13.5 to 26.5 meters. The largest width of vessel that can pass through the canal was 32.31 meters. The largest TEU of container ship that could fit in the canal was 5000 TEU. Panama Canal is a lock canal. It has 6 locks. Before the expansion, due to rapid development of world economy and large-scale container ships, the canal could not handle such transport capacity. While the canal was first designed and put into operation in last century, the largest vessel in the world was only 10000 tons. After development after 100 years, the world largest vessel reaches to 30000 DWT. (Xu, 2016) If the canal does not expand, it would be in saturation state

in the future. Till 2011, more than 47% container ships could not pass through the canal. (Chen, Cao, Liang , & Han, 2013) And pressure from some neighboring countries such as Nicaragua. Nicaragua is planning to build a canal which its navigation capacity would be beyond Panama Canal and shortens travelling time between west coast and east coast of U.S.A. In addition, with boost of some Asian countries like China and India, importance of Panama Canal that connects Asia and Europe through Atlantic and Pacific would be recognized.

World Bridge Panama Canal completed its expansion on June 26th, 2016. (Xie, 2016) Cosco Shipping Panama was the first vessel that passed through new lock. After the expansion, there would be a third pair of locks one at each end of canal, which are 55 meters in width, 427 meters in length, and 18.3 meters in depth to take ships more than twice as big. Container ships that are 8000 to 12000 TEU can pass through the canal. Scale effects from one single ship would be obvious. Transport costs of ship owner companies will be decreased. From Yantze River Delta Region passing through Panama Canal to Amazon saves three days transit time and 300 tons of bunker. (Zheng, 2014) So more of those companies will be attracted to deliver cargo through Panama Canal. Usually firms from Asia, ships to US inland ports choose between West and East Coast ports. (Martinez, Steven & Dresne, 2016) This makes new Panamax pass through the Canal possible. Vessels 49 meters in width, 366 meters in length and 15.2 meters in draught, container ships with 12000 TEUS can pass through expanded canal. (Shi, 2014) It is estimated that pass-through rate of post Panamax will be raised from 0% to 86.6%. The number would be 1023, up to 71.8 million TEU. (Cai, 2014) The transportation ways from Asia to USEC would be chosen, many cargo owners may choose Panama Canal, which will transit through all water way instead of route combined with both water way and inland route. (Wang,

2016) Some cargoes that used to be shipped round Suez Canal or Strait of Magellan would be attracted to pass through Panama Canal with relatively low cost. Its expansion would cause change of container shipping routes and fleet. What's more, ship owners start to buy, finance in vessel types, such as super Panamax, and some other large-scale container ships, which can fit in Panama Canal after its expansion. Positive impact of expansion would lead to more upgrades on container vessel types. This expansion would lead to maximization of containership, route planning, which will certainly have influence on future container liner industry.

1.2 Purpose

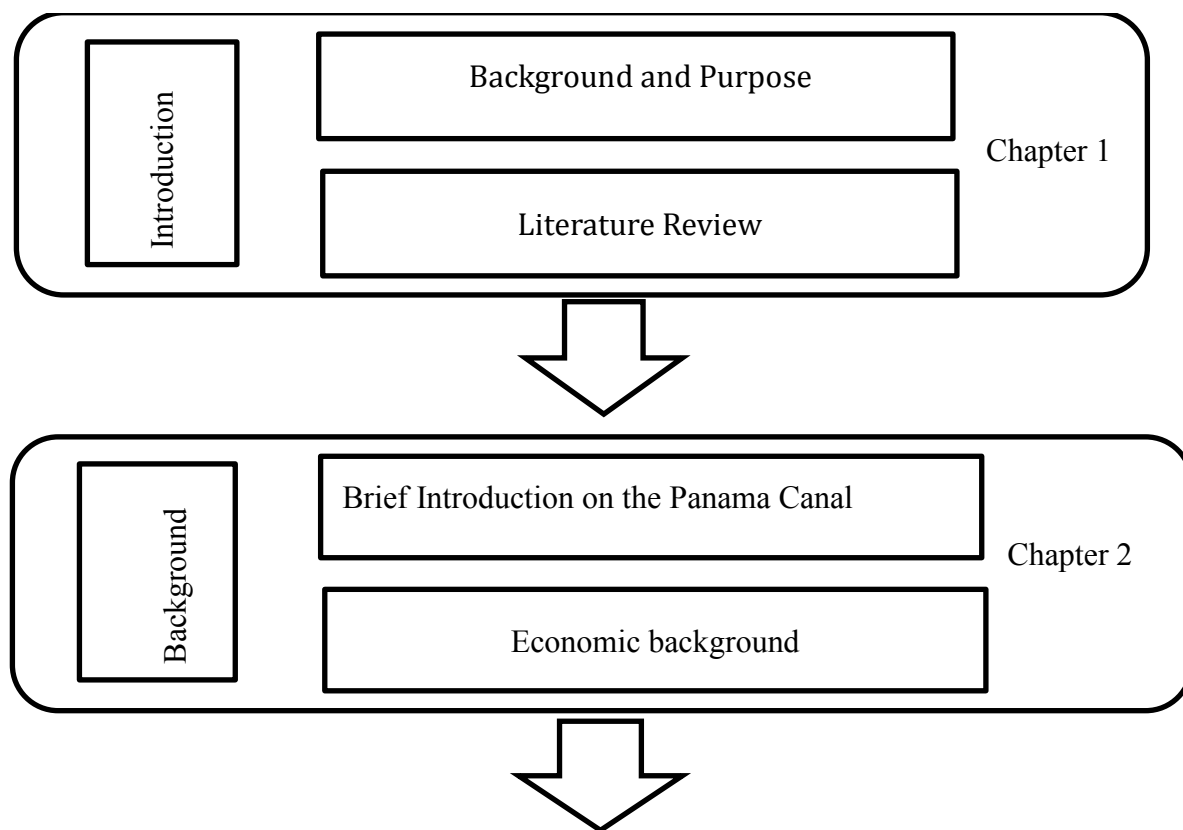
In recent years, container line market does not perform well. So how to effectively organize container line is quite important to ensure not lose more through depressing market. The expansion of Panama Canal will undoubtedly bring many positive effects. After expansion, U.S.A. would be the biggest winner. To trade with every corner throughout the world, Panama Canal is the most essential and economical water way. And China is the second biggest user of the canal. Panama Canal has occupied a very important position in China's global trade. First of all is the container line trade. As the second biggest trading partners, third biggest export market and biggest importers, container ships that travel to east coast of North America, east part of South America pass through Panama Canal frequently. After the expansion, larger container ships can pass through the canal, decent quantity of container transport can be expected. In this dissertation, chapter 1 introduce the background, purpose, methodology and literature review. In Chapter 2, the Panama Canal is briefly introduced by ways of transit, main cargo type, vessel type, service of the Canal and its competitors. And general economy

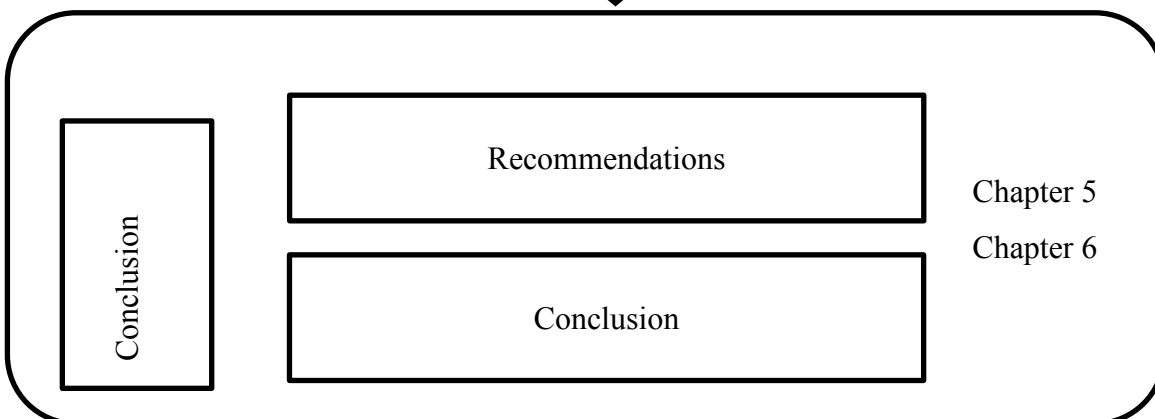
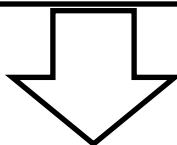
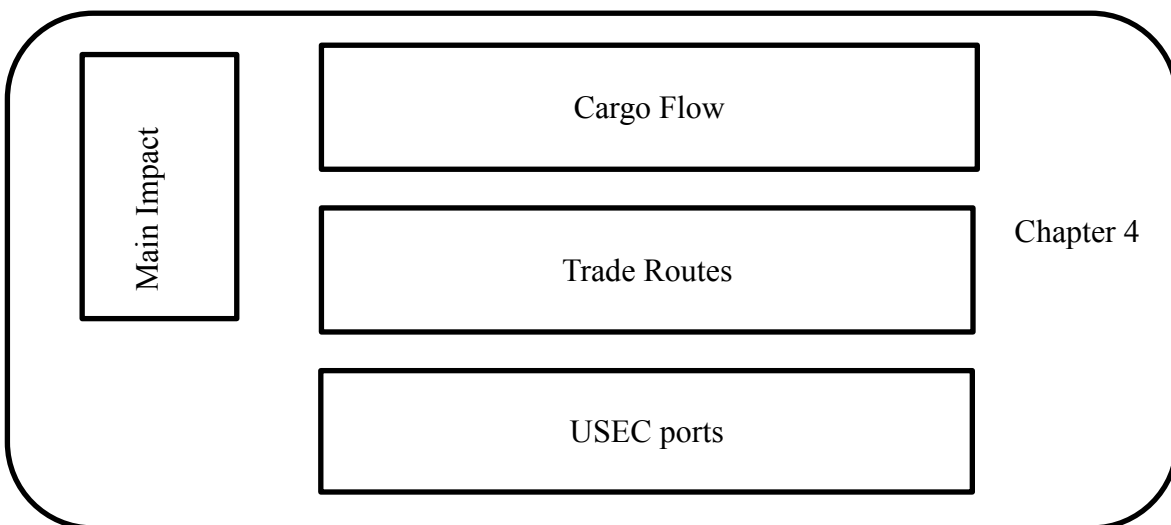
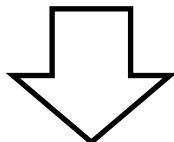
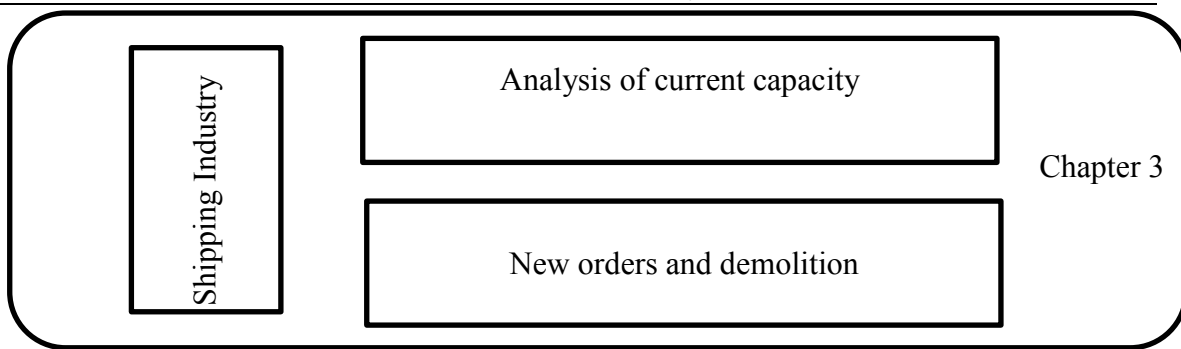
background is also analyzed. Then in Chapter 3, current container liner shipping industry is analyzed through analysis of current capacity, new orders and demolition. Chapter 4 analyzed impact of the Panama Canal expansion on container liner industry by container capacity, source of cargo, cargo flow, and operational costs on specific trade lanes. Chapter 5 offers certain recommendations to container liners companies and USEC ports.

1.3 Methodology

This thesis will be written by using literature research method combine with qualitative analysis and quantitative analysis. View literature, essays studies and dissertations from researchers that related to Panama Canal expansion, container line, relationship between both two and some other related materials as reference.

Figure 1 Research content and path





1.4 Literature Review

1.4.1 Introduction

Panama Canal plays an important role in world shipping. It is called World Bridge since it connects trade between America and Asia. Before expansion, Panama Canal showed its limitation on large vessel, especially large container ships. Some vessels could not fit in the Canal had to go around to Cape Horn, which took much more time and cost. Panama Canal holds about 5% of world trade, and with the rapid development and trend of large-scale vessels, Panama Canal had to expand to meet certain demand and make profit. Former secretary-general William A. O'NEIL stated in his speech about Panama Canal that it would be a threat if the Canal remained unchanged with growing population and global trade. He also stated fact that ships are getting larger, and containerization is presenting an upward tendency. It would be a problem if limited capacity problem of the Canal were ignored. (O'Neil 2007)

The literature review will try to find out first how is the current situation of container liner shipping industry, how they compare Panama Canal expansion before and after and then view what is impact of the expansion on world container line market , also the impact on China's container lines development. And how researchers view relationship between container lines and Panama Canal expansion. What's more, factors affect container line fleet decision would be very helpful for further research.

1.4.2 Expansion's influence on world container line

Lee, M.C., Chao, L.T., Chien, C.C. and Yun, L.S. (2015) stated that large vessels are able to bring relatively lower cost and higher capacity. And their study indicates that vessel type development can cause competition in shipping market.

Chen, Cao, Liang & Han (2014) conclude that comparing all water way cost of 4500TEU container ship passes through Panama Canal before expansion with that of 8000TEU to 12000TEU container ship passes through the canal, the cost can be decreased about 16%.

Le, Z. H., Li, N., Han, J. and Qiu, B. (2014) stated in their study that supply of container transport capacity exceeds the demand, it is key to make decision whether to slow steaming and idle capacity.

1.4.2.1 Vessel type development

Chen, Cao, Liang & Han (2014) also point out that the expansion can help boost new-building market to some extent because ship owners start to buy and finance in building vessels that can fit in new canal. Although due to financial crisis, global container ship transport market was unusually frustrated, container line capacity is rapidly rising. According to statistics from Drewry, 15.225 million TEU. Due to positive effect of the expansion, Post Panamax and other large-scale container vessel types are developed rapidly.

According to Wu (2016), after getting materials of canal expansion, ship owners, ship design company and ship builders started to research and develop new Panamax specially designed for new Panama. Comparing to traditional Panamax, new Panamax would be expanded from 32.3 meters to 48.2 meters in width. For container ships, width expansion means

more containers can be loaded. TEU for vessels that pass through Panama Canal can increase from 5000 containers to 10000 containers. According to Drewry, after expansion, middle size 4000 to 5000 TEU Panamax would be a surplus. To balance demand and supply, half of capacity would be scrapped, no matter new or old.

Liu, X.D. (2016) combined development of container ports with current situation of maximization of container ships, analyzed advantage and disadvantage of the maximization and provided reasonable suggestions.

1.4.2.2 Change of trade route

Reyes and Imai (2013) illustrated that Panama Canal plays an important role in container transport. It is a time and distance saver for routes from Pacific to Atlantic. They used regression analysis to find out the relationship among, transit waiting time, number of transits and numbers of maintenance days.

Cai (2014) pointed out that after expansion, if U.S.A's inland transport facility remains unchanged, TEU of its direct call all waterway routes passes through Panama Canal will increase from 36% to over 50%. In addition, because route from Asia to east coast of U.S.A that passes through Panama Canal can use 8000 to 12000 TEU vessels, and route from Asia passes through Indian Ocean, Suez Canal and the Atlantic to US east coast can also use this type of vessels, therefore, after expansion, these two routes are likely to be combined into one route, and form a more adaptable global Equatorial line. Ship owner companies can properly allocate cargoes to deal with unbalance between loading heavy containers and empty ones in order to improve operational efficiency. Transport cost of ship owner companies would be

decreased, so ship owner companies would like to set up new trade route to east coast of America passing through Panama Canal. In the long run, expansion of the canal would do help for ship owner companies to establish Equatorial line.

Long (2016) stated that, after expansion, new lock design can fit in 99.4% of present orders in container ships, which means 12000TEU or less can perfectly pass through the canal. This expansion can drive container development of U.S.A east coast and west coast, Far East to U.S.A. east coast, which leads to decrease on percentage of containers of this line passes through Suez Canal dramatically. He also pointed out that container vessel over 8000TEU passes through this line would be a main force in the future. Due to cost leadership, current trend of container vessel maximization might be slowed down.

Martinez, Steven and Dresner (2016) used multilogit modeling to figure out what are the factors that Panama Canal can have impact on shippers' decisions to choose which route, West Coast or East Coast. They consider freight charge ratio, transit time ratio, commodity as their variables. They reached a conclusion that after expansion, transit time could be saved from Asia to USEC.

Liu, Q., Wilson, W. W. and Luo, M. F. (2016) used cooperative game-theory model to analyze the expansion of Panama Canal have potential impacts on distribution on Asia-North America route by regarding possible changes in ship sizes, freight rates. They also used methodology of case study. They chose one route from Hong Kong to Norfolk. They had a conclusion that containers are shipped more through Norfolk than through Los Angeles. After the expansion, East Coast would gain more market power than West Coast. And they used sensitivity analysis and concluded that even if rates of West Coast is decreased, it would not

lead more containers to West Coast.

1.4.3 Expansion's influence on China's container line

Wang (2016) concluded that Panama Canal is an important channel for China in the western hemisphere. With increase of trade between China and western hemisphere, China is now the second biggest user of Panama Canal. First, the expansion is beneficial for improving China's shipbuilding industry. Since 1980s, China has accumulated large amount of technology and experience on building and repairing Panamax, and has had ability to compete with World top shipbuilding industry. Taking advantage of increase on new Panamax, China can take actions to improve shipbuilding skill and expand its market share. He stated that, the expansion leaves expansion on China. China should take positive attitude to get involved in development of setting up world ocean strategic channel.

After calculations, Zeng, Wu and Sun (2016) s' results show that among different container transport routes from China to US east coast, probability of choosing Panama Canal is the largest. After expansion of the Canal, this probability will be increased a step forward. This probability matches with their former calculation on cost and time spent on various routes from China to US east coast that 8000TEU container ship has cost leadership and time saving advantage, comparing with that of time and cost pass through Suez Canal to Long Beach.

1.4.4 Expansion impact on ports of USEC

As Camil, Adams and Martin (2016) found from their study, with the completion of Canal's expansion, there is small decrease on transit time from Asia to USEC. Cai (2014)

concluded in his study that after expansion of the Canal, capacity of large, post container vessels would be further improved. But due to limitations from channel and ports of USEC, not all container ships that pass through the Panama Canal can call at ports of USEC. Some USEC container ports are not able to provide capable modern handling facilities and berth which is suitable for ultra large container ships.

1.4.5 Multimodal transport

Wang, Guo and Wu (2014) stated in their study that compared with trade lines that pass through the Panama Canal, considering transit time, transit distance, transit costs and transit ways intermodality has more advantages. Li (2014) concluded in his thesis that multimodal transport has four advantages which are improving quality and effectiveness of cargo transportation; the second is decreasing the transportation cost; the third is multimodal of container can scientize transportation, what's more, the appearance of multimodal drives innovation of science and management technology and avoids production of environmental pollution, which controls greenhouse emission to some extent.

1.4.6 Summary and existing problems

1.4.6.1 Summary

In the literature review, some researchers have their views on expansion's Influence on world container lines development from aspects of vessel type development and changes of transporting routes. Some researchers have their focus on canal expansion's influence on China's container lines development. Last but not least, there are researchers analyze factors

that affect container lines' fleet decision, which can make a conclusion that expansion of Panama Canal have effects on maximization of container ships, which indirectly influences container lines' decisions on building large vessels in the future.

1.4.6.2 Existing problems

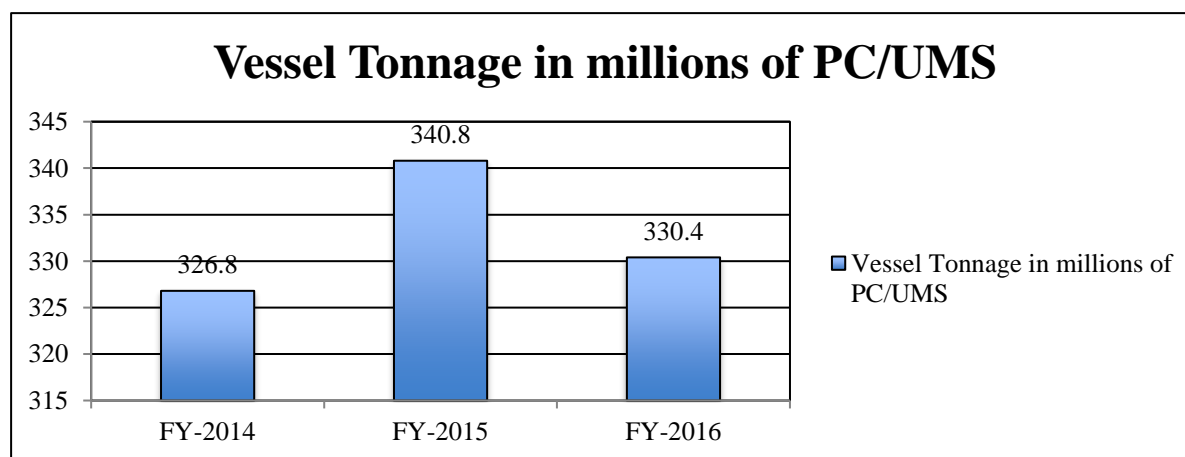
Although there are lots of researches on how expansion have effects on world shipping market, there's few focuses on how this expansion directly effects on container lines deployment decisions. There's few papers analyze relationships among expansion, fuel consumption, shipping speed, commodity on specific route. Since Panama Canal has expanded, there must be changes on choices of shipping routes, ship scrap, new building containership for container line. There are not quite a lot specific materials discuss how Panama Canal's expansion has impacts choosing most economical trade routes and optimal vessel size. So in my dissertation, data of total containership fleet development, TEU of container ships and demolition, deliveries of container ships, cargo flow from specific trade routes will be analyzed to view the impact of the Panama Canal on container liners shipping industry.

Chapter 2 Background of the Panama Canal

2.1 Brief introduction to the Panama Canal

Panama Canal is important water way connects Pacific and Atlantic, it locates at the narrowest Isthmus of Panama. Its overall length is 82 miles, widest area can reach up to 300 meters, and the narrowest is only 91 meters. Most part of canal surface is 26 meters higher than sea level. To ensure vessel can pass through successfully, locks were built along both sides of canal to adjust gap between water levels. (Zhang, 2017). To let more and bigger vessel to pass through the Panama Canal, government of Panama started to expand the Canal in 2007, and finished the expansion in 2016.

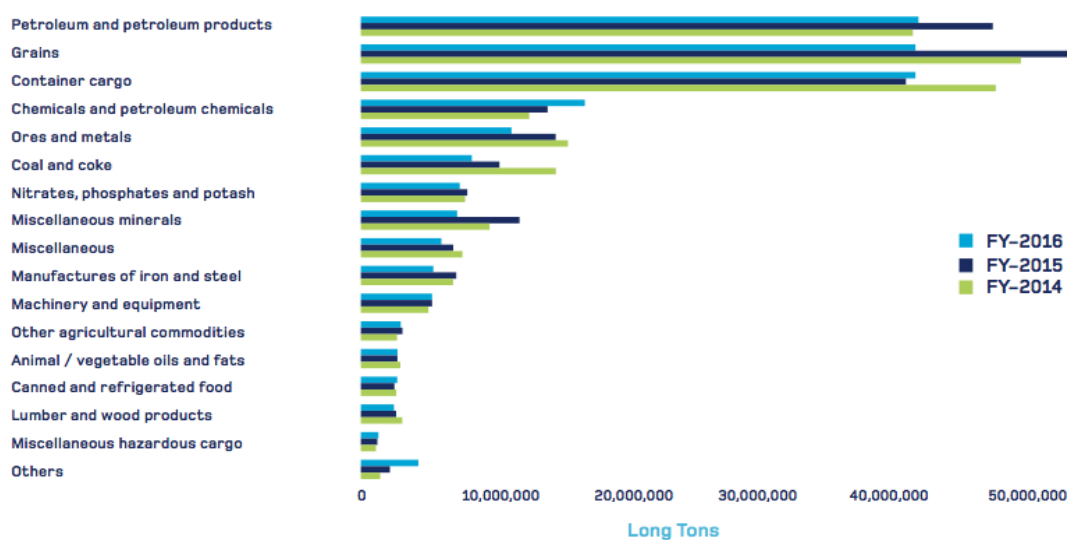
Figure 2 Vessel tonnage in million of PC/UMS



*Data from annual report of Panama Canal

Figure 3 Principal commodities shipped through the Panama Canal in Y2014, Y2015 & Y2016

Principal Commodities Shipped Through the Panama Canal



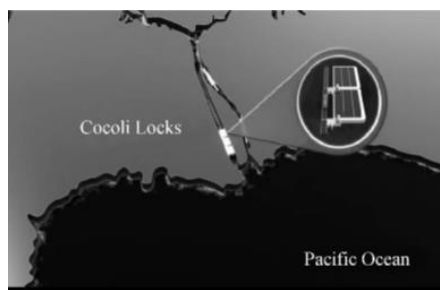
*Data from annual report of Panama Canal

2.1.1 Comparison before and after the expansion

To let more and bigger vessel to pass through the Panama Canal, government of Panama started to expand the Canal in 2007, and finished the expansion in 2016. First voyage ceremony was held on June 26, 2016. COSCO Shipping Panama was the first container ship that passes through new Panama Canal. Later on May 24, 2017, OOCL France, which has 13208 TEU, turned to be the biggest container vessel passed through Panama Canal.

There are first and second locks on the side of Pacific Ocean. The Atlantic one has the third lock. (see picture 1 and 2) The door was hinged one, lock chamber was 304.8 meters in length, 33.53 meters in length and 12.8 meters in depth. Old locks were only suitable for vessels that were 294.13 meters in length, 32.31 meters in width, and 12.04 in draft, which means it fits for vessel that is 5000 TEU. After expansion, new lock was built on each side of Pacific Ocean and the Atlantic. Each lock has three lock chambers. The new lock is fit for 13000 TEU

vessels in maximum. (Zhang, 2017) Currently Panamax still go through old locks, only super post Panamax or new Panamax go through new locks.



Pic 1 Old lock from side of Pacific Ocean



Pic 2 Old lock from side of Atlantic Ocean

Table 1 Comparison of passable vessel type through new and old lock

	Old lock	New lock
Length of vessel (meter)	294.13	366
Width of vessel (meter)	32.31	49
Draft (meter)	12.04	15.2
TEU	4500 TEU	12000 TEU

* Data from official website of the Panama Canal

2.1.1.1 Main cargo type

From the aspect of principal commodities, as showed in below figure 2.2, in year 2015, grains were shipped most through Panama Canal, while petroleum and petroleum products the second and container cargo the third. But in 2016, the amount of grains shipped through the Panama Canal dropped dramatically from exceeds 50 million long tons to around 40 million long tons, and amount of container cargo slightly rose, in fiscal year 2016, petroleum and

petroleum products were shipped most.

2.1.1.2 Main vessel type

The new lock transits 224 Neopanamax, 144 full containers, 51 LPG, 15 LNG and 10 vehicle carriers. In fiscal year 2016, the net tonnage registered from Panama Canal was 330.34 million Panama Canal / Universal Measurement System (Figure 2) decreased 3.0 % from previous year. Tolls revenue was B/. 1933 million, dropped 3.1% from previous fiscal year. And the canal experienced 5.5 % transit reduction, from 13874 in FY2015 to 13114 in FY 2016. Among various segments of vessel types that pass through the Panama Canal, under the segment of full container vessels, container vessel registered 2977 transits passing through Panama Canal, with a volume of 120 million PC/UMS tons, 12.4 million TEUs capacity. Above numbers show that compared with last fiscal year, the full container vessel segment decreased 2.9 % in transits, increases 4.1 % in PC/UMS tons, 2.8% in capacity, and 0.2% toll revenues.

2.1.1.3 Service of the Canal

As for the service of Panama Canal, after the expansion, there was no incident due to good preparation. Before official operation of new Canal, the Canal trained 1687 workers who are involved in canal expansion operation, such as pilots, line handlers, tugboat captain, emergency response personnel who were trained for dealing with emergency that is caused by LNG vessels and so on. Those good preparations can enable service with good quality and satisfy customers. Good way to measure efficiency of the Panama Canal is Canal Waters time and In-transit time. For Canal Waters time, reported that it is 32.69 hours on average in fiscal year 2016, compared

with 30.59 hours in fiscal year 2015, Canal Waters time exceeds 1.8 hours. This is mainly affected by queues for the first two month of fiscal year, due to lock maintenance at the end of 2015. There is a progress for Percentage of PC/UMS tons with CWT of each markets, which is 83.35%, slightly improved 1.59% compared with fiscal year 2015. Another is In-transit Time, the percentage of fiscal year 2016 is 0.48 hours less than that of fiscal year 2015.

2.1.2 Competitors

As for new opportunities and competitors, among all the lines that pass through Panama Canal, volume Ex Asia to east coast of North America occupies 31% of world volume, the second is 11% for East coast of North America to West coast of South America. The third, which is ex Europe to west coast of South America. Shipping line that ex Asia to North America is the world largest trade line besides intra-Asia line. On this line, if choose East coast of North America and the Gulf of Mexico as origin or port of departure, there are two routes, one is multi-modal transportation passes through west coast of North America, which is ex Asia to the Gulf of West coast, and transfer to inland transportation to East coast or the Gulf of Mexico.

The second is marine transport passing through the Suez Canal. They compete with each other. Although the expansion of Panama Canal enables more large vessels to pass through, it seems that volumes might not increase as expected. Since April, 2013, Maersk altered two lines that pass through Panama Canal into the Suez Canal for line ex Asia to East coast. The reason is that cost of passing through Panama Canal is higher than the Suez Canal one. Toll of Panama Canal is increasing every year, except year 2009 to 2010, when it was financial crisis. From 2005 to 2011, toll was doubled. Due to this reason, Maersk changed the ex-Asia to east coast

line to pass through the Suez Canal instead of the Panama Canal since 2013. What's more, according to related materials from Japanese Ship-owners Association, number of Japanese fleet that pass through the Panama Canal is lower than that of the Suez Canal since 1999. While toll of the Panama Canal rises every 10%, volume of Japanese fleet pass through the Canal will decrease 11.1%. Since Panama Canal enable more large container ships to pass through, current mid-west region will be separated to east and west according to specific lines. It would be advantage for south-east of Gulf of Mexico centered to pass through the Panama Canal. On the other hand, according to container transit time of ex north-east of Asia to east coast, it might take 18.3 days to transport via west coast through way of multi modal, but if choose Panama Canal, it might take 21.6 days. According to investigation, multi-modal is suitable for those speed- centered cargos, if freight rates do not decrease dramatically, the Panama Canal would not be selected. In addition, even though ship types that able to pass through Panama Canal is able to match with that of the Suez Canal, the increase extent of volumes will probably only reach to 20%. Main reasons might be some manufacturing factories tend to move to west, increase of volume and decrease of cargo quantity cancel each other out.

Besides the old and long competitor Suez Canal, there are some new competitors, one is Arctic shipping route, currently ex Asia to Europe line is 113000 miles, if this route put into operation, the voyage length can be shortened to 6865 miles, decrease 4435 miles. From this decrease, great economic potential contained can be expected. From North America to Asia, with Arctic line, it travels around 3500 miles less than through the Panama Canal, shipping cost can be saved about 40%. North East of the arctic route has high commercial use. It is calculated that start from far east port, pass through Bering strait, along with north east of Arctic to west

can take 3000 miles less than through traditional routes such as the strait of Malacca, the Suez Canal, save 40% voyage time. Especially Far East to Russian port which is located in the Arctic. It can save 30-40 days of voyage time. So its economic efficiency is more obvious. The program of COSCO Shipping which is called 'Yong Sheng +', using round trip between ports to expand its operation scale of north east arctic routes, to provide customers better and quicker choice. Saving voyage length and time, it cannot only save fuel cost, tolls, security costs personnel costs and loss, decrease operational costs, but also decrease fuel commission and CO2 emission and improve energy efficiency and reduce pollution. In the future, There might be more routes from Asia to Europe, no need for ships to pass through busy and crowded Suez Canal, and they can keep away from those sensitive and dangerous regions. Norwegian Ship-owners Association estimated that before 2020, amount of cargo transport could reach up to 50 million tons on north east of arctic route.

Another new competitor is Nicaragua Canal, it is invested by HKND, this canal which established in 5 year-time would be another important water way connects between the Pacific and the Atlantic after the Panama Canal. It will be three times longer than the Panama Canal. After operation of this Canal, voyage distance of large ships passing through Asian countries to USEC and Europe can be shortened greatly. Using shipping line from New York to Japan, because some large vessels cannot get across the Panama Canal and the Suez Canal, the total voyage distance is 0.24 million miles and takes 36 days. If same route but passes through Nicaragua Canal, the total voyage distance can be shortened 0.17 million miles and arrive 11 days earlier at the destination. So there are threats are more than opportunities for Panama Canal. After Expansion, among main carriers that passed through the new Panama Canal, top 15

carriers of entering occupies 73.7% of total. MSC was 11.9% and is the top one, MOL was the second and Shell was the third. And it is not surprised that NYK, Maersk and Hamburg Süd was the last three of the list due to the reason of high toll when enter the Panama Canal.

2.2 Economic background

2.2.1 Economy of USA and Asia

Fiscal year 2016 was not so optimistic. It was marked as an increase in business uncertainty. This led to a negative impact on investment and economy in the U.S. In the fourth quarter at the end of 2015, IMF and some other international organizations estimated that there was a slight improvement on US economy. But there were some macroeconomic changes such as president election of United States, the Brexit, and decrease of oil price. There were some positive progress in employment and consumption. The appreciation of US dollar let US exports went down, at the same time its government cut spending.

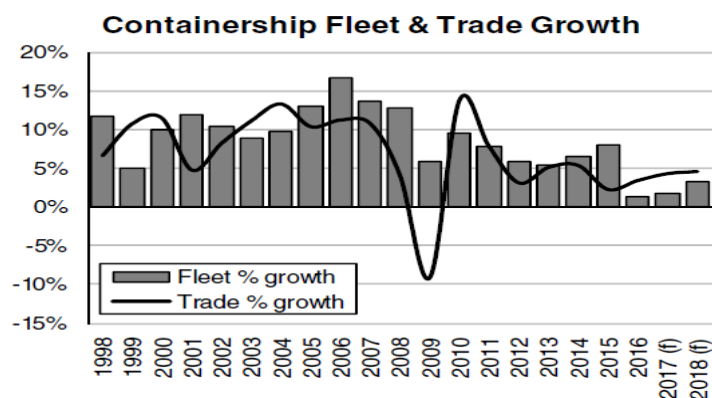
Federal Reserve rose 0.25 points at end 2015 for the first time in 9 years. Race of president election, Syrian war and problems occurred in Eurozone, they all increased risk and uncertainty and decreased investment. In 2016, relationship between U.S and Russia became intense. In a word, economy has grown in a slow pace.

The economy in Asia was also not optimistic. Because China's economic growth slowed down since China is driving force of Asia. Authorities of China tried to keep economic growth with several actions, such as lowering interest rates. RMB which is Chinese currency was added into IMF reserve currencies.

2.2.2 Supply and demand

In full year 2016, the demand of container shipping demand seems grow quicker than its supply, global demand and supply index increased to 82.4 points. Even though this trend may continue in 2017, there is still pressure on oversupplied capacity with downturn of global economy. The pressure from this surplus influenced dramatically on freight rates. So it is very stressful for both operators and ship owners. In 2016, Liner companies reported negative margins.

Figure 4 Containership fleet & trade growth



*Source: Clarksons Research

Level of Container ship capacity idle can show scale of surplus capacity, which is around 7.5% at the end of 2016. Idle containership capacity reached to a peak, 1.5 million TEU, about 11.8% of fleet capacity back in December 2009 due to financial crisis. But the total level of idle capacity dropped to around 5.6% at the end of first quarter in 2017.

With delivery of very large containership in the future, although it seems that the volume of main lane goes up. For North-South trade volume, to find deployment opportunities for these ships would be more challenging. There might be a hope after the operation of Panama Canal expansion for diminishing the oversupply.

The Panama expansion may lead to changes to deployment since its opening in June 2016. It has quite big changes on container ship deployment on transpacific route. At the beginning of 2nd quarter of 2017, around 40 old Panamax ships did not deployed on Asia to USEC passing through the Panama Canal. At the beginning of June 2016, around 60 Panamax ships remained idle. At the same time, for Asia to USEC services, the expanded locks of the Panama Canal enabled about 90 box ships which is about 8,000 to 14,000 TEU and 6,000 to 8,000 TEU container ships to be deployed at the beginning of 2017.

To conclude, actually the unbalance between supply and demand does not show a tendency of improvement.

Table 2 Main lane container shipping supply and demand trend estimate

	end year					forecast		current & forecast, end				Trend
	2012	2013	2014	2015	2016	2017	2018	Q1 17	Q2 17	Q3 17	Q4 17	%
TRANSPACIFIC, 000 TEU												
E/B Trade	13,277	13,832	14,650	15,593	16,311	17,006	17,653	3,960	4,118	4,665	4,263	5.0%
annual growth		4%	6%	6%	5%	4%	4%					
W/B Trade	7,569	7,854	7,546	7,303	7,834	8,093	8,320	2,052	2,066	1,971	2,004	1.2%
annual growth		4%	-4%	-3%	7%	3%	3%					
Transpacific Trade	20,846	21,686	22,197	22,895	24,145	25,099	25,973	6,012	6,184	6,636	6,267	3.7%
annual growth		4%	2%	3%	5%	4%	3%					
E/B Capacity	18,606	18,643	20,329	20,813	20,781	21,670	22,404	22,107	22,172	21,932	21,670	
W/B Capacity	16,746	16,779	18,296	18,732	18,703	19,503	20,164	19,896	19,955	19,739	19,503	
Average Capacity	17,676	17,711	19,312	19,773	19,742	20,587	21,284	21,002	21,063	20,835	20,587	3.7%
annual growth		0%	9%	2%	0%	4%	3%					
TRANSPACIFIC SUPPLY/DEMAND												
E/B Index	124	129	126	131	137	137	137	130	132	136	137	
W/B Index	81	84	74	70	75	74	74	72	73	74	74	

Source: Clarksons Research

The Transpacific supply and demand balance fell during first quarter in 2017, following gains in the second half of 2016. By the start of April 2017, the Transpacific supply and demand index stood at 130 points, but still up compared to levels recorded in the first half of 2016. The SCFI spot rate on the origin Shanghai to USEC route averaged \$3,164/FEU in first quarter in 2017, and up 50% compared to the 2016 average. However, by the end of March, rates on this

route were on a downwards trend which is below \$2,500/FEU in April. Meanwhile, volume growth on the eastbound transpacific route has remained relatively firm following a strong performance in the second half of 2016. There remains uncertainty over US trade given the potential for international trade to be impacted by policy changes from President Donald Trump. (Clarkson Research, 2017) Upsizing on the Asia to USEC route continued in first quarter of 2017, reflecting service changes as the new alliance structures began operations at the start of April 2017. At the end of first quarter, there were around 95 container ships at capacity of 8,000 TEU and above operating on the Asia-USEC route via the expanded Panama Canal locks. At the same time, the number of old Panamax deployed on the route stood at around 40 ships at the start of April 2017, down from over 150 in mid of 2016.

The phenomenon of oversupply still remains, motivation of market is not strong. Change of container transport market structure and its influence on competitive behaviors of liners are important factors that affect future market. First, from the aspect of North America line, United States' economic recovery start to speed up, consumption and investment status perform well, and residents' employment level improves steadily. The increase of capacity is a main factor that hinders North America line to go up. Under circumstance of high frequency of deliveries, due to Panama Canal expansion, and withdraw of Hanjin which leads to part of its market share is left, so liners might be invest more capacity into north America line. This makes oversupply even worse and hinders rise of freight rate.

The second aspect is European line, with Europe Central Bank implement quantized loose monetary policy starts to lose its effects, after-effect of financial crisis start to surface. On one hand, internal unbalance and structural conflict has not been defused, some national banks'

balance sheets are still remain unrepaired, rather high unemployment and bad financial status of residents constraints consumption demand. On the other hand, British and Italian referendums worsen instability of European economic recovery. This year, new building large-scale container ships will be delivered in high frequency. Because large vessels are able to save operation costs, seize market share and promote service quality for liner shipping companies. So it can be predicted that updates of vessel type for European shipping line. The unbalance between demand and supply cannot be altered easily.

The third is on the aspect of Japan line. Japan economy is influenced by appreciation of Yen exchange rate, shrinking population. Although Japanese government has launched various policies to lower currency, postpone imposition of consumption duty and increase budget. It can be predicted that Japan economy would remain low growth. Under this background, lines from China to Japan are not able to show sign of a rise. Relationship between supply and demand still face up with pressure from unbalance. But thanks to self-regulation of most liner shipping companies on this line, total freight level can be expected to be stable. Fourth is South-North line, concentrated deliveries will upgrade capacity from east-west to north-south, which may cause compensation of positive factors brought from rising consumption demand. And North-West line is not major line, so its market sensitivity to capacity is rather high. Therefore, liners' allocation among various regions would be main factors that interfere market tendency. What's more, as for intra-Asia line, with deepening of One Belt One Road and integration of whole Asia regions, transportation demand remains rather high momentum of growth. But entry level of intra-Asia line is quite low, increasing amount of cargo attract more and more liner shipping companies to input their capacity. In addition, some intra-Asia lines are duplicated

with some East-West line. So it is predicted that lines of intra-Asia would be affected by expansion of major East-West lines. The competition will be fiercer.

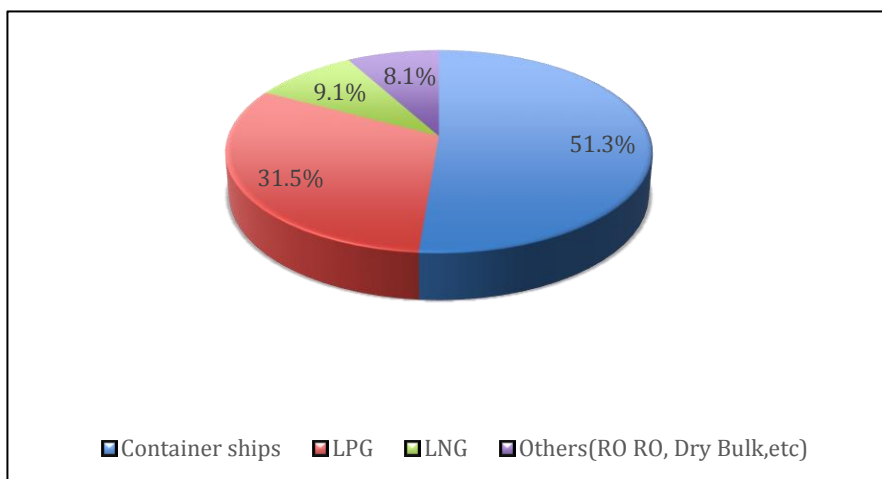
When liner shipping companies deploy ships by line, except considering self shipping demand, it is more important to combine demand and supply of the whole container shipping market when making any decisions. The second is that when liner shipping companies seek for lowering cost of single container, they still have to face up with the problems of expansion of capacity and over supply. The third is number of ships and frequencies on each line are the most effective way to deal with current phenomenon of oversupply. Freight rates remain low, with more capacity of new and larger ships are under construction. Shippers try to maximize efficiency and lower cost through acquisition (such as COSCO and China Shipping; Maersk and Hamburg Sud), and create new alliance, such as G6, CKYH and current new alliance called Ocean Alliance, which is biggest container alliance till now. By alliance, ship owners can produce scale of economy through corporation to save unit purchase cost. Alliance can also help to decrease capital cost, ship owners can decrease frequency on buying new ships and avoid capital risk brought from purchasing new ships. Alliance can also enable ship owners to expand service, reallocate resource and capacity, which are oversupplied.

Chapter 3 Current container liner shipping industry

3.1 Analysis of current capacity

After a year of June 26, 2017, which was the first day that new Panama Canal officially put into operation, there are 1535 ships passed through new locks, 51.3% were container ships; 31.5% were LPG, 9.1% were LNG, others were 8.1%, (which included dry bulk, RO-RO, cruise and so on.) In other words, about 5.9 ships passed through new locks, 2 to 3 ships more than expectation. With increase of ship number, tonnage of ship has increased 22.2% in 2017, compared with fiscal year 2017. So it can be concluded that container ships are main force that pass through the Panama Canal. According to figure 6, the total quantity of shipments of 2016 was 330.4 million PC/UMS Tons, 120 million PC/UMS Tons (12.4 million TEU) of total shipments were container vessel, which occupied over one thirds of total shipments. Counted with number of ships, in 2016, there were 13114 ships transits through the Panama Canal, 2977 of them were container vessels, which occupied 22.7 of total transits. As for Toll revenue, total toll revenue for the Panama Canal in 2016 was B/.1933 million, which occupied 49% of total toll revenue, almost half of total revenue, which also the largest source of income. Therefore, it can be concluded that no matter from aspect of shipment quantity, transit quantity, or toll revenue, transits of container vessels have close relationship with the Panama Canal.

Figure 5 Percentage of each vessel type pass through the Panama Canal



*Data from Panama Canal annual report of 2016

Table 3 Number of container ships transits the Panama Canal in 2016

	Container vessel	Panama Canal	Proportion %
Quantity of shipments (PC/UMS Ton)	120 million	330.4 million	36.3%
Quantity of transit (ship)	2977	13114	22.7%
Toll revenue (Dollar)	B/. 948 million	B/.1,933 million	49%

*Data from Panama Canal annual report of 2016

COSCO shipping Panama as they first container ships passed through the new Panama Canal. And later in May 24, 2017, less than week when COSCO Shipping Development set the last record, OOCL France now is the largest capacity that passed through the Panama Canal. On June 12, Panama announced to set up diplomatic relationship with China. From the statistics from Panama Canal authority, quantity of shipments from or to China that pass through the canal occupies 20% of total quantity. China has been the second biggest user while the first biggest is United States. China shipping companies pay hundreds of millions of US dollars to

Panama government.

3.2 New orders and demolition

The actual container ships deliveries to customer in 2016 was 11.8 million DWT, estimated deliveries to customer was 18.4 million DWT, slightly increase about 3.0 % without consideration of delay in delivery. (Table 4) (Qin, Qi, Shen, Liu & Jiang, 2017)

Table 4 Statistics on increase of container ship from 2016-2017

Vessel Type	Container ship
Expected deliveries in 2017 (10,000 DWT)	13020
Deliveries in 2016 (10,000 DWT)	11470
Expected capacity increase in 2017 (without consideration of late deliveries)	4.6%
Expected capacity increase in 2017 (include consideration of late deliveries)	2.6%
Capacity increase in 2016	3.0%

* Data from Clarkson

In 2017, global economy is going to maintain growth in the future. According to IMF's estimation, world trade will increase 3.8%, expected to rise 1.9 percentage points. (SSE, 2017)

With rapid growth of world trade and economy, demand of global container transportation will further increase. Clarkson predicted that the demand would rise 4%, increase 0.8 percentage points compared to 2016. And Drewry estimated that the demand would increase 2.4 %, rise 1.1 percentage points compared to 2016. Considering unstable and weak basis of economic recovery, it is not quite possible for the demand to increase dramatically. Although the demand in 2016 increased, unbalance of the market might not be improved because of dramatic growth of new-building ships and oversupply. Clarkson estimated that demand of trans Pacific ,

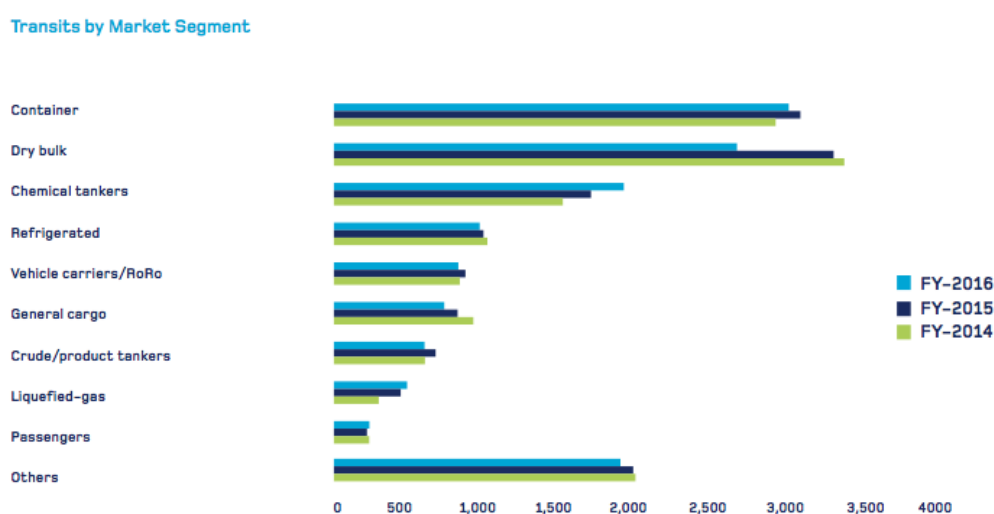
European line, and Atlantic lines would increase 2.9%, 3.2% and 2.9%, they all do not exceed increase of transport capacity. Among those three lines, Increase of European line and trans pacific lines are far less than increase of capacity of container ships, which are over 8000 TEU. The unbalance of global container shipping market is still severe. Under fierce competition among liners, mergers and acquisitions are growing. After merger of CMA CGM and APL, China Shipping Group and COSCO, Maersk announced to acquire Hamburg Sud on December, 2016. In addition, with earlier announced mergers of Hapag Lloyd and United Arab Shipping Company, NYK, MOL and K line, and bankruptcy of Hanjin, those phenomena all show that liner shipping industry concentration step forward. Currently, market shares of top eight liner shipping companies are 62.3%. If above acquisitions are all done, market share of top four would be rise to 71.4%. This urges container shipping market transforms from a low concentration oligopoly industry into a high concentration oligopoly one, to lower competition of market price.

Chapter 4 Impact of The Panama Canal expansion on container liner industry

4.1 Impact on container ship capacity

In year 2016, per annual report from Panama Canal (Figure 6), container ships stand the highest in the transits by market segments. And always be top three in year 2014 and year 2015.

Figure 6 Transits by market segment in FY2014, FY2015 and FY2016



*Data from Panama Canal annual report

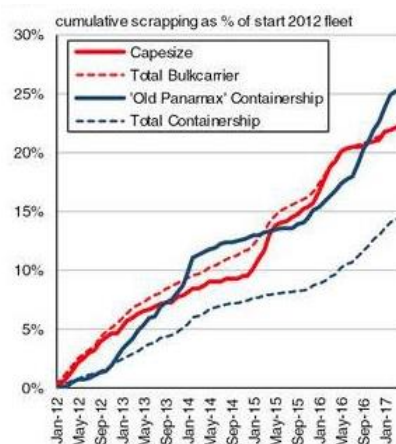
After expansion, it can bring positive influence on global container shipping line pattern. In the long run, based on Panama Canal, world container shipping market will form wider network. First, some shipping companies can use 8,000-12,000 TEU super container ships and select to establish Equatorial line in order to accomplish cargo transportation to East and West with lower cost. And the expansion enables liners to set up Pendulum lines among South America, North America to Europe or Australia to form branch network and expand scale of Equatorial line transportation. At the same time, with operation of new Panama Canal, Pendulum lines will be more efficient and flexible. Additionally, internal transport network can be built in south Asia, the Mediterranean, and Caribbean to connect regional port system as

well as form hub and spoke world container shipping network. Maersk, CMA CGM and COSCO Shipping stated that they would adjust shipping lines and capacity according to the change brought from Panama Canal expansion.

According to Clarkson research, number of scrapping container ships encountered a sharp rise, reached to over 654,400 TEU, 194 ships. (Table 5) It is the highest and it break historical record. An important and main reason for this dramatically rise is that Panama Canal Expansion cause oversupply of Panamax. Due to the Panama Canal expansion, container ships up to 12,000 TEU can pass through the canal, so to some extent, ship owners may want to build larger container ships and scrap oversupplied container ships for scale economy, Containerships which are from 3,000-5,999 TEU (Intermediate), 6,000 TEU to 6,999 TEU (Intermediate) decreased in 2017, compared with 2016, but for container ships from 8000 TEU to 11999 TEU (Neo-Panamax), 12,000 TEU to 14,999 TEU (Neo-Panamax) increased in 2017, compared with 2016. From Table 6, the orders of container ships encountered a sharp decreased in 2016, which is from 249 ships (2,274,400 TEU) in 2015 decreased to 82 ships (204,500 TEU) in 2016. In 2017 till now, only 8 orders were placed. The deliveries of containerships performed not well, either. There is also a decrease in number of deliveries, quite match with sharp decrease of orders, there was 213 (1,678,400 TEU) container ships were delivered in 2015, 131 container ships (904,800 TEU) were delivered in 2016. In 2017 till now, the number of container ships delivered is 31 (182,400 TEU) ships. From the report of CNSA for 2016, BDI was always under 1300 points, and fell down to 290 points, which broke the recorded lows. Under background of capacity oversupply and overspending, scrapping idle ships was still operational choice for ship owners. Most noteworthy, due to influence from Panama Canal Expansion, container ships from

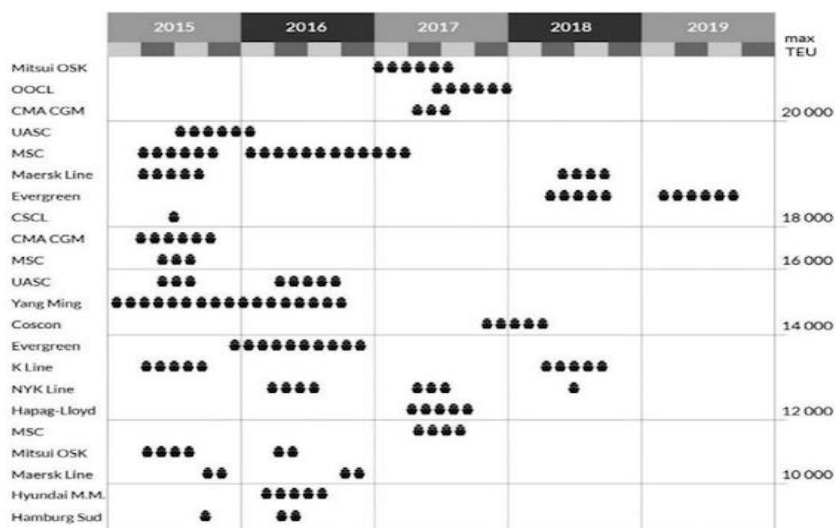
8000-12000 TEU had been main force of passing through the Canal. The number of scrapping some old, traditional Panamax container ships raised significantly, especially the rise of some China old container ships scrapping, occupied 45.3% of china light deadweight, experienced year on year growth of 34.2 percentage points. (CNSA, 2017) In recent years, number of scrapping Panamax container ships stays in high position without going down. Trace back to year 2012, due to high deliveries and revenue pressure, scrapping of old Panamax container ships was in the upward trend. Throughout year 2012, fleet of Panamax container ship occupied 2.6% of total fleet and about 100,000 TEU capacity were scraped. So Panamax fleet finish its 'Infantilization'. In early 2012, average age of Panamax Container ships was around 8.9 years. Compared with fleets number at beginning of 2012, till September 13, 2013, there were 7.3% Panamax container ships were scraped. For the whole year of 2013, container market was a downturn, so number of scrapping for container ship was only 240,000 TEU, occupied 6% of total fleet. In 2015, till May 15 of that year, accumulated number of scrapping was 13.4% for Panamax. The depreciation rate for Panamax broke record. Because of revenue decline, financial difficulties and Panama Canal expansion, including 71 Panamax container ships, about 300000 TEU were sent to scrapping yard. Till beginning of 2017, the scrapping rate for Panamax container ships is 25.4% (See Table 6), which remains historically high, but it has slowed down slightly. In total, around 200,000 TEU were sold in first quarter of 2017 for recycle purpose, about half of this number is old Panamax vessels. As it shows in below figure 2.3, it can be concluded that all current container ships are between 10,000-20,000 TEU and larger container ships, which are above 20,000 TEU have been ordered. Therefore, it can be indicated that larger container vessels have been a trend in the future.

Figure 7 Cumulative scrapping as % of start 2012 fleet



Source: Clarkson Research

Figure 8 Current and future deployment of containers ships between 10000-20000TEU and larger



*Data from Adam and Jan. (2016)

Table 5 Container ship demolition from 2010 to 2017

Year	No. of Demolition	000 TEU
2010	88	132.6
2011	62	77.9
2012	183	334.7
2013	199	444.2
2014	171	372.6
2015	92	193.3
2016	194	654.4
2017	63	204.7

*Data from Clarkson research

Table 6 Orders and deliveries from 2013 to 2017

Year	Orders		Deliveries	
	No	000 TEU	No	000 TEU
2013	290	2161.2	206	1346.1
2014	168	1122.9	205	1489.9
2015	249	2274.4	213	1678.4
2016	82	204.5	131	904.8
2017	8	15.3	31	182.4

*Data from Clarkson Research

4.2 Impact on container lines' shipping routes

There are mainly three ways for container vessels from Asia to USEC. First is from Asia across Pacific Ocean to USEC through the Panama Canal. The second is multimodal transportation. The third is origin start from Asia, across the India Ocean Suez Canal and the Atlantic to USEC. This route has long voyage distance, low efficiency. During the voyage, vessels have to stop at several ports in order to pick up cargoes. For ship owner companies, it will be more challenging because they have to seek for source of goods. Early 1980s, 80% of container cargo were transported through the Panama Canal, and 20% used post Panamax to transport to West coast, and delivered to destination via railway. When 1990s, the situation was completely converted, only 20% of vessels passed through the Panama Canal, 80% transported via intermodal transported. Among routes that pass through the Panama Canal, route from Asia to USEC occupies biggest portion. So the Panama Canal expansion has fundamental impact on this route. Due to limited economic efficiency, many ship owners choose USWC and transport cargo via railway. When new choice occur, those ship owners need to consider how to deploy

ships. As it shows in table 3.1, among main lane from east to west, transpacific e/b and Far East-Europe w/b are top two trade in mainline East to West. In 2015 and 2016, transpacific e/b was top one, which were 15.6 million TEU and 16.3 million TEU, occupied 30.2% of total trade in 2015, and 30.6% of total trade in 2016, and with upward tendency, transpacific e/b is expected to be the highest in 2017 and 2018.

Table 7 Estimated global container trade, million TEU

	2010	2011	2012	2013	2014	2015	2016 (e)	2017 (f)	2018 (f)
Mainlane East-West	45.6	47.3	47.1	49.1	51.1	51.5	53.1	55.0	56.6
	11.5%	3.8%	-0.5%	4.4%	4.0%	0.8%	3.2%	3.4%	3.1%
Transpacific e/b	13.1	13.2	13.3	13.8	14.7	15.6	16.3	17.0	17.7
Transpacific w/b	7.2	7.6	7.6	7.9	7.5	7.3	7.8	8.1	8.3
Far East-Europe w/b	13.8	14.2	13.6	14.3	15.4	14.9	15.1	15.5	15.9
Europe-Far East e/b	5.8	6.2	6.5	6.9	6.9	6.9	7.0	7.2	7.4
Transatlantic w/b	3.0	3.3	3.5	3.6	3.9	4.2	4.3	4.5	4.7
Transatlantic e/b	2.7	2.8	2.6	2.7	2.7	2.6	2.6	2.6	2.7

*Data from Clarkson Research

4.2.1 Source of cargo

Among trade lanes that pass through the Panama Canal, quantity of cargo that shipped from Asia to USEC occupies most. So the expansion's impact on container transport can be reflected on trade between Asia and USA. As main trade countries on Asia to USEC, import and export from China to USA increased 21.3% in the first half of 2017. In June 2017, the export growth from China to US reached to 8.13 percentage point, which was the highest since

2014. According to department of commerce of the United States, in 2017, from January to May, import and export of American cargo was 1,561.37 billion US dollars, have year on year growth 7.3% (The same below). Among them, 624.45 billion US dollars are export, increases 6.7%; import 936.93 billion dollars, increases 7.7 %. Export deficit was 312.48 billion US dollars, increases 9.6%. From January to May of 2017, bilateral import volume is 237.25 billion US dollars, increases 9.8%. Among this volume, United States exports to China 49.53 billion US dollars, increases 16.7%, and occupies 7.9% of total volume of United States export amount, which increases 0.1 percentage point. The amount that United States imported from China is 187.62 billion US dollars, which increases 8.1%, occupies 20% of US total import, increases 0.1 percentage point. U.S. trade deficit is 138.09 billion US dollars, increases 5.3%. Till the end of May of 2017, China is second biggest trade partner, the third export market and the first import original source of mechanical and electrical products, textiles, raw material, plastics, rubber, and glass-ceramics. Main products that United States imports from China are mechanical and electrical products. Furniture, toys, textile, raw materials, base metal and its products are the second, the third and the forth of import products export from China to USA. According to IMF, overall economic growth is strengthening, some developing countries continuously support the economy through domestic policies, generally recovered oil price and credit growth. According to five year history for top 10 trade lanes for imports via Savannah from Georgia Ports Authority (See Table 8). Northeast Asia is the top 1 trade lane since FY2012, in FY2016, the trade lane from Northeast Asia loaded 1,000,446 TEU. In Northeast Asia, the most influential countries are China, Asia and Korea. Northeast Asia occupies 60% of total trade lanes for imports via Savannah port. In FY 2016, retail consumer goods is the top import

commodity group via Savannah. Total container trade of Savannah trade reduced 1.6% in FY2016. Due to labor issues in West Coast in FY2015, some cargo were diverted to port of Savannah. Container liners started to arrange trade lanes to USEC, Cargo owners started to consider logistics distribution center and improvement of supply chain. In FY2015, import of total container trade from port of Savannah had year on year growth of 20%.

Table 8 Five year history for top 10 trade lanes for imports via Savannah (Fiscal Year)

Trade Lane	2012	2013	2014	2015	2016	% Growth (5YR)
Northeast Asia	639,557	629,513	726,355	917,576	1,000,446	56%
Southeast Asia	110,069	118,677	115,082	164,033	184,798	68%
Southern Asia/Indian Subcontinent	65,054	66,404	88,402	110,661	133,048	105%
Mediterranean	92,200	97,264	107,153	110,398	128,149	39%
North Europe	73,085	69,724	77,843	93,768	118,715	62%
East Coast South America	18,760	22,288	22,494	21,865	24,088	28%
Middle East	14,899	16,200	15,463	16,765	20,624	38%
Eastern Europe	14,380	13,789	16,842	19,115	19,904	38%
West Coast South America	14,273	11,592	14,163	13,153	18,190	27%
Central America	16,960	14,855	15,725	11,854	12,189	-28%
Other*	25,607	19,018	17,199	17,004	16,514	-36%
Total	1,084,844	1,079,326	1,216,721	1,496,193	1,676,666	55%

*Source: Georgia Port Authority

4.2.1.1 Cargo flow from Asia to USEC via the Suez Canal

The Suez Canal was built and officially open to operation in 1869. It is a sea level waterway, located in Egypt, across Isthmus of Suez, connects the Mediterranean Sea and the Red Sea, and provides trade lanes from Europe to the Indian Ocean and West Atlantic. It is boundary between Asia and Africa. According to data from the Suez Canal Authority, ship draft was 66 feet in 2010 (see Table 9) around 17000 container ships transits through the Suez Canal. When ships from Singapore to New York, it can save 2373 miles, which is 19% of distance via the Suez Canal than via the Panama Canal.

Table 9 Characteristics of the Suez Canal

Item	Unit	1989	2001	2010	2015
Overall length	Km	164	191.8	193.30	193.30
ByPasses Length	Km	--	79	80.5	113.3
Width at 11m depth	m	--	195/215	205/225	205/225
Water depth max	m	8	22.5	24	24
Draft of ship	Feet	22	62	66	66
Cross Sectional Area	m ²	304	4350/4800	4800/2500	4800/5200
Max. Loaded ship	DWT	5000	210000	240000	240000

*Source from the Suez Canal Authority

From the set of container trade lanes via the Suez Canal to the United States, taking OOCL as example, according to Figure 9, they have India East Coast Express (IEX) trade lanes which origin is Mundra, Nhava Sheva and Karachi to destination USEC (Including New York, Norfolk, Charleston and Savannah) via the Suez Canal. Due to distance, trade lane from South East Asia or South China ports to USEC will usually choose via the Suez Canal. This trade lane includes 80 % import container cargo quantity. The trade lanes via the Panama Canal will not have influence on Indian subcontinent. So the Panama expansion will not have impact on cargo that from Indian subcontinent to USEC via the Suez Canal. But it might have some impact on cargo that from south China ports and South East Asia. As for cargo USEC that imports from Asia, due to development of container ships' cascading, recently there are mis-match between ship size and delivered capacity. Running capacity of trade lanes has been managed by redeployment of current ships with new ships have already joined liner. With delivery of very large container

vessels, although the volume on main lane trades has grown, cascading may still lead to some small container ships be redeployed. It is quite challenging to look for new redeployment opportunities for those ships. Major transfer for deployment occurred after the opening of Panama Canal new locks. At the beginning of second quarter of 2017, around 40 old Panamaxs were not deployed on trade lane from Asia to USEC via the Panama Canal, and there were around 150 old Panamaxs from the beginning of June, 2016, in total, around 60 Panamaxs remained idle. The expanded Panama Canal new locks enabled 90 container ships in 8000 to 14000 TEU at the beginning of 2017 on trade lane from Asia to USEC via the Panama Canal, additionally, 14 container ships in 6,000 to 8,000 TEU.

Figure 9 India East Coast Express (IEX)



*Source: official website of OOCL

4.2.1.2 Cargo flow from Asia to USWC

Due to intensive railways and highway network, favorable freight system, the multi-modal of containers in the United States are developing steadily and effectively. Containers discharged at port of Los Angeles can be transported to Chicago via railway in 5 days, to New York in 7 days. From United States Maritime Administration, imports of port of Los Angeles and port of

Long Beach always occupy 40% of total. Despite of the high cargo quantity to the West Coast of United States (USWC), 87% of cargo discharged at port of Los Angeles are kept at California, only 1.5% of cargo were shipped to USEC. Cargo discharged at USEC were kept at USEC, mainly at New York and New Jersey.

Table 10 Cargo flow of USEC and USWC

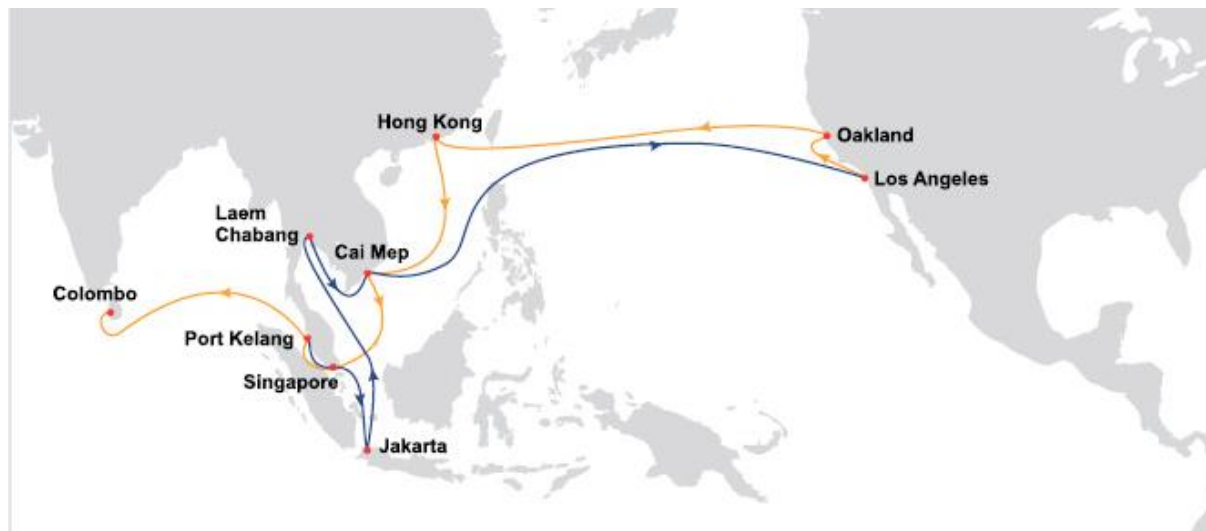
Inflow	Outflow	Los Angeles/ Long	New York/ New
		Beach	Jersey
Main States in USWC	Washington	0.78%	0.23%
	Oregon	0.76%	0.03%
	California	87.52%	0.59%
	Arizona	2.02%	0.07%
	Nevada	1.99%	0.04%
	Utah	0.58%	0.04%
	Total	93.65%	1.00%
Main States in USEC	Virginia	0.16%	1.04%
	North Carolina	0.16%	0.56%
	Georgia	0.22%	0.15%
	Florida	0.31%	1.05%
	New York	0.32%	1.05%
	New Jersey	0.30%	39.94%
	Total	1.47%	81.10%

*Source: Commodity Flow Survey from U.S. Bureau of Transportation Statistics

As for from imports at USWC to central areas such as Chicago, Dallas and Memphis, on the one hand, time using multimodal transported to central areas is shorter than transported to USEC via waterway, and low cost on rail way makes sea transportation lose its cost advantage. On the other hand, because cargo that central area of United States are mainly high value electronic products with high time cost, therefore 90% of imports to Chicago and other central cities are transported from West Coast ports. The Panama expansion will only has impact on

transportation of some low-valued containers.

Figure 10 South East Asia Pendulum (SEAP)



*Source: official website of OOCL

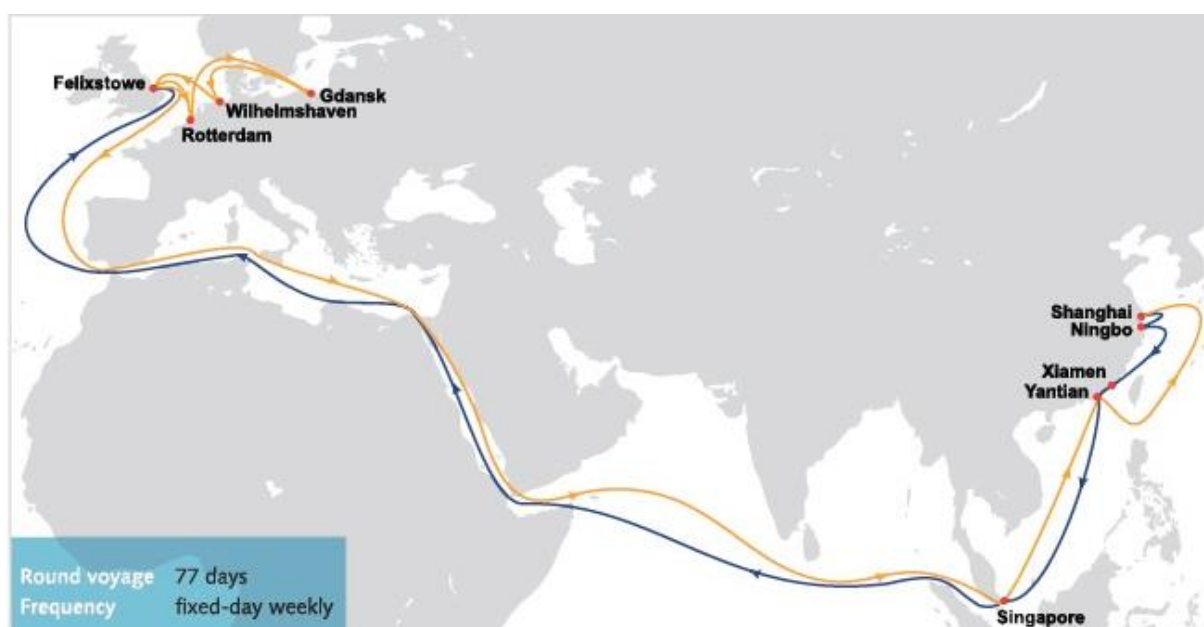
4.2.1.3 Cargo flow from Asia to Europe

Due to weakness of Euros, most European countries' economy increase slightly, and under sanctions to Russia, with sharp rise of capacity, trade lanes from Asia to Europe were struggling from the whole year of 2015 and 2016. Cargo encountered negative growth in most time of 2016. To tackle with this hard situation, liners started to integrate trade lanes to lower loss, which slowly improved depressing rates under the circumstance of continuous deliveries of large, new vessels. Freight rate generally recovered from the new lowest record in history, cargo quantity improved, and carrying rate of most trade lanes rose steadily. In fourth quarter of 2016, economy of European countries developed soundly, which lead to freight rates back to normal level.

As statistics from European Union (EU in the following), in 2016, value of exports from 27 countries in European Union was 1941.86 billion US dollars, had a year on year decrease of

2.1%. Import value was 1893.7 billion US dollars, decreased 1.5%. The trade deficit was 48.16 billion US dollars, decreases 34%. The value of European Union exports to the United States was 397488 million US dollars, occupies 20.5% of total export, which is the top one among EU's main trade partners. China is the second biggest, occupies 9.6% of total export. EU's main export products were nuclear reactor, boiler, and mechanical appliance were top one export products.

Figure 11 Asia-North Europe Loop1



*Source: official website of OOCL

4.2.1.4 Cargo flow from Asia to USEC via the Panama Canal

According to Georgia Ports Authority, in FY2016, retail consumer goods was the top 1 import commodity group via Savannah, occupied 15% among 10 top commodity groups. (Table 11) It grew most among commodity groups from FY2015 to FY 2016, increased around 35,041 TEU, about 87% in 5 years' time from 2012 to 2016. The top 2 commodity group was machinery, appliances and electronics, which increased about 69% in from 2012 to 2016. This commodity

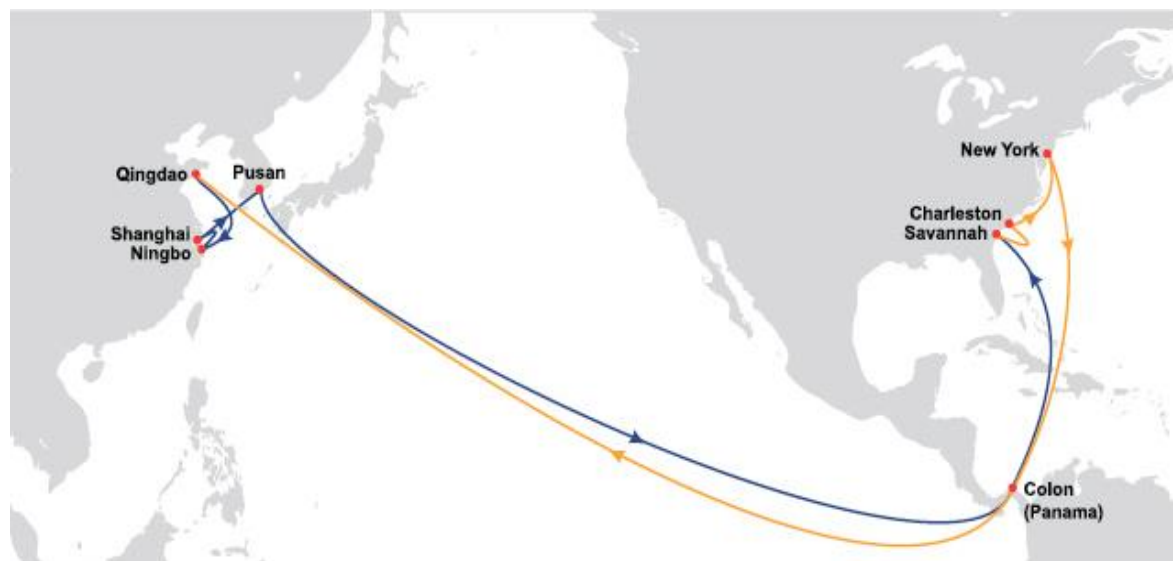
group is also the top 1 China's export to the United States. As per Table 8, five-year history for top 10 trade lanes for imports via Savannah (Fiscal Year) was origin North East Asia. From North East Asia to USEC, the fastest and efficient way is transiting via the Panama Canal. As per OOCL's trade route East Coast China 2, from Pusan, Korea to Savannah, via the Panama Canal, it takes 23 days to transit. And from FY 2015 to FY2016, top 1 import commodity group retail consumer goods increased 35,041 TEU, which is larger than the amount increased from FY 2014 to FY2015, which was 28,620 TEU. With the update of port facilities as well as the efficient Panama Canal expansion, it can be estimated that cargo from Asia to USEC via the Panama Canal would show an upward trend in the future.

Table 11 Five Year History for Top 10 Commodity Groups for Imports via Savannah (Fiscal Year)

Commodity Grouping	2012	2013	2014	2015	2016	% Growth (5YR)
Retail Consumer Goods	132,244	122,590	183,068	211,688	246,729	87%
Machinery, Appliances & Electronics	121,482	121,398	143,459	180,192	205,833	69%
Furniture	143,412	153,535	148,712	179,556	196,123	37%
Automotive	96,576	109,617	123,864	153,623	179,909	86%
Hardware & Houseware	98,877	93,640	104,309	127,485	140,799	42%
Food	80,078	76,473	76,897	82,979	91,533	14%
Apparel	55,800	52,363	58,481	87,511	84,622	52%
Mineral	49,373	52,698	56,322	66,059	82,673	67%
Toys	49,666	37,603	39,540	56,978	57,829	16%
Chemical	36,436	37,628	40,149	45,431	51,299	41%
Other	220,900	221,781	241,920	304,690	339,316	54%
Total	1,084,844	1,079,326	1,216,721	1,496,193	1,676,666	55%

*Source: Georgia Ports Authority

Figure 12 East Coast China 2



*Source: official website of OOCL

4.2.2 Operational costs

It is always principal and mission for companies to maximize the benefits, but with floating shipping market, the only thing liners can do is to lower the operational cost. For liner companies, bunker costs and operation of vessel occupy most part of operational costs. Using OOCL as example, its operation costs including cargo handling cost, vessel cost, voyage cost, container cost, and empty container return cost were lower than that of 2015 due to saving on fuel cost. Cargo handling cost involves charge from container terminal, road transport cost, and commission etc., mainly paid by local currency. Although cargo quantity increased, the handling cost was quite the same level as 2015. Voyage cost includes bunker cost, port cost, canal toll insurance and cargo indemnity. In 2016, its vessel and voyage costs occupied 19% of total operational cost.

4.2.2.1 Vessel cost

Still using OOCL as example, their Vessel cost includes fleet operation cost, depreciation, rental cost from vessels and slots that were borrowed to maintain current service level. With operation of large vessel, capacity rose from 561,421 general purpose containers in 2015 to 574,318 general purpose containers in 2016. OOCL's own vessels reduced from 103 to 96. Their vessel costs (not including fuel cost) were saved in 2016 due to lowered charter fee.

Choosing the smallest and largest vessels that are deployed on trade lanes via the Suez Canal and the Panama Canal to compare. Suppose 70% of ship building price is loan, using 6.5% loan rate to calculate actual vessel cost via straight line depreciation, the fund cost is as follows:

Table 12 Comparison of vessel price and depreciation price on each trade lane

TEU		Trade lane	Vessel Price (million US dollars)	Depreciation of vessel (ten thousand US dollars/day)
5000		Shanghai-New York (the Suez Canal)	53	1.170
9600		Shanghai-New York (the Suez Canal)	95	1.342
4000		Shanghai-New York (the Panama Canal)	47	1.145
5100		Shanghai-New York (the Panama Canal)	56	1.185
After Expansion	8000	Shanghai-New York (the Panama Canal)	80	1.281
	10000	Shanghai-New York (the Panama Canal)	95	1.342
	13200	Shanghai-New York (the Panama Canal)	116	1.429

	Panama Canal)		
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* Source: Clarkson, Alphaliner

4.2.2.2 Cost from Canal

To enable customer to have maintained safe, reliable and efficient service for customers, the approved toll adjustment was effective after operation of new Panama Canal. (See table 4.9) Compared with 2011, before the adjustment, the tariff for TTA maximum capacity of the Panamax vessel was 74 US dollars per TEU, and tariff for loaded containers on board was 8 US dollars per TEU.

Table 13 Tariff for 2016

Locks	TEU Range	Tariff for TTA maximum capacity	Tariff for Loaded containers on board (TEU)
Panamax 1/	< 1,000	\$60	\$30
	>=1,000 < 2,000	\$60	\$30
	>=2,000 < 3,500	\$60	\$30
	>=3500	\$60	\$30
Neopanamax 2/	<6,000	\$60	\$40
	>=6,000 < 7,000	\$50	\$40
	>=7,000 < 8,000	\$50	\$40
	>=8,000 < 9,000	\$50	\$40
	>=9,000 < 10,000	\$50	\$35
	>=9,000 < 10,000	\$50	\$35
	>=10,000 < 11,000	\$50	\$35
	>=11,000 < 12,000	\$50	\$35
	>=12,000	\$50	\$35

* Source: Official website of the Panama Canal

The Panama Canal Authority launched loyalty program to offer discount on tariff for customers who's accumulated TEU in 12 consecutive months reach to certain amount.

The total length for the Suez Canal was 118 meters. Due to no big floating on its sea level, it does not need to adjust draft for vessels, and even canal locks. Its ship draft reached to 66 feet in 2010, this stage, the Suez Canal can take all container vessels. In 2015, the ship draft remained 66 feet. It is estimated that after reaching 72 feet in the future, the Suez Canal will be able to take all container vessels.

Table 14 Comparison of toll on Shanghai to New York via the Suez Canal and the Panama Canal

TEU		Trade lane	Toll (ten thousand US dollars/time)
5000		Shanghai-New York (the Suez Canal)	26
9600		Shanghai-New York (the Suez Canal)	35
4000		Shanghai-New York (the Panama Canal)	33.6
5100		Shanghai-New York (the Panama Canal)	42.8
After the Panama Canal expansion	8000	Shanghai-New York (the Panama Canal)	65.6
	10000	Shanghai-New York (the Panama Canal)	78
	13200	Shanghai-New York (the Panama Canal)	102.9

* Source: the Suez Canal Authority, Clarkson

4.2.2.3 Bunker cost

Bunker cost is a part of voyage cost, Fuel price decreased from average 311 US dollars per

ton in 2015 to 216 US dollars per ton in 2016, so the fuel cost decreased 28% compared with 2015. Although the toll to transit via the Suez Canal is lower than toll transits via the Panama Canal, because of trade lane distance, transits through the Suez Canal to USEC takes 5 more days in average than trade lane via the Panama Canal. Generally speaking, navigation speed of container vessels is relatively faster, therefore fuel consumption occupies not small percentage of operational costs. According to annual report of OOCL, fuel cost occupied 9% of total operational costs in 2016. According to table 4.11, it can be concluded that larger vessel with slower speed can save fuel consumption

Table 15 Comparison of main parameters on deployment on Shanghai/New York

TEU	Trade lane		Transit time	Vessel parameters	
				Speed (Knot)	Fuel consumption (Ton/day)
5000	Shanghai-New York (the Suez Canal)		34	24.7	193
9600	Shanghai-New York (the Suez Canal)		34	24.6	246.1
4000	Shanghai-New York (the Panama Canal)		31	24.1	145
5100	Shanghai-New York (the Panama Canal)		27	25	166.5
After expansion	8000	Shanghai-New York (the Panama Canal)	27	24.6	243.1
	10000	Shanghai-New York (the Panama Canal)	27	24.6	246.1
	13200	Shanghai-New York (the Panama Canal)	30	21	217.3

*Source: Clarkson, Alphaliner

4.3 Impact on USEC ports

In order to gain effect of scale economy, it is key to maintain large container vessels' stowage rate exceeds small vessels. Otherwise, not only long port time but lack of stowage will increase the operational costs of single container. Due to high building price, heavy competitive cost, facing up with depression of the shipping market, liner companies that have large vessels are all striving for alliance with other liners, through improving trade routes, slots exchange and sharing. Therefore, when arranging call ports, ports have to take slot exchange and sharing demands from liners into consideration.

As annual report of Georgia Ports Authority (GPA in the following), port of Savannah which located in the southeast of the country. It is the fastest growing container port in the United States. It is also the fourth busiest container port in the United States. In FY 2016, the Georgia Port Authority 3.6 million TEU container units.

In the past 2016, Jimmy DeLoach Parkway Connector was opened to provide a straight link for Savannah port and interstates 95 and 16. The improvement of intermodal rail hub is under development in North Georgia, which would connect north and west logistically. MOL Benefactor at capacity of 10100 TEU is the very first vessel to call on port of Savannah through expanded Panama Canal's new locks, which is also one of the largest ships call on Savannah. To pair with the Panama Canal expansion, terminal improvements will be made for intermodal service to provide efficient gateway to Midwest. 4 new cranes will arrive in 2017, and another 4 will arrive in 2018. GPA states that they have taken a step forward on Savannah harbor

expansion project. Dredges are deepened outer harbor to 49 feet. It is crucial for the port of Savannah to complete this project, due to Panama Canal expansion, the expansion has increased over 10000 TEU vessels to port of Savannah. The harbor expansion project is estimated to be completed in 2020. With the improvement of facilities, harbor deepening, largest container handlers, Georgia Port Authority will enable larger ships, more cargo to transit. It conducted that this harbor expansion project can decrease net shipping cost by 174 million US dollars. In addition, the expanded container space can provide for over 14770 TEU containers. According to table 4.12, except port of Baltimore, Houston have currently have no plan on expansion, other main USEC ports have plans on expanding channel depth to meet current situation of maximization of vessels and its cascading.

Table 16 Comparison of water level among main ports of USEC (Feet)

Ports	Average low water level	Planned channel depth
New York/ New Jersey	13.7-15.2	15.2
Savannah	12.8	>=14.3
Charleston	13.7	>14.3
Baltimore	15.2	No plan
Boston	12.2	14.6-15.2
Miami	12.8	15.2
New Orleans	14.3	15.2
Houston	13.7	No plan

*Source: official websites of above USEC ports

In addition, limitations on clearance height will also interfere passing of the vessels. Around 40% of container vessels call on port of New Jersey, but to call on port of New Jersey, vessels must pass through Bayonne Bridge, which clearance height is 46 meters, cannot adapt to container vessels at the capacity of 12,000 TEU.

4.4 Impact on container liners' strategy

While opening of Panama Canal new locks, the 'old Panamax' size remains as high surplus capacity, the demand of larger size vessels has increased to some extent. The operation of new locks enables redeployment of container vessels. Larger vessels 'Neo-Panamax' which are about 13,500 TEU can be expected to be deployed on trade lane from Asia to USEC. Some USEC ports have completed their expansion or the expansion is undergoing to meet demand from maximization of container vessels. But due to limited cargo diversion from USWC to USEC, opportunities for deployment of those 'old Panamax' are not ideal, so scrapping of old Panamax may still be a choice for container liners.

What's more, enable to acquire scale economy, merger and acquisitions are current trend and choice for container liners to lower their cost, enhance their competitiveness, expand service loop, and redeploy their oversupplied capacity.

Table 17 Current container liners' alliances

Alliances	Liners	Total capacity(TEU)
2M Alliance (2014)	1. Maersk Line (Hamburg Süd) 2. MSC	6,495,319
THE Alliance (2016)	1. Hapag-Lloyd (United Arab Shipping Company) 2. MOL 3. NYK Line	3,571,921

	<ol style="list-style-type: none"> 4. Yang Ming Line 5. Kawasaki Kisen Kaisha, Ltd. ('K' Line) 	
Ocean Alliance (2016)	<ol style="list-style-type: none"> 1. COSCO Shipping 2. CMA CGM (APL Limited) 3. Evergreen 4. OOCL 	5,819,991

*Source: The North West Seaport Alliance, Alphaliner

In 2016, liner shipping industry encountered tremendous change, the world 8th largest container liner Hanjin collapsed financially. Hapag-Lloyd completed its acquisition of UASC, and Maersk Line's acquisition of Hamburg Süd. And 3 major Japanese shipping lines, NYK, MOL and K Line intended to merge into a joint venture. (Clarkson, 2017) This year, COSCO Shipping and Shanghai International Port (Group) Co Ltd. (SIPG) have launched a voluntary general offer to acquire all of the issued shares of Orient Overseas (International) OOIL. At the beginning of second quarter of 2017, top 10 liners' deployment of container ship capacity will rise up to 80 % after above acquisitions or merger.

In 2016, Maersk Line adjusted their trade lane TP12 and upgraded it to a unique, extensive trade route, enable to shorten transit time from Asia to USEC. Through Asia to USEC, TP12 passes through expanded Panama Canal, and calls at USEC ports, such as Newark, Norfolk and Baltimore. As for the voyage back to Asia, TP 12 will passes through the Suez Canal, calls at Salalah, Colombo and Singapore. This trade lane makes Maersk offer better service for both customers from Asia and USEC. This trade lane passes through the Panama Canal can save transit time from Asia to USA, and short voyage distance can help them reduce emission of

CO2 and discharge gas. Maersk Line's TP11 and TP 8 were combined to form Pendulum line. Its capacity on network of Asia to USEC remained unchanged, Maersk deployed 11 container ships at capacity of 8500 TEU, and deployed 17 container ships at capacity of 8500 TEU on newly combined TP11 and TP8.

Chapter 5 Recommendation

After the expansion of the Panama Canal, container ships at capacity of 8000 TEU not only have advantage on single container cost, but also lower cost for single container cost per day on average when transit through the Panama Canal. (Zeng, 2016) So for container liners, they can deploy container vessels around 8000 TEU on trade line Asia to USEC via the Panama Canal to save costs and obtain scale economy. Liners can also take advantage of alliance to mitigate risk from oversupply to some extent, deploy container vessels at capacity of 4,000 TEU to 5,000 TEU on intra- Asia lanes. Due to improved efficiency after the Panama Canal expansion, with steady recovery of European countries' economy, trade lane from Europe to West Coast of United States can be developed.

For USEC ports, due to the Panama Expansion and maximization of container vessels, vessels' safety level of berthing are enhanced, hull of vessels become larger, wider with deeper draft. But water depth and boundaries are limited, operations of ports have scale boundaries, berth occupancy of two large vessels might be lower than three relatively small vessels. Although main ports can basically satisfy call from ultra large vessels, it might be difficult to meet demand of full load. Therefore, ports should enhance strategic corporation on hub planning, transit link, vessel design with alliances, in order to match scale economy with each other to achieve efficiency and benefits. To pair with maximization of vessels, improving automatic level is not enough, it's better to speed up operation and competitive mode to restructure balance between ports. The congestion of ports in West Coast of the United States mainly due to maximization of vessels brings high frequency of berth and discharge during the

peak season. Operations of chassis are operated in state of disorder. With the Panama Canal expansion and transfer of some logistics distribution centers, number of vessels call on ports of USEC generally increase, those ports will face up with the same problems as the West Coast. Therefore, China's container liner shipping companies should coordinate with ports for inland transportation and facilities. As for discharge at the ports, to decrease the waiting time during peak season, Container liner shipping companies in China should also coordinate with ports of New York/New Jersey, Savannah and Charleston and other base ports to acquire sufficient and efficient information of berth, yard. As for facilities, to avoid same disorder problem in the West Coast, container liner shipping companies in China should allocate and expand their own chassis supply by enhancing corporation with chassis fleet from other ports.

Chapter 6 Conclusion

In this dissertation, chapter 1 introduce the background, purpose, methodology and literature review. In Chapter 2, the Panama Canal is briefly introduced by ways of transit, main cargo type, vessel type, service of the Canal and its competitors. And general economy background is also analyzed. Then in Chapter 3, current container liner shipping industry is analyzed though analysis of current capacity, new orders and demolition. Chapter 4 analyzed impact of the Panama Canal expansion on container liner industry by container capacity, source of cargo, cargo flow, and operational costs on specific trade lanes. Chapter 5 offers certain recommendations to container liners companies and USEC ports.

Under the background of container ships' maximization, fierce competition among liner shipping companies, with the opening of Panama Canal new locks, orders for large container ships would show an upward trend. In 2016, due to oversupply, there were lots of 'old Panamax' scrapped or transferred to non-main lanes. Although some liner company indicated that their the westbound lifting of the Asia to North America West Coast service and the Asia to US East Coast service via the Panama Canal increased but revenue showed a decrease, mainly due to a decline in freight rates. Moreover, toll of entering the Panama Canal is increasing year by year, especially from 2005 to 2011, the toll was doubled. Because of this reason, Maersk and some Japanese liners changed the ex-Asia to east coast line to pass through the Suez Canal instead of the Panama Canal. So although there are some positive aspects of the expansion, there is no historically change due to global economy and unbalance between supply and demand.

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