8-22-2015

The impact of Panama Canal expansion on the U.S. gateway ports' attractiveness to the discretionary cargo shippers

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The Impact of Panama Canal Expansion on the U.S. Gateway Ports' attractiveness to the Discretionary Cargo Shippers

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

MASTER OF SCIENCE

In

(International Transport & Logistics)

2015

Declaration

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

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

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Date: 3 July, 2015

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Acknowledgement

I would like to express my sincere thanks to Associate Prof. GuWeihong, my supervisor, for her valuable advice and support. I also want to thank my family and my friends for their support and recommendations.

Abstract

Title of research paper: **The Impact of Panama Canal expansion on the U.S. Gateway Ports' attractiveness to the Discretionary Cargo Shippers**

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

Currently, more of the containerized imports from Far East to the US inland market are handled by the U.S. west coast ports mainly compared to the U.S. East Coast ports mainly due to the better overall performance achieved in the intermodal shipment by virtue of the deployment of post-Panamax containerships, state-of-the-art infrastructure at major west coast ports together with the liner and rail service surrounding these ports. While with the completion of the Panama Canal expansion in the early 2016, there is a wide speculation as to if there will be a paradigm shift in routing options for these discretionary containerized imports and where will most of these containerized imports likely to enter the U.S. in the new normal.

In this study, the port choice analysis using the Multinomial Logistic Regression (MLR) is conducted to look into the various potential predict variables which could help to find out which factors are of great concerns to shippers in their routing decisions through which a port of entry is chosen. Then, the potential changes in some of factors due to the expansion of Panama Canal are taken into account for the MLR model to further evaluate the potential impact of Panama Canal expansion on the port choice by shippers. Finally, some of evaluation and conclusion of this study is presented.

Keywords: Port Choice, Shippers, Panama Canal Expansion, Economies of Scale, Discretionary Cargo, Cargo diversion, Multinomial Logistic Regression

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List of Abbreviations

PCA	Panama Canal Authority
BCO	Beneficial Cargo Owner
BEA	Business Economic Area
IIA	Irrelevant Independent Alternative
LA	Port of Los Angeles
LB	Port of Long Beach
MLR	.Multinomial Logistic Regression
NK	Port of Norfolk
NY/NJ	Port of New York/New Jersey
OA	Port of Oakland
PCUMS	Panama Canal Universal Measurement System
PMA	.Pacific Maritime Association
POE	Port of Entry
SAV	Port of Savannah
SPSS	.Software Package used for Statistical Analysis
TA	Port of Tacoma
TEU	Twenty-foot Equivalent Unit
TSA	Transpacific Stabilization Agreement
USEC	United States East Coast
USWC	United States West Coast
WIL	Port of Wilmington

Chapter1: Introduction

The Panama Canal, with its unique location at the narrowest point of Isthmus of Panama between the Atlantic and Pacific oceans, has had a far-reaching effect on world economic and commercial developments throughout most of this century. Since the Panama Canal first opened in 1914, it has been a significant piece in the global trade network which has served over one million vessel transits around the world – as of 2014, it is serving more than 144 maritime trade routes connecting 160 countries and reaching about 1,700 ports worldwide with an aggregate share of 5% of global seaborne trade[1]. Of its various market segments, the full container vessels segment is consistently the most important one which constituted 3.7% of total maritime trade volume transiting the Canal in terms of metric ton while contributing47.8% of the overall Canal toll revenues for fiscal year 2014.

In recent decades, the Panama Canal has come under pressure to cope with ever-increasing transit demands from various users which reversely hamper the further expansion of its business with its existing set of Panamax Locks and relevant supporting facilities. As evidenced by the full container vessels segment, some major indicators reflecting its performance showed various extents of under-performance, with the total transits of containerships declining at the annual rate of 6.8% since 2012, the corresponding total TEU capacity of containerships also contracted to a lesser extent from12.2 million to 11.6 million TEU capacity due to the steady increase in the average container vessel size from 3,659TEUs in fiscal year 2012 to 4,004 TEUs in the fiscal year 2014.

[1] According to the latest statistics by Annual Report of PCA, 2014

To retain its position as the critical element of the global transportation network, the Panama Canal expansion project which initiated in 2007 is currently under final construction with the aim of doubling the Canal's maximum cargo-carrying capacity in terms of PCUMS Tons[2] to allow the transit of larger vessels that are currently restricted by the dimensions of the existing Canal locks and to maximize the Canal's total possible volume of cargo and other traffic.

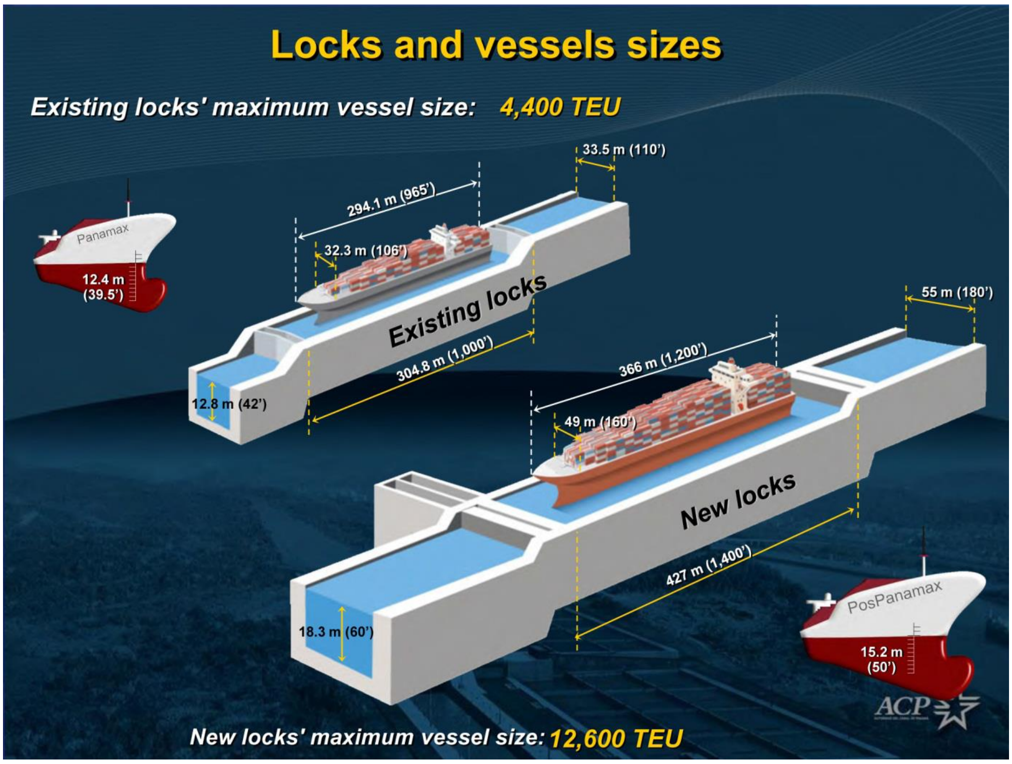
To be more detail, the expansion of the canal is composed of the following five main components:

1. Construction of a new set of Neo-Panamax Locks, one at the Atlantic (North) and another at the Pacific (South) ends of the Canal;
2. Deepening and widening the Canal entrances；
3. Excavation of a new north access channel for the Pacific Neo-Panamax Locks;
4. Elevation of Gatun Lake's maximum operation level;
5. Deepening and widening of the Gatun Lake and Culebra Cut navigational channels

As for the containerships, the maximum capacity of the vessel that could transit the Panama Canal will significantly increase from the current capacity of 4,400 TEUs to 12,600 TEU as shown in Figure 1.

[2] The abbreviation of "Panama Canal/Universal Measurement System", which is the basic unit measure of cargo volumes moving through the Panama Canal.

Figure 1. The Comparison of vessel sized and locks



Source: *Panama Canal Authority, Canal Expansion Program – Components Report, p. 6, April 2012.Available at: http://www.pancanal.com/eng/expansion/rpts/components/2012.pdf*

At the same time, the Panama Canal Authority will also introduce a whole new toll system to encourage the use of the much larger new locks for the transit of larger Post-Panamax vessel when the expansion is complete.

In view of the aforementioned latest update of the operation of the Panama Canal and its expansion, the majority of industry practitioners as well as academia researchers generally believe that the container shipping on several major trade lanes via the expanded Panama Canal will greatly benefit from the unprecedented economies of scale resulting from the deployment of much larger, more fuel-efficient Post-Panamax containerships which will significantly lower the unit operating costs for ocean carriers. Among the various trade lanes via the Panama Canal, the East

Coast of U.S. to Asia (All-Water Route) which accounts for nearly 37% of total traffic transiting the Canal is expected to gain more momentum in the competition against other major traditional routing options for the U.S. containerized imports from the Far East mainly due to the potential significant unit cost reduction for the long-haul ocean transportation.

Historically, the U.S. West Coast ports represented by the Port of Los Angeles and Port of Long Beach handled the majority of the U.S. Containerized imports from Asia either bound for the large local markets where the ports located or destined for the vast U.S. hinterland area through the advanced intermodal rail network. As a whole, the major West Coast gateway terminals are almost equipped with 50-feet berth depth as well as navigational channel, coupled with sufficient Post-Panamax or Super-Post-Panamax quay cranes at berths and average container storage space of 100 to 400 acres in size, all of these terminal infrastructures combined with the developed intermodal transportation have enabled ports to accommodate the growing amount of the cargo on board the prevailing mega Post-Panamax containerships especially from the Far East in a cost-effective and reliable manner.

While in the recent few years, due to the issues such as shortage of chassis, lack of rail capacity as well as ever-worsening port congestion resulting from the growing demands for containerized imports from U.S. consumers, west coast ports' position as the leading gateway for the U.S imports is somewhat eroded. An observable amount of cargos are gradually being diverted to the U.S East Coast ports as well as ports in Mexico and Canada by shippers to mitigate mounting uncertainties incurred on the west coast intermodal routes. As the consequence, the U.S. East Coast ports have gradually closed the gap with its West coast counterparts in terms of their respective share of U.S. containerized imports. In 2014, East Coast and Gulf Coast ports combined represented 46% of the total container volumes from Asia to the U.S. while that figure stood at around 35% the year before[3].

Considering that the overall performance of major U.S East Coast gateways is still to various extent not competitive with their west coast counterparts in terms of harbor depths, the scale of high-performance terminal infrastructure and connectivity with the surface transportation network, the higher-than-expected performance achieved by the East Coast ports is generally viewed as the result of temporary cargo diversion from the West Coast ports to avoid the severe backlog of both cargos and containerships caused by the unsettled labor contract dispute between ILWU and PMA which represent interests of the employees and employers of ports respectively.

It remains to be seen whether the staying power of the cargo diversion from the West Coast to the East Coast will continue even after the backlog of cargos and vessels are cleared up in the West Coast. For the time being, nearly all the major U.S. East Coast ports are scrambling to deepen their respective harbors and upgrade their respective terminal infrastructure in anticipation of better accommodating greater amount of cargos and post-Panamax containerships that could transit the Expanded Panama Canal in the early 2016.

When it comes to the major trade lane serving the US containerized import from the Far East, there are currently altogether three alternative routes at the discretion of the shippers: The intermodal routes moving through the U.S west coast gateways are still preferred by most shippers although their growth rate of market share is gradually overtaken by their East Coast competitors; All-water route via Panama Canal is

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[3] "US West Coast ports dominate despite Congestion Woes", US Port, JOC.com, available at http://www.joc.com/port-news/us-ports/port-los-angeles/us-west-coast-ports-dominate-despite-congestion-woes-report-finds 20150506.html

viewed as more cost-effective and reliable routing option for cargo bound for the East Coast while it further development is strictly restrained by the size limit of the existing Panamax locks as well as by the overall capacity of various East coast ports; the All-water route via the Suez Canal is currently gaining growing popularity among some top ocean carriers as an alternative to All-water route via the Panama Canal due to the greater economies of scale inherent in the deployed post-Panamax containerships.

It is generally believed that there are likely to be paradigm shift in the routing options for the U.S. containerized imports from Asia, especially for those cargos which bound for the inland part of the U.S. (hereinafter called "Discretionary Cargo[4]") after the Panama Canal expansion is completed. The Panama Canal administrator Jorge Quijano said that it is very likely that the Panama Canal will benefit from a permanent shift of some cargos to the alternative gateways up and down the east coast. In addition, a survey conducted by Maersk Line also revealed the similar feedback from its customers that "a substantial portion of the discretionary cargos will be diverted to East and Gulf coast ports simply because shippers need more than one gateway for their shipments so that their potential bets will be hedged." A study commissioned by PMA also estimated that the price levels on the all-water Panama Canal route for Asia cargo bound for Chicago will significantly drop 12-14 percent from $3,200 to $2,800 per 40-foot container in the three to seven years following the expansion of the canal.

While at the same time, other arguments tend to dim the prospects of the cargo diversion from the West coast ports. Some experts contend that most of the high-valued commodity will be invariably moving through the west coast gateway

[4] Discretionary Cargo refers to those containerized imports bounded for the destination which is far away from the location where the port of entry is located.

since the inventory-in-transit involved in the shipment is much lower compared to the time-consuming all-water route. Others are of the opinion that if only the west coast ports' terminal operators could manage their operation without any man-made disruption, the west coast intermodal routes is the most reliable route as it was for shippers since the capability of the expanded Panama Canal as well as the upgraded East Coast ports to handle increased containerized imports and mega containerships in a timely and reliable way will be a great challenge to meet.

Despite the above various opinions on the potential effect of the Panama Canal expansion on the shifting trade flow within the U.S., the competition among various gateways on both seaboards for the discretionary cargos will mostly likely to intensify as shippers intend to get the most out of the expanded Panama Canal to diversify their routing options for their shipments in case of any uncontrolled disruption as exemplified by the lingering port congestion in the west coast. In that sense, the ability to preciously understand the interaction of a wide variety of factors valued by shippers involved in the port choice for their individual shipment will be the key to the success in retaining their current market share as well as attracting new business in the era of the expanded Panama Canal.

The paper will be organized as follows: Chapter 2 will have an overview literature view on the topic of port choice from the perspective of Shipper or Carriers; Chapter 3 will introduce and present various sources of data for the further analysis; Chapter 4 will introduce the intended Analysis Model, fit the compiled data to the model to find out the most pronounced factors behind the port choice by the shipper and then the modified data on the relevant factors will be input into the dataset to predict if the possibility of the each US east coast ports being chosen as port of entry for the Asia origin shipments will improve after the completion of the Panama Canal Expansion.

Chapter 5 will draw the conclusion from this study and give some recommendation on the further research.

Chapter 2: Literature View

2.1 Rationale behind Port Choice

The container shipping industry is generally viewed as a derived demand of cargo owners for international merchandise trade. With the introduction of the Ocean Shipping Act of 1998, the ocean freight rates were no longer fixed between the given port-pair among various shipping companies, but rather the rates were negotiated individually by the shippers and ocean Carriers and kept confidential as the business secret.

Many studies have been conducted to look into the reasons why BCO[5] tends to choose a particular port over the other available options for their shipment options.

Of which, some studies agree that attributes not under the control of port management are more important than attributes under port management control in the port selection process as exemplified by Malchow and Kanafani, 2004 and Anderson et al., 2009.

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[5]Abbreviation of "Beneficial Cargo Owner", which is used interchangeably with "shipper" and "cargo Owners" in this study.

However, there is a common major deficiency in many of these studies in that their models did not include many of the port characteristic and service options that are, indeed, under the direct control of port managers. Instead, these studies simply assumed that the factors under the control of port management were less of a factor in the port choice process and did not need to be included in the model, which is evident by the study conducted by Anderson et al., (2009) who suggested that since the major container ports are all modern and large, productivity across them would not vary that enough to influence the port choice decision.

In addition, some other studies concluded that the impact of the level of freight rates on the ports choice was just too little to be taken into account.

Malchow and Kanafani (2001, 2004) acknowledged the omission of transportation price (cost) in their port choice study, but stated that this omission was without consequence since price (cost) variability across sea ports was quite minimal.

As a whole, all of the above assumptions that these variables have less importance compared to the other factors in a port choice model have not been empirically investigated in a rigorous manner.

While other studies tended to include as much influential factors into their model as possible. There are quite a few studies viewing port choice from the perspective of the ocean carrier as the principal decision maker.

In some cases, these studies model the process as the shippers choosing a port dependent on their chosen ocean carriers calling at that port; in other studies, the process is viewed as the ocean carrier deciding to call at a particular port.

The study commissioned by Malchow and Kanafani,(2001, 2004); Fleming and

Hayuth, (1994); Lirn et al., 2004); Song and Yeo, (2004)assuming the critical role of the ocean carrier in the sea port selection have found that distance, both oceanic and inland, are important factors affecting the choice of certain ports.

First, some studies contend that the shippers select an ocean carrier and turnover the route and sea port choice decisions to that ocean carrier. In accordance with this viewpoint, the shippers do not make the final decisions about individual sea ports as evidenced by the study conducted by Slack, 1985; Fleming and Hayuth, 1994; Malchow and Kanafani, 2001, 2004. As they argue it is especially the case of some big box retailers who prefer carriers' door-to-door delivery which can offer them on-time and cost-effective service regardless of any chosen ports of entry for their shipments.

On the contrary, multiple papers also focus a great deal on the role of the shippers in the process of port selection for their respective shipments. These studies regarded the shipper as making a sea port selection decision initially, followed by the selection of the ocean carrier based on the available ocean carriers serving the selected port. The conclusion of these studies is that the same set of factors influences the sea port selection regardless of who makes the choice. For instance, distance by Tiwari et al., 2003a,b; Anderson et al.,2009), transit time related to distance (Nir et al., 2003; Anderson et al., 2009), port congestion (Tiwari et al., 2003b), port efficiency, reliability, infrastructure (Guy and Bruno, 2006; Tongzon, 2009; Anderson et al., 2009), cost(Guy and Bruno,2006;Tongzon, 2009; Anderson et al., 2009), and port connectivity Tang et al., (2011)were found to be significantly related to the choice of a port. In addition, Tabernacle (1995) showed that crane productivity is very important measure of port performance and Baird (1996) suggested that faster ship turnaround time within the port contributes positively to port advancement. High crane productivity facilitates faster vessel operations at ports, speedier delivery, and lower total transit time. Therefore, crane productivity could benefit the shipper as well.

Tiwari et al.(2003a), Tongzon (2009)and Anderson et al. (2009)contended that the ultimate decision about the route, including the individual seaport, lies with the shippers including importers or exporter or their designated agents.

A few studies commissioned by Lirn et al., (2004); Tongzon and Sawant, (2007); Tongzon et al., (2008) in this field have also found that port infrastructure, port charges, port efficiency, berth availability and size are important attributes ocean carriers consider in deciding which ports to call.

2.2 Analytical Method

Regarding the major analytical methods applied to the port choice, the followings are generally recognized as the most useful ones.

The discrete choice model relies on the set of independent variable coefficients in equation one (the aggregate ocean freight rate model) to compute fitted ocean freight rate values for individual shipments. It is used in estimating the effects of these variables on the chances of selecting a port for a shipment and the alternatives available to shippers are the various ports they can choose from. To be specific, the conditional logistic (McFadden, 1974) model is better suited than the multinomial logistic since we are investigating alternative specific attributes instead of a case specific attribute effect on the choice of the alternative.

Veldman and Beckmann (2003) used a logistic model to explain the market share of the port's routings for each of the traffic zones or regions that comprise a port's potential hinterland. They quantified the routing choice and placed considerable importance on deriving a demand function to forecast port traffic and market shares for use in the economic and financial evaluation of container port projects. They consider logistic models are important tools for assessing container market shares in an overlapping market/network where a part of the network has to be singled out without loss of consistency.

Niret. al look at port choice behavior from the viewpoint of the shipper and apply multinomial logistic models to investigate the preferences "revealed" on a survey for alternative of ports in Taiwan. However where Veldman and Nir opt for stated preference analysis for calibrating their models, there are advantages to using revealed preference methods when there is an abundance of secondary data and to avoid the short-comings or biases of stated preference methods. A cross disciplinary investigation of competitive positioning by McNamara, Deephouse et al. (2003)infers that the development of firms, which is also be applicable to ports, is based on resources and their effects on competitive positions.

Tsung-Sheng Chang (2008) studied how to select best routes for shipments through the international intermodal network and formulated the international intermodal routing problem as a multi-objective multimodal multi-commodity flow problem.

Leachman (2008) describes an economic optimization model of waterborne containerized imports from Asia to the U.S. where imports are allocated to alternative ports and logistics channels so as to minimize total transportation and inventory costs for importers.

Imai et. Al on the other hand studied two typical service networks with different ship sizes: multi-port calling by conventional ship size and hub-and-spoke by mega-ship with a carrying capacity of more than 10,000 TEUs by investigating the service network design and container distribution.

Fan et. al factor the Panama Canal into their cost optimization model that integrates international and North America inland transport networks to ascertain optimal ship size, route, port, and interior shipping corridor and argues that these are highly reflective of observed shipments. The model developed by Fan determines least (ocean and rail) cost routings subject to constraints which when relaxed to incorporate the new Canal dimension and shows that diversion of larger vessels through the Canal is currently limited by the draft restrictions of East coast ports.

A recent study presented at TRB Annual meeting in Washington in January 2011 is relevant to this research. This model simulates changes in the flow of international containerized cargo, stemming from investments in ports and reduction in charges. The study uses a cost minimization strategy to factor the effects of scale economies in container shipping and the impact of the construction of deeper container berths on carrier shipping pattern decisions and compares the results to actual shipping patterns to investigate the paramount factors that influence the utility of discrete preference for a port by the carrier and subject to existing constraints, determine where that utility is highest.

To sum up, these aforementioned literatures were conducted to have a general view of the impact of various factors on the port choice. But to my best knowledge, there is not many study focus on impact of any change of factors on the port choice by shipper. In this sense, this paper will choose to adopt the multinomial logistic regression to the analysis of the port choice among U.S. BCOs for their shipments from Asia and try to find out the most critical factors which can best explain decision of the port choice by shippers. And any variation in the certain factors due to the expansion of the canal will be examined based on the model.

Chapter 3: Model Formulation

3.1 Preparation of Study

As previously stated, there are currently three alternatives for the containerized import shipment from Asia to the US. In the current context, each alternative has their own advantages over others in the different parts of the U.S. BEAs. For the intermodal route via the West Coast port, it historically handled nearly 50% of total U.S. containerized import. By 2013, the West Coast ports' share had fallen to 43.5%. Some industry practitioners take the view that although the intermodal route still enjoy the significant advantage in time savings and the marginal cost savings to the most parts of the U.S., the recent port congestion within the Southern California port range represented by the Port of Los Angeles and Long Beach, has gradually take their toll on the normal performance of these major gateways which in turn adversely impact the dominance of the Port of LA and LB for the majority of US containerized imports especially for the discretionary container cargos bounded to Midwest part of the country.

The all-water routing is gradually gaining increased popularity among the US east coast regions within which the major gateways up and down Atlantic Seaboard are located. Although the transit time from the major gateways from Asia to the US East Coast ports is much longer for the all-water route than for the intermodal route, the substantial unit cost saving gained by the use of much-larger post-Panamax vessel deployed on the All-water service via the Suez Canal has even be more competitive with the intermodal routes for the cargos destined to the major metropolitan areas in the east coastal regions. What is more, the All-water route via the Panama Canal is relatively less time-consuming compared to the All-water route via the Suez Canal to the most of Middle and South Atlantic gateways. The size of the containership that can pass through the current Panama Canal is restricted to less than 5,000 TEUs. As a result, the market share of the all-water service for the East coast is gradually decline from the historic high of 80% achieved five years ago to nearly below 50% as compared to the All-water route via the Suez Canal.

But when the newly-expanded Panama Canal is completed by the end of 2015, a huge amounts of post-Panamax containerships which has deployed on other major trade routes and greater amounts of cargo on board are allowed to transit the canal and therefore present the golden opportunity to the multiple major gateways in the east coast to better safeguard their respective market share for the local market, but also the promising heartland market where the large amount of discretionary cargos are up for grabs for ports on both coasts.

According to official announcement by TSA[6], more than 90% of total Asia-U.S. container traffic moves under 12-month service contract, which means the majority of BCOs in the U.S. conclude their service contracts with their preferred shipping

[6]Abbreviation of "Transpacific Stabilization Agreement", which is a research and discussion forum of major ocean container shipping lines that serve the transpacific trade in both directions between Asia and the U.S.

lines to fix the price and term of services usually ahead of the May 1st of each year. Usually these BCOs are mainly some big-box retailers and some other enterprises which have constant demand of imports from Asia. In the next chapter, the major factors determining the port choice by multiple BCOs for their respective container shipments will be analyzed to find out the relative importance among them.

With regard to the distribution of U.S. containerized imports, the State of Illinois ranks the highest among all the inland states in terms of trade volumes. For the time being, up to 65% of containerized imports bound for the Midwest are moving through the West Coast ports, while the East and Gulf Coast ports share the remaining share. The upcoming Panama Canal Expansion is generally viewed as the game change for the port choice involved in the routing options of discretionary cargos by shippers due to the projection that the USEC ports will have greater chance to grab portion of cargo from their west coast counterparts.

Given the aforementioned status quos as a whole, the U.S. containerized imports from Shanghai of China to the Chicago of the U.S. is selected as the most representative trade flow which is most likely to be influenced by the expansion of Panama Canal mainly due to the following reasons:

1. China is so far the largest source of U.S. imports from Asia, which accounts for more than 78% of total import from the Northeast Asia. Despite the tendency toward some shift in labor-intensified manufacturing industry from China to the much-cheaper South-East Asia regions[7], China is still expected to maintain its

[7] U.S. Containerized Ocean Trade with Asian Countries in 2014, Trade Data, Journal of Commerce, available at http://www.joc.com/international-trade-news/trade-data/us-containerized-ocean-trade-asian-countries_20150312.html

leading role in the manufacturing industry to better meet the surging demand of US consumers due to the ever-growing U.S. economy.

2. Shanghai, as the largest container gateway in China, is especially singled out as the Port of Loading in this study just for the simplicity purpose.

3. Chicago metropolitan area, as the one of the largest and most important US interior market, is most renowned for its superior surface network linking itself to the rest of the U.S..

4. As a practice, most of the long-haul inland shipment with a distance of over 800 miles is best suited to be delivered on rail other than on truck with the consideration of delivery reliability and cost effectiveness. As a matter of fact, all the major Class I railroad in the U.S. has various service network directly to the Chicago and some major East Coast railroads are striving to update their infrastructure to offer better access from the main gateways on the East seaboard to the Midwest, so the potential improvements for the East Coast railroad can be expected from the following years after the Canal expansion.

3.2 Source of Data

3.2.1 Individual Shipments information

The basic supporting information on individual shipment in this study is solely derived from the PIERS[8], the most comprehensive database of US waterborne trade in the world, from which about 317 records[9] of the individual container shipments of different shippers from Shanghai as the Port of Loading in China to Chicago as the destination of shipments during a period of month in July of 2014 are available through the spreadsheet generated by the system of website according to the specified requirements. The major information provided in each individual shipment consists of the following items:

a. The Name of ocean carrier for the shipments
b. Port of Loading
c. POE in the U.S.
d. TEUs of each shipment
e. The weight of the shipment
f. The approx. value of the shipment
g. The name of the commodity

This set of data will not be used directly as the input of the model analysis to be discussed in the next chapter. Rather, the name of ocean carrier for each shipment will further give information on the vessel-operating attributes of each carrier; the attributes of POEs through which each shipment moves can be obtained on the official website of each port authority; the TEU & Weight aspect of each shipment will be used as the input for the calculation of the U.S. rail freight cost for the inland delivery.

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[8]The abbreviation of "Port Import Export Reporting Service", which is a world renowned database for US waterborne trade with other countries in the world. " where the dataset of individual Shipment between two end point of trade flow can be attained

[9] These 317 records of container shipment is elaborately selected to include as many different shippers as possible during a typical peaking shipping season as exemplified by July in 2014

3.2.2 Overview of U.S. Seaports in the Dataset

Geographically, there are three major the port ranges situation located in different coast of the US. The West Coast port is mainly composed of the five gateway ports (Port of LA, Port of LB, Port of Oakland, Port of Tacoma and Port of Seattle) in Southern California, Northern California and Pacific Northwest which as a whole handles more than 60% of the US imports from Asia as of 2014[10]; East Coast Ports up and down the Atlantic seaboard is relatively small in port size and less competitive with their west coast counterparts in terms of their capacity to handle the prevalent post-Panamax vessels. As for the Transpacific eastbound trade lanes, up to 90% of total container shipments are moving either through the West Coast or East Coast ports, only the port of Houston rank among the Top 10 U.S. ports in 2013 as shown in Figure 2.

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[10] "3 Reasons Panama Canal Won't Divert Imports from West to East Ports." *Universal Cargo Management*, March 2013. Available form http://www.universalcargo.com/blog/bid/95228/3-Reasons -Panama- Canal- Expansion-Won-t-Divert-Imports-from-West-to-East-Coast

Figure 2. Top 10 U.S. Container Ports in 2013

Top 20 U.S. Ports in TEUs

Ranking	Ports	2013	2012
1	Los Angeles	5,668,068	5,943,509
2	Long Beach	4,964,524	4,363,954
3	New York – New Jersey	4,200,565	4,291,998
4	Georgia	2,365,597	2,289,561
5	Virginia	1,836,112	1,646,802
6	Oakland	1,615,013	1,544,772
7	Houston	1,582,055	1,516,654
8	Tacoma	1,305,513	1,091,738
9	South Carolina	1,294,235	1,216,510
10	Seattle	961,017	1,240,259
11	Jacksonville	750,023	743,733
12	Miami	715,853	720866
13	Port Everglades	696,357	660,579
14	Delaware River Ports	612,541	556,610
15	Baltimore	536,768	515,265
16	New Orleans	301,980	299,878
17	North Carolina Ports	220,371	203,027
18	Mobile	171,537	152,139
19	Gulfport	171,326	176,248
20	Boston	161,577	152,851
	Total Top U.S. Ports Total	30,131,032	29,326,944
	All U.S. Ports – Total	30,823,714	29,989,334

Source: Journal of Commerce PIERS – Port Import/Export Reporting Service

Source: Journal of Commerce PIERS – Port Import/Export Reporting Service

According to the 317 individual shipment records compiled from the PIERS, they almost moved through eight major container gateway ports to enter the U.S.. With some other USEC and Gulf coast ports such as Houston, Miami and Charleston respectively handled a relatively far less share of container shipments compared to the major eight port of entry, so they are intentionally omitted from the dataset of this study.

The detail distribution of shipments among the ports are shown in below Table 1,

Table1. Distribution of Shipments among major U.S. Gateways Ports

Ranking	Port of Entry	Shipments	Pct
1	Long Beach	75	23.7%
2	Los Angeles	63	19.9%
3	Tacoma	51	16.1%
4	New York	38	12.0%
5	Savannah	35	11.1%
6	Oakland	23	7.3%
7	Norfolk	18	5.7%
8	Wilmington	13	4.1%

Source: The data compiled from the container shipments of PIERS

It can be clearly seen from the table that the most of shipments were concentrated within west coast and east coast ports, with only a few exceptions belonged to the Gulf Coast, Canadian and Mexico gateways which are excluded from this study.

3.2.3. Container Terminal Attributes

As shown in the below Table 2, these in-depth information of individual port is collected from the official website of each port authority to which it belongs. The most of the U.S. seaport is composed of several container terminals which are either operated by the port authority itself or by the private owners. In addition, a couple of attributes within the same port, let alone the heterogeneity of attributes exist among the alternative ports.

Table2. Container Terminal Attributes of Major U.S. Gateway Ports

Port	Container Terminal	Berth Length	Berth	Water Depth	Number of Super Post-Pmax	Number of Post Pmax	Number of Pmax	On Dock Rail	Terminal Area
LA	West Basin 1	2500	2	53	8			Yes	136
	West Basin 2	2500	2	45		5		Yes	186
	Trans P	5400	4	45~53		10		No	185
	Yusen	5800	2	45		8		Yes	185
	Seaside	3200	2	45	8			Yes	205
	Eagle Marine	4000	3	45~50		16		Yes	292
	APM	5279	5	55	14			Yes	393
	CUT	1950	1	55	5			Yes	91
LB	TTI-Pier T	5000	5	55	14			Yes	385
	PCT-Pier J	5900	6	49~50	15			Yes	256
	ITS-Pier G	6379	4	42~52		6	11	Yes	258
	LBCT-Pier F	2750	3	50	2	5		Yes	102
	SSA7-Pier A	3600	4	50	10			Yes	200
SE	T-18	4440	4	50	1	6		Yes	196
	T-30	2700	2	50	3		3	No	65
	T-46	2300	2	50	3	2		No	88
TA	APM	2200	2	51	4	1		No	132
	Evergreen	2260	2	51	7			Yes	141
	Husky	2700	2	51	2	2		Yes	93
	Olympic	1100	1	51		4		Yes	54
	Washington	2000	2	51	2	4		Yes	47
OA	Maersk	3512	3	42		7		No	102
	TransBay	2172	2	50		4		No	66
	TraPac	2172	2	50		4		No	66
	Ben E. Nutter	3119	3	50		4		No	58
	Hanjin	2400	2	50		4		No	120
	Oakland Intl.	3600	3	50		6		No	151
	APL	2743	4	42		4		No	79
	Charles P.	1946	2	42		4		No	50
NK	Norfolk	7300	5	50	14			Yes	693
NY/NJ	NY Container	3012	3	45		9		Yes	187
	APM Terminal	6001	6	50	4	8	3	No	347
	Maher Terminal	10128	8	50	9	7		Yes	445
SAV	Garden City	9693	9	42	16	6	5	Yes	1200

Source: Based on Data from the Official Website of Major U.S. Gateway Ports

Apart from the attributes of port facilities included in the above table, the port productivity is also important comprehensive measure of operating efficiency of given port. According to the JOC Port Productivity, the Port of Los Angeles and Port of Long Beach has long dominated the ranking in terms of the total container moves per vessel per hour, while several major East Coast ports have gradually catch up with some of their west coast counterparts even though they are relatively less competitive with regard to their ability to accommodate the larger containerships in the current context, the average port productivity of each individual port terminal is shown in Table 3.

Table 3. Average Vessel Productivity of Major US Gateways

(Total Container Moves per Vessel per Hour)

Port of Entry	LA	LB	TA	OA	NK	NY/NJ	SAV	WIL
Vessel Productivity	80	70	68	63	62	65	64	60

Source: Port Productivity Report by JOC, 2014

As an increasingly number of larger containerships deployed to the market, the ability of container terminal to handle the vessel in the efficient manner will greatly reduce the potential increased time vessels stay in port, which in turn helps to ensure the economies of scale inherent in the larger vessel during the period of port operation.

Of all these attributes concerning the port terminal, several of these will be selected as the predict variables for the intended model, which will explain in detail in the next Chapter.

3.2.4 Vessel Operating Attribute

a. Vessel Size

During the past decades, the average size of the containerships deployed on the transpacific US West Coast trade lane has grown steadily from 4564 TEUs in 2003 to 7894 TEUs in 2013[11]. With the formation of four mega shipping alliance in the main East-West trade lanes, liner shipping companies is vigorously capitalize on the alliance operation to achieve improved economies of scale through better vessel utilization, wider port coverage and more frequent weekly services. More importantly, the competition among major shipping lines are not discounted as a result of the alliance operation, the fact is that the shipping lines belonging to the same alliance offer quite different service from their follow member liners. As for the shippers, this is no doubt the welcoming news since they will have more choice of service for their container shipments.

The detail information on the deployment of container vessels by various shipping lines on the transpacific trade lane for the intermodal shipment is compiled from the individual shipment record provided by the PIERS as shown in Table 4.

Table4. The Deployments of Vessels by various Shipping lines on Transpacific Routes

[11] Romelda Ascutia, "Asia Cargo diverted to USEC grows amid USWC congestion", *PortCalls Asia*, February 18, 2015, available from http://www.portcalls.com/asia-cargo-diverted-to-usec-grows-amid-uswc-congestion/

Alliance	Vessel Name	Ownership	Nominal Capacity	Ports of call	Trade Routes
G6	APL HOLLAND	Owned	5,514	W / LA	CC1, CC3, CC4
	APL SCOTLAND	Owned	5,514	W / LA	CC1, CC3, CC4
	APL ENGLAND	Owned	5,514	W / LA	CC1, CC3, CC4
	HYD FORCE	Owned	8,750	W / TA, Seattle	NP2
	HYD TOKYO	chartered-in	6,763	W / LA	CC1, CC3, CC4
	HYD COURAGE	Owned	8,562	W / TA	NP2
	APL/ HYD FAITH	Owned	8,750	W / Seattle	NP2
	HYUNDAI FAITH	Owned	8,750	W / LA	CC1, CC3, CC4
	HYD INTEGRAL	Owned	4,922	E / NK	CC1, CC3, CC4
	HYD LOYALTY	chartered-in	8,562	W / TA	NP2, NP3
	HYD MERCURY	chartered-in	8,562	W / TA	NP2, NP3
	HYD Global	Owned	8,562	W / TA, Seattle	NP2
	HYD New York	chartered-in	6,350	W / LB	CC1, CC3
	HYD TACOMA	chartered-in	6,350	W / LA	CC1, CC3
	MOL CALEDON	chartered-in	4,922	E / Miami	CC1, CC3
	OOCL CHINA	chartered-in	5,344	W / TA	NP2, NP3
	OOCL ANTWERP	Owned	5,888	W / LB	CC2
	OOCL ITALY	chartered-in	5,888	W / LB	CC2
	OOCL KUALA LUMPUR	chartered-in	5,888	W / LB	CC2
	NYK DENEB	Owned	4,882	E / NY	NCE
	NYK REMUS	Owned	4,922	E / SAV	NCE
	NYK TERRA	Owned	6,622	W / LA, Oakland	CC1, CC3, CC4
	NYK TRITON	Owned	6,500	W / LA	CC1, CC3, CC4
	NYK CONSTELLATION	Owned	4,800	W / TA	NP2
	H-L PRAGUE EXPRESS	Owned	8,580	W / TA	NP2

2M	MAERSK LINE ALBERT	Owned	9,310	W / Seattle	TP-9
	ADRIAN MAERSK	Owned	9,310	E / NY	TP-11
	MAERSK CLEMENTINE	Owned	8,890	E / SAV	TP-11
	MAERSK ARNOLD	Owned	9,310	W / Seattle	TP-9
	MSC HEIDI	Owned	8,402	W / LB	Yang tse
	MSC LUCIANA	Owned	11,660	W / LB	Jaguar Eastbound
	MSC IVANA	Owned	11,660	W / LB,Oakland	Jaguar Eastbound
	MSC NAVARINO	chartered-in	8,530	W / LB	Yang tse
	MSC Rania	Owned	8,402	W / LB	Yang tse
	MSC TEXAS	chartered-in	8,238	W / LB	Yang tse
	MSC TORONTO	chartered-in	8,089	W / LB	Yang tse

CKYHE	COSCO KAOHSIUNG	Owned	10,020	W / LB	PSX
	COSCO GENOA	Owned	4,253	E / NY	AWE-2
	COSCO TIANJIN	Owned	5,570	W / Seattle	PNW-COSCO
	COSCO HONG KONG	Owned	5,440	W / Seattle	PNW-COSCO
	COSCO JINHE	Owned	5,440	W / Seattle	PNW-COSCO
	K-Line BAI CHAY BRIDGE	Owned	4,432	W / LB	PSW
	K-Line BALTIMORE BRIDGE	Owned	4,432	W / LB	PSW
	K-Line BAY BRIDGE	Owned	4,432	W / LB	PSW
	K-Line BRUSSELS BRIDGE	Owned	4,432	W / LB	PSW
	K-Line BREMEN BRIDGE	chartered-in	5,888	E / NY, NK	AWE-4
	K-Line GLEN CANYON BRID(	Owned	5,624	E / SAV	AWE-4
	K-Line VALENCIA BRIDGE	Owned	4,734	E / WIL	AWE-1, AWE-3
	K-Line VECCHIO BRIDGE	Owned	4,738	E / WIL	AWE-1, AWE-3
	K-Line VENICE BRIDGE	Owned	4,738	E / WIL	AWE-1, AWE-3
	K-Line SUEZ CANAL BRIDGE	Owned	5,608	E / NY	AWE-4
	K-Line AKINADA BRIDGE	Owned	5,608	E / NY,SAV	AWE-4
	YM FOUNTAIN	Owned	5,551	W / TA	PNW
	YM KAOHSIUNG	chartered-in	4,031	E / WIL	AWE-1, AWE-3
	YM MARCH	chartered-in	5,576	W / TA	PNW
	YM ETERNITY	Owned	4,250	E / SAV	AWE-1, AWE-3
	YM PLUM	Owned	5,551	W / TA	PNW
	YM GREAT	chartered-in	5,570	E / NK	AWE-4
	HJ CONTI MADRID	chartered-in	5,762	E / NY,SAV	AWK
	HJ Duesseldorf	chartered-in	4,253	E / WIL	AWE-1, AWE-3
	HJ Montevideo	chartered-in	4,250	E / WIL	AWE-1, AWE-3

O3	CSCL Bohai Sea	Owned	10,036	W / Oakland	PSW-4
	CSCL SPRING	Owned	10,036	W / LA,Oakland	PSW-4
	CSCL Summer	Owned	10,036	W / LA	PSW-4
	CSCL AUTUMN	Owned	10,036	W / LA,Oakland	PSW-4
	CSCL YELLOW SEA	Owned	10,000	W / LA,Oakland	PSW-4
	CSCL Xin Nan Tong	Owned	4,051	E / SAV	AAE-1
	CSCL XIN YANG PU	Owned	4,250	E / NY	AAE-1
	CSCL Xin Tai Cang	Owned	4,253	E / NY, Miami	AAE-1
	CSCL VANCOUVER	Owned	4,251	E / NY	AAE-1
	CMA-CGM NORMA	Owned	9,415	W / LB,Oakland	BOHAI RIM
	CMA CGM MEDEA	Owned	9,415	W / LB	BOHAI RIM
	CMA-CGM ORFEO	chartered-in	9,661	W / LB	BOHAI RIM
	CMA-CGM BIANCA	chartered-in	8,465	W / Seattle	Columbus PNW
	CMA-CGM LA SCALA	Owned	8,456	E / NY	Columbus USEC
	CMA-CGM New Jersy	Owned	5,042	E / Miami	PEX-3
	CMA-CGM DALILA	Owned	8,465	W / Seattle	Columbus PNW

Source: Based on the service network information of relevant shipping companies

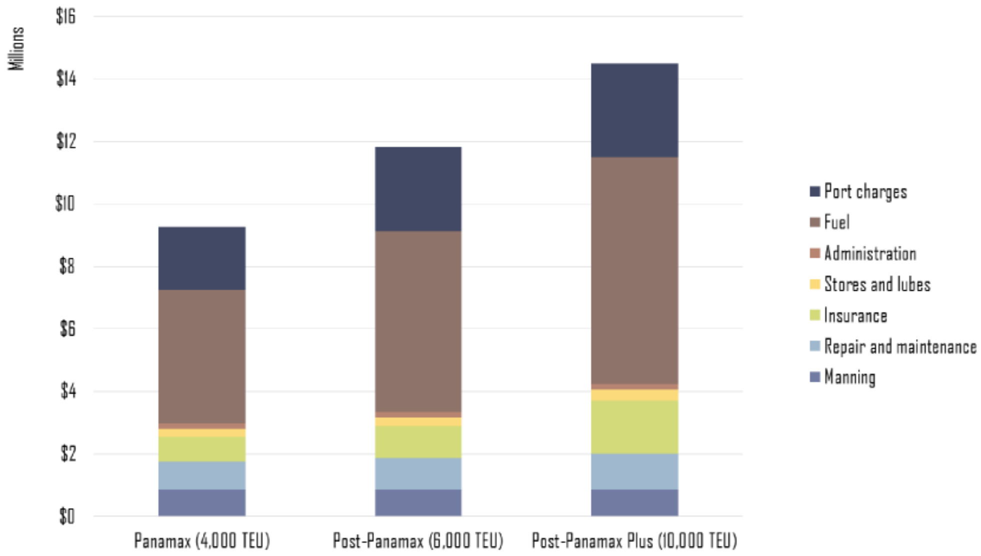
b. Vessel Operating Cost

Currently, due to the fact that the growth in the supply of containerships on the major trade lanes still marginally outpace that of the overall demands for the container shipments, the average freight rates among major shipping line on the transpacific trade lane still remained at a low level. In addition, maritime container shipping is highly sensitive (elastic) to bunker fuel costs as they represent between 45 and 50% of operating costs with limited opportunities to mitigate outside slow steaming. Still, from a comparative perspective, maritime shipping has less fuel price sensitivity than trucking and rail, implying that higher energy prices are likely to trigger the consideration of routing options that have a port call the closest possible to the destination of the shipments.

For a standard Panamax containership of a capacity of 4,800TEUs, it has operational costs of about $9 million per year, among which the most significant expenses are related to fuel (46%) and port charges (21%) as shown in Figure 3, which are variable costs. This is translated into annual operating costs of about $2,314 per TEU. Not shown here are the significant amortization costs related to the ship purchase (principal and interest). The incentive to use larger containership is quite clear from the perspective of BCOs, which led to a new generation of 10,000 TEUs containerships being introduced in 2007. In this case, fuel and port charges account respectively for 50% and 21% of their annual operating costs, while manning costs remains constant. However, annual operating costs per TEU drop by more than one half to $1,449. The principle of economies of scale is thus a strong factor in containerized maritime shipping.

In this study, the port charge is intentionally excluded from the calculation of total cost per unit for each shipment, since the info of port charge is impossible to get on the individual voyage basis and it seems that the level port charge among major U.S. does not vary a lot. So the bunker fuel cost is what we take into account in the following calculation of total cost.

Figure 3. Typical Components of Operating Cost for Containerships of Various Sizes



Source: Operating Costs of Panamax and Post-Panamax Containerships, The Geography of Transport Systems, available at http://people.hofstra.edu/geotrans/eng/ch3en/conc3en/containeroperatingcosts.html

Given the substantial difference in the average size of the vessel calling at U.S. East Coast and U.S. West Coast ports, the different cost profile for containership of various sizes is needed for further calculation of unit vessel operating cost. The most representative data on the cost profile can be achieved from USACE, the United

Sates Army Corps Engineer, as shown in the below Table 5

Table5. The Main Component of Operating Cost for containerships of Various Sizes

Vessel Size	4750 TEUs	5500 TEUs	7750 TEUs	10000 TEUs
Time Charter Rate /day	US$8,100	US$9,400	US$13,745	US$17,100
Vessel Cost / day	US$16,000	US$18,900	US$26,660	US$34,400
Fuel Consumption MT / day	133	154	217	280
Bunker Fuel Price	US$600	US$600	US$600	US$600

Source: SeaIntel Sunday Spotlight, March 1, 2015, SeaIntel Maritime Analysis

We can see from the Table 4 that the ocean carriers either own the vessel by itself or charter-in the vessel from other ship-owners. The time charter rate / day can serve as an approx. indicator of the balance of supply and demand of container shipping. At the point of time when these data was collect, since the overcapacity of fleet compared to the demand still exist among the major trade lane, so this set of data is well below that of the booming period back in 2007and 2008, which is more favorable to the ocean carrier as well as beneficial cargo owners, while the daily cost of vessel owned by the ocean carrier is relatively high and stable, which consists of significant amortization costs incurred by the purchase of the vessel, crew costs, repair &maintenance cost and voyage costs.

c. Vessel Operations by Mega Alliances

With the formation of mega shipping alliances on the major trade lanes in the recent few years, major top 20 ocean carriers tend to no longer offer their respective shippers only by means of their own assets, instead they are working more closely with each other than ever before through slot exchange, vessel sharing etc. As the major four mega alliances on the transpacific route compete for higher market share of intermodal shipments, the individual service provided by each of them are differentiated in terms of many aspects, such as the number of weekly services offered by an given alliance between the given port-pair may be quite different from others For instance, G6 have more combined weekly liner service than CKYHE in the Port of Los Angeles, while the opposite is true for these two alliance in the Port of Long Beach; In addition, the schedule reliability of various ocean carriers show significant differences even if they belong to the same mega alliances and each of these ocean carriers has varying level of on-time performance among different port within the dataset, the aggregate info about the two indicators are shown in the below Table 6 and Table 7 respectively.

Table 6. Weekly Services offered by ocean carriers at each POE

Carrier \ POE	LA	LB	TA	OA	NK	NY/NJ	SAV	WIL
Maersk	8	9	8	6	3	5	4	2
MSC	9	10	7	4	3	6	5	1
CMA-CGM	8	7	7	5	4	7	4	2
APL	8	6	4	6	3	5	5	3
Hapag-lloyd	7	7	6	5	3	4	5	2
NHK	5	3	4	2	3	5	3	2
MOL	3	3	2	1	1	2	3	1
HMM	3	4	3	2	1	3	3	2
OOCL	4	4	3	2	3	4	3	2
COSCO	4	5	4	2	2	4	3	1
K-Line	3	4	3	1	2	5	4	2
Yangming	3	3	2	1	1	3	3	2
Hanjin	4	4	3	2	1	4	3	2
Evergreen	3	4	3	2	1	3	2	1
CSCL	5	4	3	2	2	5	4	2

Source: Based on the data from Service Network of relevant Shipping Liners

Table 7. Schedule Reliability of Ocean Carriers at each POE

POE / Carrier	LA	LB	TA	OA	NK	NY/NJ	SAV	WIL
Maersk	85%	86%	81%	82%	72%	75%	74%	68%
MSC	80%	80%	76%	75%	65%	70%	68%	64%
CMA-CGM	82%	81%	78%	76%	68%	74%	73%	70%
APL	78%	79%	74%	73%	65%	69%	68%	64%
Hapag-lloyd	76%	80%	75%	74%	67%	70%	71%	65%
NHK	77%	78%	74%	73%	64%	68%	67%	63%
MOL	76%	75%	73%	72%	64%	68%	64%	62%
HMM	75%	75%	72%	71%	63%	67%	67%	64%
OOCL	74%	76%	74%	70%	63%	68%	66%	65%
COSCO	79%	80%	76%	75%	66%	70%	67%	64%
K-Line	77%	76%	73%	72%	68%	70%	68%	65%
Yangming	78%	77%	76%	75%	67%	68%	68%	67%
Hanjin	78%	78%	75%	73%	65%	69%	70%	67%
Evergreen	76%	77%	75%	74%	67%	69%	70%	68%
CSCL	80%	82%	76%	75%	68%	72%	68%	65%

Source: Based on the data from On-time Performance Report of relevant Shipping liners

3.2.5 Railroad-related Attributes

Currently, there are four major Class one freight railroads throughout the U.S which support the long-haul delivery of intermodal shipments. Of which BNSF and UP mainly serve the trade flow between the West Coast port range and inland market point, while CSX and NS are dedicated to fuel the shipment between the East Coast ports and major inland points. In this study, each individual port of entry is well served by the Class one railroads. The distance between each of these ports and

Chicago as the inland destination are quite different. At the same, the level of rail freight charged by rail carrier is not close to one another across the ports of entry, as evidence by the below Table 8 and Table 9.

Table 8. Railroad Distance from various POE to Chicago (miles)

Port of Entry	LA	LB	OA	TA	NY	SAV	NK	WIL
Distance from Chicago (Miles)	2,119	2,162	2,418	2,200	889	1,083	991	866

Source: Based on data from the official website of BNSF, UP, CSX and NS

Table 9. Rail Freight Rates by Selected Class One Rail Carriers (USD / Ton-Mile)

Region / Railroad	USWC	USEC
BNSF	3.16	N/A
UP	4.17	N/A
CSX	N/A	5.11
NS	N/A	5.71

Source: Rail Freight - Q2 2014 Summary North American Railroads

As can be seen from the Table 9, the freight rates charged by the Eastern railroad are relatively higher than that of Western counterparts. Since the intermodal rail rate is generally even higher than freight rate of maritime leg, so this part of cost will be incorporated into the total intermodal shipping cost for further analysis in the next chapter.

3.2.6 Panama Canal Toll Structure

The Panama Canal toll system is most recently revised in 2011, which invariably followed the trend of previous revision by raising both loaded and total capacity portion of the toll charge. Since a set of much-larger Neo-Panamax lock complex will be put into use when the expansion of the Panama Canal is completed, the Panama Canal Authority has just put forward a whole-new toll structure as shown in Figure 4, which will be designated for the containership segments.

Figure 4. Comparison of New Toll Structure with the Existing One

Approved Tariff 2011			Proposed Tariff for 2016			
Locks	Tariff for TTA maximun capacity	Tariff for Loaded containers on board (TEU)	Locks	TEU Range	Tariff for TTA maximun capacity	Tariff for Loaded containers on board (TEU)
Panamax 1/	$74	$8	Panamax	< 1,000	$60	$30
				>= 1,000 < 2,000	$60	$30
				>= 2,000 < 3,500	$60	$30
				>= 3,500	$60	$30
Neopanamax 2/	N/A	N/A	Neopanamax	< 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
				>= 10,000 < 11,000	$50	$35
				>= 11,000 < 12,000	$50	$35
				>= 12,000	$50	$35

Source: Proposal to Modify the Regulations for the Admeasurement of Vessels and the Panama Canal Toll System, January 2015

To be more detail, the new toll proposal will include the following highlights;

1. Differentiate the vessel total TEU allowance (TTA) capacity tariff and the TEU loaded with cargo tariff to be charged to full container vessels using the

Neo-Panamax locks and/or the new locks.

2. No additional charge for the transport of empty containers at the moment of transit, as determined by the ACP.

Reducing the existing vessel total TEU allowance (TTA) tariff and increase the existing TEU loaded with cargo tariff to the full container vessels that can currently transit the Panama Canal and that will continue to use the Neo-Panamax locks.

In addition to the new toll structure, the Panama Canal Authority will also introduce the "Customer Loyalty Program for Full Containerships" which intends to classify the canal users into four categories based customers' commitment of cumulative TEU volumes of Total TEU Allowance to be achieved within one year. And the preferential tariffs will be specially applied to the respective categories to give varying level of extra discount as shown below compared to the corresponding tariff.

Category 4: regular tariff, without variation.

Category 3: tariff which reflects a $1.00 improvement on the vessel capacity tariff (TEU allowance).

Category 2: tariff which reflects a $2.00 improvement on the vessel capacity tariff (TEU allowance).

Category 1: tariff which reflects a $3.00 improvement on the vessel capacity tariff (TEU allowance).

The combination of the new toll structure and corresponding loyalty program is expected to create more cost savings for the upcoming Neo-Panamax containership for the year to come, so in the next chapter, this part of saving will be used to check its effect in the practice.

3.3 Multinomial Logistic Regression Model

As previously stated in the section of literature review, the discrete choice analysis has been applied to study of the port choice by shippers. As one of the branch of discrete choice analysis, the multinomial logistic regression model is selected in this study to examine the impact of various potential factors on the choice of alternative ports for their container shipments and give some prediction for the change in the port choice due to the variation in some of major factors which may well materialized following the year when the Panama Canal Expansion is completed.

3.3.1 Components of the Multinomial Logistic Regression Model

The multinomial logistic regression (hereinafter called "MLR") is in essence used to model nominal outcome variable (as compared to the consecutive variable commonly in the ordinary regression model), in which the log odds of the outcomes are modeled as a linear combination of the predictor variables. The mathematical expression is as follows:

$$\ln(P_{i/}P_b)= a+b_1*X_1+b_2*X_2+\ldots\ldots b_n*X_n$$

P_i:: The estimated probability of outcome categories of interest being selected

P_b: The estimated probability of baseline category being selected

X_n: The predictor variables of interest selected at the discretion of users

b_n: The regression coefficient which represents the change in log odds per unit change of the corresponding predictor variable.

In this study, eight U.S. ports of entry (hereinafter "POE") as selected from the shipment records of PIERS amount to the nominal outcome variables in the MLR and the probability of a POE being chosen for each individual shipment is modeled as a linear function of factors describing the following three parts:

1. the attributes of vessel operation by ocean carriers
2. the attributes of container terminals of each POE's
3. the attributes of total shipment (with the impact of the Panama Canal and the U.S. intermodal railroad taken into consideration)

3.3.2 Selection of Predictor Variables

In the current context of container shipping, ocean carriers tend to select the port of entry for container shipment on behalf of their shippers. There are two assumptions hold that the short or near-term vessel fleet and operation configuration remain unchanged during the time period for the shipment within the dataset; The overcapacity of vessel fleet relative to demand for shipping shall guarantee the availability of slot for the delivery of shipment on any intended vessel.

1. In terms of the elevation of ocean carriers and their corresponding vessel operations, what the shippers care most about is basically the three indicators: freight rates, transit time and schedule reliability. The mix of these factors might be quite different among the major ocean carriers for various POEs as shown in Table 4~ Table 6. In that sense, these three indicators are selected as part of the predictor variables of the MLR for further test. Besides, the number of weekly services between Port of Shanghai and the alternative ports of entry is valued by many shippers, since they will have more choices within a week to make their container shipment arrive in U.S. inland market on schedule.

2. The performance of gateway ports are playing increasingly important role in the port choice by ocean carriers at the discretion of shippers. Currently the severe congestion take its toll on the west coast ports, which have cost millions of dollars on the stakeholders of container shipping industry every day. Although the west coast ports are generally equipped with more advanced quay cranes and relevant container yard infrastructure compared to their eastern counterparts, these ports are still faced up with severe backlog of both cargos and vessels. The container storage space may be one of causes for slowdown of cargo move at many west coast ports since the capacity of terminal to handle ever-growing cargo is restrained by the limited size of the storage space; In addition, even though east coast ports has handle more cargos bounded for the local market than ever before, but their inability to accommodate the much-larger post-Panamax containerships due to the lack of enough harbor depth prevent them from gaining more cargos destined to vast inland markets. So the harbor depth is another critical factor to be considered in the port choice.

3. The toll charged by the Panama Canal Authority on the containerships transiting the canal play its own role in the overall cost of ocean leg delivery. In addition,

inland intermodal rail rates have a lion share of entire container shipping cost. So the Panama Canal Toll charge is included in the ocean freight charge for vessels transiting the Canal to the East Coast ports. The combination of both ocean shipment cost and inland rail charge form as the variable of total shipment cost,

4. Also the total transit time from Shanghai to Chicago via various POEs is also regarded as a potential factor in the MLR model.

Now, altogether five different potential predict variables from various aspects which may be of great concern for the following analysis have been selected among multiple of candidate variables in anticipation of mirroring the real-world consideration of shippers for their individual shipments. Now, the eight alternative Ports of entry as the outcome variables and five different attribute variables of interest are organized in the Excel 2010 for further analysis, with part of the dataset presented in Table 10

Table 10. Part of Compound Dataset for the Individual Shipment[12]

POE	Schedule Reliability	Total Cost Per TEU	Harbor Depth	Frequency of Service	Port Productivity	Total Transit Time
WIL	63	1750	45	3	60	34
WIL	60	1800	42	5	59	30
WIL	72	1100	45	4	60	32
WIL	60	1800	48	2	58	26
WIL	81	1800	45	3	59	33
WIL	66	1850	45	4	61	34
WIL	63	1300	42	2	60	30
WIL	60	1700	45	2	61	22
WIL	69	1800	47	3	58	20
WIL	63	1550	42	2	60	33
NK	63	1600	48	5	66	30
NK	72	2000	49	4	64	34
NK	69	1300	50	4	65	26
NK	78	1700	48	6	64	20
NK	81	1200	50	2	67	18
NK	66	1500	48	3	65	24
NK	66	1450	48	5	65	26
NK	72	1750	45	3	65	30
NK	63	1600	47	6	64	29
NK	72	1700	46	4	63	28
NK	69	1500	45	5	66	30

Due to the limited space as required in the study, only portion of the 317 container

[12] The dataset involved in this table is just part of the total 317 records of container shipments from Shanghai to Chicago

shipment records from Shanghai to Chicago are shown in Table 6. These individual shipment records are select elaborately to represent the actual port choice by 317 different shippers for their individual container shipments. Most importantly, these port choice set within the data is compliance with the law of Irrelevant Independent Alternative (IIA) as required by the MLR, that is the relative possibility of one port being chosen over the other port within the dataset won't be affected by the existence or omission of a third ports. In addition, IIA require the outcome variables can include as many potential outcomes as possible. In this sense, port choice set in this study basically meet this requirement since it cover almost all the major container ports in the U.S. while the rest ports are generally neglected by the main shipping lines on the transpacific trade route, which means the POEs involved in the dataset can approximately include all the possible POEs for moving the container shipments for shippers.

Chapter 4: Analysis and Results

4.1 The Method of Analysis

There is a variety of analytical software available for the fitting of MLR Model. In this study, SPSS is chosen as the analytical tool to examine the extent of impact aforementioned factors would have on the probability of each port being chosen for individual container shipment within the dataset.

Before we get started with fitting the proposed MLR Model into SPSS, the relationship between the variables was first investigated using regression analysis. The correlations between the predictor variables are shown in Table11.

Table 11. Description of Predictor Variable Correlation

	Schedule Reliability	Total Cost / TEU	Harbor Depth	Frequency of Service	Port Productivity	Total Transit Time
Schedule Reliability	1.000					
Total Cost / TEU	-0.363	1.000				
Harbor Depth	0.138	-0.362	1.000			
Weekly Services	0.246	-0.304	0.165	1.000		
Port Productivity	0.137	-0.320	0.212	0.207	1.000	
Total Transit Time	-0.262	0.372	-0.259	-0.242	-0.328	1.000

Judging from the results of regression analysis shown above, it can be the that there is not any pair predict variables with a high level of correlation, that is to say, each predictor variables' role in the MLR will not be in conflict with other predictor variable's, which make sure the feasibility of the MLR model to the most extent.

In addition, the various correlation between two predict variables all reflect the desired relationship of those variables as we could expect from the practice. Take the "Total cost per TEU" for example, its positive correlation with the "Total Transit Time" is just the case for the shipment from Shanghai to Chicago moving through different gateways since the transit time is observably longer for the all-water route than the intermodal route. At the same time, the total cost for the shipment is also marginally lower than that of all-water route in the current context.

The initial output generated by SPSS on “MLR Analysis” consisting of a series of indicators which give users a general understanding of whether the factors involved in the MLR model are of enough significance to explain the possibility of each outcome variables being chosen compared to baseline outcome variables. The detail information are shown in Table 12.1- Table 12.3

According to the figure of some relevant indicators in Table 12 series, all the five predict variables fit quite well with the MLR model since they are all of great significance to the outcome variables as the significance value for predict variables are below 0.05 when the analysis is set at the confidence level of 95%. Then we need to go on to have an in-depth view on each predict variable’s significance on the port choice.

Table 12.1 Model Fitting Information

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	Log Likelihood	Chi-Square	df	Sig
Intercept Only Final	1226.61 808.384	418.235	42	0.000

Table 12.2 Pseduo R-Square

Cox and Snell	0.217
Nagelkerke	0.265
McFadden	0.143

Table 12.3 Likelihood Ratio Tests

Effect	Model Fitting Criteria	Likelihood Ratio Tests		
	Likelihood of Reduced Model	Chi-Square	df	Sig
Intercept	820.459	12.076	7	0.048
Reliability	846.648	38.264	7	0.000
Total Cost	870.837	62.454	7	0.000
Harbor Depth	835.682	27.299	7	0.000
Weekly Service	869.887	61.504	7	0.000
Port Productivity	846.291	37.908	7	0.000
Total Time	869.517	61.133	7	0.000

Table 13. Parameter Estimates

Port of Entry		β	Std. Error	wald	df	Sig	Exp(β)	95% Confidence Interval for Exp(β)	
								Lower Bound	Upper Bound
LA	Intercept	9.867	5.272	2.475	1	0.160			
	On-time Ratio	-0.109	0.040	7.388	1	0.007	0.896	0.829	0.97
	Total Cost	0.324	0.002	4.987	1	0.026	1.385	1.174	1.708
	Harbor Depth	-0.169	0.076	4.913	1	0.027	0.845	0.727	0.981
	Weekly Service	-0.539	0.143	14.125	1	0.000	0.583	0.44	0.773
	Port Productivity	-0.010	0.006	2.904	1	0.048	0.990	0.979	1.002
	Total Time	0.318	0.084	14.19	1	0.000	1.374	1.165	1.622

NK	Intercept	31.083	11.682	7.079	1	0.008			
	On-time Ratio	-0.349	0.079	19.435	1	0.000	0.706	0.604	0.824
	Total Cost	0.817	0.003	33.614	1	0.000	2.217	1.711	2.823
	Harbor Depth	-0.658	0.158	17.294	1	0.000	0.519	0.382	0.706
	Weekly Service	-1.667	0.327	26.025	1	0.000	0.189	0.100	0.358
	Port Productivity	-0.050	0.014	16.582	1	0.000	0.946	0.921	0.971
	Total Time	0.742	0.133	31.012	1	0.000	2.100	1.618	2.727
NY	Intercept	11.586	7.809	2.201	1	0.013			
	On-time Ratio	-0.229	0.053	18.721	1	0.000	0.795	0.717	0.892
	Total Cost	0.651	0.02	25.147	1	0.000	1.881	1.506	2.285
	Harbor Depth	-0.286	0.101	8.075	1	0.004	0.751	0.616	0.915
	Weekly Service	-0.680	0.193	12.441	1	0.000	0.507	0.347	0.739
	Port Productivity	-0.030	0.08	13.477	1	0.000	0.971	0.955	0.986
	Total Time	0.604	0.105	32.759	1	0.000	1.829	1.487	2.249
OAK	Intercept	19.868	9.750	4.152	1	0.042			
	On-time Ratio	-0.308	0.067	21.173	1	0.000	0.735	0.645	0.838
	Total Cost	0.584	0.002	33.628	1	0.000	2.009	1.508	2.494
	Harbor Depth	-0.221	0.126	11.164	1	0.000	0.656	0.585	0.840
	Weekly Service	-1.102	0.242	20.797	1	0.000	0.332	0.285	0.534
	Port Productivity	-0.048	0.011	19.706	1	0.000	0.953	0.944	0.974
	Total Time	0.569	0.118	32.351	1	0.000	1.953	1.487	2.460
SAV	Intercept	14.882	8.337	3.186	1	0.054			
	On-time Ratio	-0.254	0.056	20.314	1	0.000	0.776	0.695	0.866
	Total Cost	0.702	0.002	29.690	1	0.000	2.012	1.608	2.416
	Harbor Depth	-0.325	0.107	9.193	1	0.000	0.722	0.585	0.891
	Weekly Service	-0.856	0.204	17.561	1	0.000	0.425	0.285	0.634
	Port Productivity	-0.040	0.009	19.600	1	0.000	0.961	0.944	0.978
	Total Time	0.610	0.109	31.513	1	0.000	1.840	1.487	2.277
TA	Intercept	7.973	6.817	1.368	1	0.024			
	On-time Ratio	-0.149	0.045	10.809	1	0.001	0.861	0.788	0.942
	Total Cost	0.482	0.02	15.576	1	0.000	1.619	1.354	1.951
	Harbor Depth	-0.226	0.086	6.909	1	0.009	0.798	0.674	0.944
	Weekly Service	-0.487	0.166	8.657	1	0.003	0.614	0.444	0.850
	Port Productivity	-0.028	0.007	6.944	1	0.008	0.982	0.970	0.995
	Total Time	0.479	0.095	25.302	1	0.000	1.614	1.339	1.945

WIL	Intercept	52.031	18.848	7.62	1	0.006			
	On-time Ratio	-0.445	0.103	18.619	1	0.000	0.641	0.523	0.784
	Total Cost	1.026	0.004	19.973	1	0.000	2.782	2.009	3.523
	Harbor Depth	-1.012	0.279	13.281	1	0.000	0.362	0.209	0.625
	Weekly Service	-3.156	0.665	22.524	1	0.000	0.043	0.012	0.157
	Port Productivity	-0.056	0.019	7.790	1	0.000	0.947	0.921	0.984
	Total Time	1.009	0.184	29.934	1	0.000	2.742	1.910	3.435

4.2 The Implication of Status Quo

According to the results of Parameter Estimate in Table 13, It can be clearly seen that the β (the regression coefficient of the predict variable) of "Number of Weekly Services" is relatively higher than that of any other predictor variables in each POE. In the case of the Port of Wilmington, with each one unit increment in the number of the weekly services for this POE, the log odds of the Port of Wilmington being chosen for a shipment over that of the Port of Long Beach will decline by 3.156 units. This statement can be translated into the fact that the shipper who needs more weekly liner services to one port for his shipment is more likely to select the Port of Long Beach compared to the Port of Wilmington, which is exactly one of the main reasons why the port of Long Beach is most frequently selected outcome within this dataset.

In the second place, "Total Cost" from Shanghai to Chicago is second only to the "Number of Weekly Services" in its impact on the port choice. This can be mainly explained by the fact that Shippers in the Midwest imported more medium and low-value commodities from Shanghai than high-value ones, where they tend to favor the relatively cost effective routing for their shipments with the consideration of lower the inventory carrying cost as much as possible. In the next section, the effect of reduction in cost differential between routing via the USEC and USWC on the port choice decision will be further examined in the context of expanded Panama Canal.

Third, the coefficient β of “Total Transit Time ” is a little bit lower than that of “Total Cost” for each POE, which suggested that the most shippers do not necessarily choose the routing with shorter transit time when an alternative route is more cost effective. The potential change in Total Transit time resulted from the new Panama Canal will also be discussed in the next section.

Furthermore, the β of port-related attributes has similar implication on the port choice just as “Weekly Services” and “Total Transit Time”. As for the “Harbor depth”, it revealed that the deeper harbors are more attractive to shippers than shallower ones. The impact that projected change in the harbor depth of several East Coast ports will have on the port choice will be quantitatively measured in the next section; Also, the result shows that the “Port Productivity” is not playing the equivalent important role in the port choice as “Harbor Depth”, which is mainly attributable to the greater improvement made by USEC ports in port productivity compared to USWC counterparts, and thanks to much less congestion and more sufficient qualified dock workers in the USEC.

4.3 Post Panama Canal Expansion Scenario

The outcome of above MLR analysis shed light on the extent of each predictable variable in determining the possibility of each POE of U.S. being chosen for an individual container shipment from Shanghai as compared to baseline Port of Long Beach. While it is widely believed that several factors as involved in the predict variables will experience varying level of change after the completion of Panama Canal Expansion

First of all, several ports up and down the U.S. East Coast are scheduled to deepen their harbors in the years following the completion of Panama Canal;

Second, the projected revision in the toll structure proposed by Panama Canal Authority together with the deployment of larger post-Panamax containerships shall bring about positive change to the unit cost of shipment in the ocean leg;

In addition, some expected change in several important attributes related to vessel operations will also play their roles in the POE choice by shippers in coming years. It is important to note that all the following analysis are based on the assumption that the relevant predictor variables with respect to the West Coast ports will kept unchanged from the status quos since the most of the positive changes are expected to occur to the U.S. East Coast ports which are regarded as the major beneficiaries of the Panama Canal expansion.

So in this section, the potential changes which are almost for certain in the near future on some of the predict variable will be incorporated into the dataset of individual shipment to further examine the potential effect of these variables in the POE's attractiveness to the great number of shippers in terms of the possibility of being selected compared to the Port of Long Beach.

Scenario 1: Revised Port Depths

As is shown in the output of “Parameter Estimates” in the previous section, “Harbor Depth” is an import factor to be considered in port choice which ranked third among the five predict variables. By reference to the port deepening project proposed by various East Coast ports, the Port of New York and the Port of Savannah will mostly likely to obtain the grants from the Federal Government for their respective project. As for the Port of New York, the average harbor depth of various terminals will increase from current level of 45 feet to 50 feet in the next two years; Harbor depth for Port of Savannah will rise significantly from 42.5 feet to 48 feet. The comparison of output of parameter estimates for the harbor depth is shown at Table 14.

Table 14. Comparison of Harbor Depth Parameter

Pre-Deepening	β	Exp(β)	95% Confidence Interval	
LA	-0.205	0.814	0.727	0.981
NK	-0.578	0.561	0.380	0.706
NY	-0.330	0.719	0.616	0.915
OAK	-0.401	0.669	0.585	0.840
SAV	-0.448	0.639	0.585	0.891
TA	-0.284	0.753	0.674	0.944
WIL	-0.705	0.494	0.209	0.625

Post-Deepening	β	Exp(β)	95% Confidence Interval	
LA	-0.187	0.830	0.730	0.943
NK	-0.525	0.591	0.484	0.723
NY	-0.190	0.847	0.654	1.089
OAK	-0.363	0.695	0.584	0.828
SAV	-0.224	0.795	0.636	0.932
TA	-0.258	0.773	0.674	0.944
WIL	-0.645	0.525	0.209	0.625

As we can see from comparison of harbor depth parameter for each POE, Exp(β) for the Port of New York has risen from the current 0.719 to the projected 0.847, that is translated to say that the Port of New York is currently 0.719 less likely to be chosen by shippers who value deeper harbor than the baseline port of Long Beach, while in the near future when the harbor deepening is completed, the Port of New York will increase its possibility of being chosen by a factor of 0.13. So from the statistics point of view, the Port of New York will close the gap with the Port of Long Beach in terms of its possibility to be chosen due to the improvement of harbor depth with all other factors being equal. The Port of Savannah is expected to achieve a more striking performance with a nearly 40% increase in likelihood being chosen than right now solely due to the significant improvement in harbor depth. To be more specific, the Port of New York will surpass the Port of Los Angeles with the improvement of Port depth alone in terms of its likelihood of being chosen for an individual shipment which is reflected by its Exp(β) of 0.847; the Port of Savannah will also overtake the Port of Tacoma in the USWC in terms of its attractiveness discretionary shippers due to the deeper harbor.

Scenario 2: Revised Panama Canal Toll Charge

As is shown in Figure 4 in the previous Chapter, the newly proposed toll structure for full containership will more focus on the portion of laden containers on board in the total toll charge for a containership. Given the primary data compiled by PIERS, the size of all the containerships currently calling at the East Coast ports either via the Panama Canal or the Suez Canal ranges from 4250 TEU to 8750 TEU, the sole effect of the change in Canal toll will be examined with the harbor depths of various East Coast ports remain unchanged.

As a matter of fact, the potential cost savings for containerships range in size from 4200TEUs to 8550TEUs are as follows:

1. For 4250~6000 TEU containership transiting the Neo-Panamax Lock, the toll charge per unit will be even higher as compared to the current toll charge. So it is better for these containerships to continue transit the old Panamax Lock with no cost savings accrued to them.

2. For 6000~9000 TEU containership with 90% utilization rate, it is better for them to transit the Neo-Panamax Lock due to the potential cost saving in toll charge of $5 per TEU compared to transit the existing Suez Canal.

The Parameter Estimate for the effect of change in toll charge is shown as below.

Table15. Comparison of parameter estimate for Total Cost per TEU
(Revised Toll Charge)

	β	Exp(β)	95% Confidence Interval	
LA	0.004	1.004	1.000	1.007
NK	0.017	1.017	1.011	1.023
NY	0.010	1.010	1.006	1.015
OAK	0.014	1.011	1.007	1.018
SAV	0.012	1.012	1.008	1.016
TA	0.070	1.007	1.004	1.011
WIL	0.016	1.016	1.009	1.023

	β	Exp(β)	95% Confidence Interval	
LA	0.005	1.005	1.002	1.008
NK	0.016	1.015	1.012	1.020
NY	0.009	1.008	1.006	1.012
OAK	0.014	1.012	1.010	1.018
SAV	0.010	1.009	1.006	1.013
TA	0.008	1.008	1.005	1.011
WIL	0.016	1.016	1.014	1.024

As we can see from the Table 15 that for the time being, the shipper who value lower total cost per TEU will be 1.017, 1,010, 1011 more likely to choose the Port of Long Beach than the Port of Norfolk, Port of New York and Port of Savannah. When the new toll fee is put into use, these three gateway ports in the East Coast will respectively close the gap with the Port of Long Beach in terms of their possibility of being chosen for shipments, although the extent of progress is not enough to catch up with that of their West Coast counterparts. So it can be inferred that only by improvement of toll structure for containership is far not enough to make the all-water route through the Panama Canal competitive with the West Coast intermodal route in terms of the cost effectiveness.

Scenario 3: Revised Vessel Size

The vessel fleet size of shipping alliance is kept at the current level to examine the effect of change in toll charge on the port choice. It is more likely that in the near future the ratio of post-Panamax containerships in the vessel fleet will be significantly increase for various shipping alliance on the All-water service route via the Panama Canal. As the initial projection by the Panama Canal Authority, the work horse size of containerships transiting the expanded Panama Canal will stand at about 9,500 TEUs. So in this section, it is assumed that US East Coast Ports (With the exception of the Port of Wilmington) will be able to handle the containerships up to 8,500TEU in size in the near future. The much larger vessels to be deployed will greatly improve the fuel efficiency which will in turn reduce the mounting ratio of bunker fuel cost in the total operating cost for shipping alliances, as a result, the cost saving in terms of vessel operating cost can be expected to the same extent which has been achieved inherent in the vessels deployed on the Transpacific West Coast port routes. In addition, the revised toll charge is much more preferential for the containerships in this range of size. As such, the combined impact of larger vessel and improvement of Canal toll on the total cost per TEU will be evaluated as below.

Table.16 Comparison of Parameter Estimates for Total Cost per TEU

(Combined effect of Vessel Size and Toll Charge)

	β	Exp(β)	95% Confidence Interval	
LA	0.004	1.004	1.000	1.007
NK	0.017	1.017	1.011	1.023
NY	0.010	1.010	1.006	1.015
OAK	0.014	1.011	1.007	1.018
SAV	0.012	1.012	1.008	1.016
TA	0.070	1.007	1.004	1.011
WIL	0.016	1.016	1.009	1.023

	β	Exp(β)	95% Confidence Interval	
LA	0.005	1.005	1.002	1.008
NK	0.016	1.015	1.012	1.020
NY	0.009	1.005	1.006	1.012
OAK	0.014	1.012	1.010	1.018
SAV	0.010	1.007	1.006	1.013
TA	0.008	1.008	1.005	1.011
WIL	0.015	1.016	1.014	1.024

As we can see from the Table 16, the possibility of Port of New York being chosen for a shipment is exactly the same with that of Port of Los Angeles as reflected by their Exp(β) of 1.005; the Port of Savannah also make a great leap forward in its possibility of being selected for the shipment. The Norfolk seems to made less significant progress compared to the Port of Savannah and Port of New York with the help of improvement in the total cost, while the progress made by the Port of Wilmington is almost negligible.

Scenario 4: Reduction in Total Transit Time

The total transit time for intermodal shipment via the U.S. East Coast is composed of the ocean sailing time, Panama Canal time and inland rail transit time. The effect of the Expanded Panama Canal is still very much in the air, which is impossible to estimate any potential change in leg of shipment at the this point of time. Due to the current severe congestion in the USWC ports, the substantial time advantage hold by the intermodal route via the USWC over the USEC has been greatly undermined.

If the new all-water route via the expanded Panama Canal is less time-consuming than ever before as expected by the ACP, together with the efficient port handling offered by the major gateways as well as the improvement of rail transit time to the inland destination of Chicago, the USEC ports will benefit more from the positive change in this indicator than their USWC counterparts.

Scenario 5：Liner Service Improvement

As shown in the initial parameter estimates for all predict variables, Both the “No. of weekly Services” and “Schedule Reliability” offered by shipping lines exert significant influence over the port choice by shippers, it remained to be seen how will various shipping lines as members of major shipping alliances and relevant port authorities of both coasts work more closely with each other in pursuit of better performance in both of the indicators. Since there is a growing trend among some big-box retailers towards positioning more of their distribution center close to the major USEC ports to better serve the populous markets in the Midwest and Eastern part of the U.S., the mega shipping alliance will have greater incentive to ply more shipping routes which directly call at several USEC ports with consideration of providing more reliable and less time-consuming services to shippers.

Scenario 6: Improved Port Productivity

As an important measure of operating efficiency of port terminals, it mainly reflect the vessel operating performance for the container terminal in terms of the total number of containers moved per vessel per hour. According to the parameter estimates as shown in Table13, shippers are more likely to opt for the west coast ports with higher port productivity, while the indicator itself is not as significant as other predict variables involved in this analysis. This is most likely due to the fact that the highly efficient container handling equipment at USWC ports is compromised by the issue of labor disputes as well as chassis dislocation, while the USEC ports seems to perform better than some of the west coast ports although they are generally as well-equipped as their USWC counterparts. If these obstacles in the USWC can be addressed in the near future when the expansion of Panama Canal is completed, this indicator may be a precise measure of port handling capacity. In that sense, if USEC ports can keep upgrading their port infrastructure to maintain the high-performance of container handling, their effort will be destined to pay off.

4.4 Conclusions from the Comparison Study:

From the above quantitative comparison study on the effect of change in "Harbor Depth" and "Total Cost" on the port choice with the consideration of the Expanded Panama Canal, we can clearly see that the deepen harbor will make USEC container ports more attractive to their shippers in the Midwest of U.S. in terms of the likelihood of being chosen for potential shipment. The Port of New York's attractiveness to the shipper will rank second only to that of the Port of Los Angeles, while the Port of Savannah will overtake the Port of Tacoma, one of the major gateway in the USWC. So if the deepened harbor can be in place in the near future, the Port of New York and the Port of Savannah will gain more popularity compared to the current status.

Total Cost savings resulting from the revised Panama Canal toll charge and the increase in the container vessel size are expected to exert the most powerful influence on the port choice by the shippers in the Midwest of U.S.. While the attractiveness of Port of New York and the Port of Savannah almost reach parity with that of port of Los Angeles, the remaining two USEC ports; Port of Norfolk and Wilmington show not much of significant improvement in performance due to the lower total cost, for the Port of Norfolk, there are already some post-Panamax containerships choose to call it due to its 50 feet harbor depth, so the additional benefit of mega vessels along with the revised toll charge by PCA alone will have quite limited impact on its improved attractiveness to the shippers.

Total Transit Time is also a critical predict variable in determining the port choice especially for the USEC ports. However, no potential change in this indicator is available right now, which is also the case with two vessel operating-related attributes and port productivity, so any change in these predict variables which can be obtained in the near future will need to be examined in the MLR analysis model to see their potential contribution in the port choice after the completion of the Panama Canal Expansion.

Chapter 5: Conclusion and Improvement

The fitting of MLR model into SPSS is used as the methodology in this study of port choice by shippers, which finally shed light on the relative attractiveness of various US gateway seaports to the container shipment from Shanghai to Chicago based on the several predict variables of great significance to port choice, As can be observed from the outcome of analysis in the previous chapter, both the vessel operation-related and port terminal-related attributes are statistically significant in explaining the port choice by shippers. It is critical to note that two compounding predict variables of “Total Cost” and “Total Transit Time” are playing their own important roles in the selection of ports of entry through which door-to-door container shipment are moving to the final destination. The combined effect of toll charge imposed by the PCA and trend of deploying larger containerships is specially examined quantitatively in the study to predict the change in the relative ratio odds of alternative POEs, which reflects that the USEC ports are likely to grab more intermodal container shipment market share than ever before at the expense of some current leading west coast ports, while the effect of change in other components of shipping cost such as bunker fuel price, rail transit cost are not taken into account in this study since their future trends are unpredictable at present.

The future operational scheme by ACP is a key to the competiveness of route through the expanded Panama Canal. If ACP can better control the number of container ships to be transit every day, combine with improved toll charge on containerships, the more reliable and time-efficient service can be rendered to the shipping liners, which will in turn greatly benefit the trade routes moving through the USEC ports.

The total cost savings achieved by the combined newly proposed Panama Canal toll charge and deployment of larger Post Panamax containerships will greatly increase the possibility of the Top 2 USEC ports being chosen for the potential shipments at the expense of the major USWC ports.

The vessel operation-related issues are of great importance as analyzed in this study it remains to be seen how the major shipping liners will revise their operating structure on the major trade routes moving through both USWC and USEC in terms of weekly services and schedule reliability in response to the new normal of expanded Panama Canal and newly-upgraded USEC ports.

At the end of the day, whether the expanded Panama Canal will bring about an expected paradigm shift in the routing options through which a host of POEs are selected for container shipments destined to the U.S. inland market will depend on the potential changes in all the predict variables incurred to the ports on both coast. At the very least, the USEC ports will more or less attract some of shippers who want to further diversify their routing options to counter any unexpected dynamic incurred on their preferred route by offering more alternatives in the port choice.

As a whole, there are some limitations involved in this paper which need to be further improved in the future study.

First, the basic dataset involved in this study is only reflective of the actual situation of container shipment from Shanghai to Chicago within a peak shipping month, while the results from this study may not be as accurate as the actual cases due to the restriction of time horizon. So in the future research, the time horizon of the dataset could be extended as long as possible so as to better reveal the actual port choice by shippers in the context of ever-changing container shipping industry.

Second， all the USWC ports involved in this study are assumed to be unchanged from the status quo in terms of the relevant predict variables determining the port choice. But in reality, the west coast gateways are poised to take aggressive actions to further upgrade their port facilities in an effort to prevent the large scale diversion of discretionary cargos to their east coast counterparts. In this sense, it can be said that the possible post Panama Canal Expansion situation may not likely to be as simple as the assumptions proposed in this study. So any change to the attributes related to the intermodal route via the USWC ports shall be taken into account to give full comprehensive and practical evaluation of impact of Panama Canal expansion on the port choice by shippers.

Third, the potential change in some components of "Total Cost" including bunker fuel price and U.S. inland railroad charge shall be taken into consideration in the future study to better reflect the actual total cost saving of alternative routings. The same is true for the "Total Transit Time", "No. of Weekly Service", "Schedule Reliability" and "Port Productivity" as the potential changes in all of these predict variable shall determine the new landscape of routing options for the U.S. containerized imports from Asia.

In terms of the value of this study, it is the first study ever to implement the MLR model to analyze the contribution of various factors determining the port choice of discretionary cargo shippers in the U.S., and further examine the impact of change in some of these factors on the port choice under the new normal of expanded Panama Canal. At the same time, it can be extended to be a decision-making tool for various port authorities to increase the attractiveness of ports to discretionary cargo shippers by offering state-of-the-art port facilities and working closely with all the stakeholders along the route including ACP, shipping liners and inland railroad carriers to make sure that the relative cost-effective, less time-consuming and reliable container shipping service can be achieved by the combined efforts of all parties involved.

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