COMPETITIVE CONDITIONS IN CONTAINER LINER SHIPPING INDUSTRY

Hirata, Enna

(Degree)
博士（経営学）
(Date of Degree)
2016-03-25
(Date of Publication)
2018-03-25
(Resource Type)
doctoral thesis
(Report Number)
甲第6600号
(URL)
https://hdl.handle.net/20.500.14094/D1006600

博士論文

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2016年1月

神戸大学経営学研究科
正司研究室
経営学専攻

学籍番号　116B417B
氏名　平田燕奈

COMPETITIVE CONDITIONS IN CONTAINER LINER SHIPPING INDUSTRY

Enna Hirata

Submitted to the committee on

the Graduate School of Business and Administration

in partial fulfilment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in Business Administration

at Kobe University

January 2016

Doctoral Committee

Prof. Dr. Kenichi Shoji, Chair-Supervisor

Prof. Dr. Fumitoshi Mizutani

Prof. Dr. Kenji Matsui

Dedication

This dissertation is dedicated to my grandfather. I have no doubt that he will fight cancer with the same ferocious determination that he has with other challenges in his life. I know that the great strength he has will prevail.

"Hope is the only thing stronger than fear."

I have promised to make my grandfather proud by the achievement of this monumental academic goal and I hope I have fulfilled that promise.

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Acknowledgements

I owe credit for this thesis to so many people. I may possibly forget to mention someone and if I do please forgive me. First, I would like to thank my former supervisor Prof. Hideki Murakami (1964 - 2015) for accepting me as his Ph.D. student without any hesitation. Prof. Murakami was a resourceful and hard-working scholar. He inspired me to become an independent researcher.

I thank my supervisor Prof. Kenichi Shoji, for motivating me to always do better and to accomplish more than I ever thought possible. I also thank him for his confidence and mentorship. Without his enlightening instruction, impressive kindness and patience, I could not have completed my thesis this early.

I thank my committee members Prof. Toshifumi Mizutani and Prof. Kenji Matsui for their interest in and unequivocally feedback on my research work. Their guidance about how to write research paper effectively has been invaluable. I also thank Prof. Shigeru Yoshida, Prof. Mikio Takebayashi and Prof. Hideo Suehiro for generously sharing their views. I also need to thank professors and administrative staffs in Graduate School of Business and Administration for their dedication and facilitation of academic administrative procedures.

I thank my fellow graduate students Hirokazu Nishizawa, Yeon-Jung Song, Ryohei Yamamoto, Jinji Cui, Koji Adachi and Yukari Matsuse for insightful discussions. Gratitude also goes to my senior Okan Duru, currently Assistant Professor at Texas A&M University at Galveston for giving advice during the difficult time.

I thank all anonymous reviewers for their extensive and helpful feedback on my papers, which contributed to this dissertation.

Pursuing Ph.D. study while working full time has been a challenging and exciting journey. I thank Fredrik Grill, Customer Service Director in Maersk Line North East Asia head office, who has been my direct manager for last three years. His support, insight and inspiration have been important for me to complete the Ph.D. research. A number of colleagues offered help by sharing data and their feedback.

And now I must go back to the beginning, where everything really started, with my family. I have been extremely fortunate in my life to have grandparents who have shown me unconditional love and support. My parents, who gave me every learning opportunity they could think of, have never doubted about my dreams and always been there for me. My sister and my brother have always opened their minds to me, encouraged me to pursue my research. My in-laws, who live close, have offered their unfailing support all the time.

Finally my special gratitude to my husband Shinya for providing constant encouragement and support during the entire process. To my two little boys Momoki and Haruki, who missed out on a lot of mommy time while I sought intellectual enlightenment. I thank all three of you for your patience and love.

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Chapter 1 Introduction

1.1 Background and Research Motivation

Since the Ideal-X was modified to be the first container ship in 1956, container liner shipping has developed rapidly in the ensuing 60 years. Endured both golden times and periodical recessions over long history, the industry has been experiencing dramatic shuffling especially in past two years. Two new alliances 2M and O3 (see description in Appendix V) formed in 2014 among five top container carriers operating jointly in the six East-West routes (Appendix V). The average number of operators and slot charterers per service has increased significantly in most East-West routes, driven partly by cooperation in and across alliances.

2015 witnessed an unstable container liner freight market. Shanghai Containerized Freight Index (SCFI) [1] reported largest week-on-week loss record in November 2015 since the index was launched in 2009 – spot rates on Asia North Europe route plummeted by 31.8%. In the meanwhile, a flurry of industry news was released in November with most of it paint a very bleak picture for the rest of 2015. Besides freight fluctuation, 2015 also saw merger and acquisition talks. At the time of writing, the French CMA-CGM has exclusively acquired Singapore-based NOL[2].

Three common concerns exist in contemporary container liner shipping industry. First, whether container liner market is competitive or not; second, what are the competitive conditions in container liner market; third, how the container liner industry contributes to economic growth. The dissertation consists of three studies to address aforementioned concerns respectively.

1.2 Layout of Thesis

The dissertation consists of five chapters. With this chapter serves as an introduction, chapter 2, 3, 4 each focuses on one topic of the competitive conditions in container liner shipping industry. Finally, chapter 5 draws the conclusions.

Chapter 2 examines contestability in contemporary container liner market. Liner freight has been fluctuating dramatically in last two decades. It is of the entire industry's interest to understand the causes of freight rate fluctuation as well as how liner carriers should operate to stay profitable. Alliance is one of the forms carriers have taken to cooperate for mutual benefit. The first alliance was formed between Maersk and Sea-land in 1990s. Alliance has been prevailing in container liner market since conference regime abolishment in 2008. Merger and reformation of alliances have taken place frequently in recent years. The industry is full of large alliances now. Applying to industry statistics, the chapter aims to identify if the container liner market in alliance era is competitive.

Contestable market theory proposed by Baumol (1982) is applied to test the competiveness. A market is perfectly contestable if entry is absolutely free and exit is costless. In a world of alliances, entry to liner market nowadays does not refer to new companies appearing, but rather to existing ones expanding their networks with new services (new markets). In the form of alliance, a carrier can enter or leave rapidly any market without losing their capital; entry and exit barrier to the market is low. The features match the conditions of contestable market.

This chapter first investigates market concentration level measured by Herfindahl-Hirschman Index (HHI). HHI is a commonly accepted measure of market concentration level. The lower the market's concentration level, the closer the market is to being competitive. If HHI has no or less impact on liner freight rates, one can conclude that the contestable market feature-matching container liner market is competitive.

The model is derived from supply and demand functions. The empirical results estimated with Ordinary Least Squares (OLS) and Box-Cox methods show the coefficient of HHI on liner freight rate is -0.009 and it is statistically insignificant even at 10% significant level. The null hypothesis that the effect of HHI on liner freight rates is zero cannot be rejected. Higher concentration level does not lead to higher liner freight rate.

Coefficient of alliance member's share on liner freight rate is statistically significant at 1% level in both models. Higher alliance share leads to higher freight rate. This maybe explained that alliance allows member lines to adjust short-term capacity supply relevantly easier, higher alliance share enables better efficiency to adjust supply and demand imbalance to reach a new equilibrium point. In reality, it suggests that carriers need to cooperate to achieve efficiency especially in declining market situation.

This study also finds that static equilibrium does not exist in contemporary liner market. Equilibrium is established when price (freight rate) is approximately equal to marginal cost (MC). Since formation of alliance allows member lines to have a lower marginal cost, those member lines are profitable. With new entrants joined, supply curve becomes more flat, new equilibrium establishes at lower price level. When price is too low for most carriers to be break even, some carriers opt to reduce capacity or withdrawn from certain routes (markets), slop of supply curve comes deeper, which shifts the equilibrium point upwards. Some carriers become profitable again. However, the situation will not last long - equilibrium point shifts again with the movements of industry average cost triggered by technology advance or reforming of alliance.

In conclusion, the empirical results in this chapter suggest contemporary container liner market is contestable. Higher concentration level leads to lower freight rate. To survive in a declining market, carriers have no choice but to cooperate for agile response to supply and demand changes. Alliance does not hamper competition but is rather a way to sustain container liner shipping industry. It also suggests that regulators should be more lenient in evaluating carrier's alliance filing requests.

The objective of chapter 3 is to examine the competitive conduct in container liner shipping market. This chapter tackles on the competitive conditions of liner market measured with H-statistic developed by Panzar and Rosse (P-R Test). Panzar and Rosse (1977, 1987) developed H-statistic to measure the competitive structure of an industry. H-statistic is estimated as the sum of the elasticities of the reduced form (equilibrium) revenues with respect to input prices. It is interpreted as that if $H \leq 0$ the market is monopoly. With perfect competition, $H = 1$. When $0 < H < 1$, the market is in monopolistic competition. A higher H-statistic is often interpreted as an indicator of higher degree of competitiveness.

Two relevant studies are conducted to container liner shipping industry. Endo (2005) estimated H statistic for top three Japanese carriers (NYK Line, MOL, K-Line) during 1986 – 2002 is 0.54, which indicated the top three Japanese container carriers operated in monopolistic competitive condition. Sys et al. (2011) investigated the competitive conditions in container liner market for the period 1999 to 2008 (the period before the abolishment of the conference in 2008) for a sample of 18 container liner carriers, and found the H-statistic during that period varies from 0.68 to 0.87.

This chapter follows Shaffer's (1982, 1983) demonstration of P-R test for the relationship of competitive conduct and demand elasticity, or $H = E+1$, where E is the demand elasticity across the entire market or industry. The demand elasticties are obtained using Autoregressive Distributed Lag (ADL) model in order to separate short-run and long-run effects. The demand elasticities are estimated basis on container liner industry statistics for the period of 2009 to 2014 in the six East-West routes. The H-statistic calculated basis on estimated demand elasticities ranges from 0.72 to 0.79. The result is consistent with the findings in previous research that container liner shipping industry can be described as displaying monopolistic competitive behaviour.

Chapter 4 estimates the effects of container liner industry on economic growth from macroeconomic angle. Container liner shipping and the influence it has had on global trade have been significantly important over the past 50 years. Declining transport costs have allowed low value cargo to be traded, and cargo from remote areas to be sold in new markets. Trade growth in East Asia, notably in China, has clearly contributed to their container shipping industries. However, few studies have quantified such positive effects, and its implications to carriers and regulators in other regions.

The model is derived from the macroeconomic identity: Y=C+I+G+NX where GDP (Y) is the sum of Consumption (C), Investment (I), Government Purchase (G) and Net Exports (NX). Since Export and Import are composed of commodity value and transport costs, Net Exports can be expressed as net results of commodity value and transport costs. Given the fact that more than 75% of international transport are containerised (Notteboom and Rodrigue 2008), the relationship between GDP (Y) and container liner freight rate (fr) can be estimated applying to statistical methods.

This study applies panel data for 31 countries over seven years. In addition to liner freight rate, liner connectivity index is introduced into the model to better assess the effects of liner shipping industry have had in economic growth. The model is estimated with both fixed effects (using Ordinary Least Squares) and random effects (using Feasible Generalised Least Squares) to accommodate missing periods and unobserved effects. The results suggest the coefficient of liner freight rate is statistically significant at the 5% level, ceteris paribus one point increase in liner freight rate increases GDP growth by approximately 0.0014 points. The positive relationship of liner freight rate and GDP growth differs from the conclusions drawn in previous research for different period. Reducing transport costs do not contribute to trade growth nowadays.

Chapter 5 concludes the dissertation. It summarises the methods applied and major outcomes, followed by description of originality and impacts of study, as well as the limitations of study. The chapter ends with prospect of future research topics.

Chapter 2 Container Liner Shipping Market Contestability

This chapter tests container liner market contestability in alliance era applying panel data for a sample of six East-West container liner shipping routes. The empirical model derived from supply and demand function estimates the effects that concentration measured by Herfindahl-Hirschman Index (HHI), alliance share and fuel prices have on liner freight rates. The null hypothesis that the impact of market concentration level on container liner freight rates is zero cannot be rejected even at 10% level of significance. Coefficient of HHI may be zero. The estimated HHI coefficient is extremely small and has negative value of -0.009, which implies market concentration level has little impact on container liner freight rates. Container liner market is hence considered as highly contestable. The empirical results also suggest that alliance plays a role to stabilize container liner shipping market.

2.1 Introduction

Shipping conference and alliance are two main forms of liner shipping organisation. Shipping conference concentrated mainly on routes to and from Europe, peaked in 1995-1996 (Haralambides 2004) and was abolished as from 18 October 2008 (EEC Regulation no. 4056/86) [3]. First shipping alliance was formed between Maersk and Sea-Land in Trans-Pacific and Trans-Atlantic routes in 1990s. Table 2.1 outlines key events in conference and alliance history in chronological order.

Shipping conference refers to association formed by shipping companies to agree on and set freight rates over different shipping routes. There are different shipping conferences for different regions of the world. Conference is commonly considered as a cartel-like route based coalition of carriers, have price setting as objective. In the UNCTAD Code of Conduct for Liner Conferences (UNCTAD, 1974), the term conference or liner conference is defined as '...a group of two or more vessel operating carriers which provides international liner services for the carriage of cargo on a particular route or routes within specified geographical limits and which has an agreement or arrangement, whatever its nature, within the framework of which they operate under uniform or common freight rates and any other agreed conditions with respect to the provision of liner services'.

Table 2.1. A chronological table of shipping conference and alliance

Year	Milestones	Source
1830s	Earliest shipping conferences activities were evidenced in 1830s in British coastal shipping	Armstrong (1991)
1875	The first modern liner conference, the U.K. - Calcutta conference, was founded	Aldcroft (1968)
1879	The Far East Conference (later renamed to the Far East Freight Conference) was founded	Federal Maritime Commission(2012)
1974	UNCTAD Convention on code of Conduct for Liner Conferences took effect	UNCTAD[4]
1990s	Maersk and Sea-Land introduced alliance system and began sharing vessels in the Atlantic and Pacific oceans	Slack et al. (2002)
1994	The Global Alliance formed (APL, MOL, OOCL, Nedlloyd)	Stopford (2009)
1995	Grand Alliance formed (Hapag Lloyd, NYK, NOL, P&O)	Stopford (2009)
1995	Maersk and Sea-land	Stopford (2009)
1998	New World Alliance formed (APL, MOL, Hyundai Merchant Marine)	PR News[5]
2000	CKYH Alliance formed (Cosco, K-line, Yangming, Hanjin)	Lu et al. (2006)
2008	FEFC abolished	EEC Regulation[3]
2011	G6 Alliance formed (APL, MOL, Hyundai, Hapag Lloyd, NYK, OOCL)	Websites[6]
2014	2M Alliance formed (Maersk, MSC)	Websites[7]
2014	Ocean 3 Alliance formed (CSG, CMA-CGM, UASC)	Websites[8]
2014	CKYHE Alliance formed with Evergreen joined	Websites[9]

Haralambides (2000) uses a simplified case to illustrate formation of liner conference. A customer comes with a container of cargo to ship while the ship is not yet full, its operator would be tempted to take the cargo, even at the price of as low as marginal cargo handling costs involved in loading the container on board. If this were common practice for all operators, competition amongst them would push the price down to the level of short-run marginal costs. Consequently, liner industry would not be sustainable in long-run, since operators would not be able to cover voyage costs and capital costs (Pirrong 1992). To keep liner industry reliable and sustainable, price competition should be limited and a mechanism needs to be established to allow carriers to recover long-run average total costs. The mechanism was found to be shipping conference.

Comparing to liner conferences, 'shipping alliances are also coalitions of carriers, but contrarily to the route-based character and price-setting objectives of conferences.' Alliances are not involved in price-setting and one of their main objectives is to offer shippers greater geographical coverage 'through cooperation and dovetailing of their members' operations' (Haralambides and Veenstra 2000). Alliance allows members to use capacity more efficiently and better control capacity supply.

Over last two decades, numbers of member lines in each alliance have increasing trend (Figure 2.1). Each alliance expanded global network coverage and fleet scale. In 2014, the 16 carriers in the four large alliances (CKYHE/2M/O3/G6) control 95 percent of cargo volumes moving in the major East-West routes. [10]

Figure 2.1. Alliances in 1995, 2001 and 2014

Source: Alphaliner[11]

1995		2001		2014	
Global Alliance	APL MOL OOCL Nedlloyd	New World Alliance	APL/NOL MOL Hyundai	G6 Alliance	APL MOL Hyundai Hapag Lloyd NYK OOCL
Grand Alliance	Hapag Lloyd NOL NYK P&O	Grand Alliance	P&O/Nedlloyd Hapag Lloyd NYK MISC		
Maersk- Sealand	Maersk Sealand		Maersk Sealand Safmarine	2M Alliance	Maersk MSC
Tricon/Hanjin (United Alliance)	Cho-yang DSR-Senator Hanjin		Senator Hanjin UASC	O3 Alliance	CSG CMA UASC
		Sino-Japanese Alliance	Cosco K-Line Yang Ming	CKYHE alliance	Cosco K-Line Yang Ming Hanjin Evergreen

Unlike conference has price-setting objective, alliance allows member lines to use capacity more efficiently and to better control capacity supply. Alliances members have the flexibility of suspending certain sailings or port calls to adjust supply, so that one can still provide the advertised schedule without having to cater for low paying cargo to fill the vessel. Due to these features, large alliances are perceived as anti-competition. A recent example is that in 2014 China blocked on the proposed P3 alliance of Maersk, MSC and CMA CGM after deeming it anti-competitive. The interest of this chapter is to investigate whether the market structure of container liner industry in alliance era is competitive or not, which will be tested in following sections applying to contestable theory.

Contestable market refers to a market in which there are only a few companies that, because of the threat of new entrants, behave in a competitive manner. A market is deemed to be contestable if entry and exit are relatively easy. A market is perfectly contestable if entry is absolutely free and exit is costless (Baumol 1982).

In a world of alliances, entry to liner market nowadays does not refer to new companies appearing, but rather to existing ones expanding their networks with new services as new markets. In the form of alliance, a carrier can enter or leave rapidly any market without losing their capital and competitors have the same cost function as incumbent. In other word, entry and exist barrier to the market is low. These characters match the conditions of contestable market.

This chapter examines the impact of market concentration level measured by HHI on liner freight rate to evaluate the contestability in contemporary liner shipping market. If a market is proved to be contestable, one can conclude the market achieves similar efficiency as a competitive market does.

This chapter is divided into five sections. Section 2.2 reviews previous research on liner organizations and liner market contestability. Section 2.3 derives empirical model to test contestability in liner market. Section 2.4 describes the data available for estimation, Section 2.5 presents the results, and conclusions are drawn in the final section of this chapter.

2.2 Literature Review and Market Concentration Level

2.2.1 Previous Research

Since Maersk and Sea-Land introduced alliance system and began sharing vessels in the Atlantic and Pacific oceans in 1990s, strategic alliances have become increasingly common. Two facts are considered as the driving forces of global alliance formation. Firstly, fast-paced changes in globalization of world economy since the beginning of the 1990s permanently alter the shape of liner shipping industry. Shipping companies have no choice but to follow their customers on a global scale and to provide viable solutions to their extended requirements. Secondly, protracted unsatisfactory financial performance of liner shipping industry pushed liner companies towards new forms of co-operation. The demands for the massive investments required by the globalization of routes are unfortunately not met by profitability level. On the contrary, container freight rates on every major route have dropped faster than the gains in productivity (Fossey 1997). In 2007, out of 17 top liner companies that published financial results, only two companies (K-Line and Hapag Lloyd) reported profit while all of the rest were in loss [12]. This accelerated reformation of alliance to be in larger scale.

On alliance formation, Yoshida et al. (2004) analyse network economy effects of strategic alliance and conclude that Japanese shipping lines have achieved cost reduction through network extension in form of alliance. Lu et al. (2006) study CKYH alliance member lines applying Delphi method. Their results show the top five reasons of forming alliances are: (a) extend service coverage, (b) provide more frequent sailing services, (c) faster entry to new routes, (d) share the risks of providing new liner services and (e) maximize operational synergy. Huang and Yoshida (2013) discuss contribution of alliance and empirically prove alliance formation of alliance improves service quality and reduces operation cost.

Yamagishi (2014) reviews development of international shipping industry in last 70 years and suggests that liner carriers form alliance in meeting shipper's changing needs for faster transit time, on-time delivery and service frequency. Alliance plays an important role to survive liner industry since the beginning of 21st century, it is however not a ready-made panacea to all problems. Future of alliance depends on economic environment.

On liner market contestability, Davies (1986) argues that entrants and incumbents have the same access to technology; sunk costs are very low as ships can be easily diverted from one route to another; liners face competitions from tramp and bulk carriers. With these arguments, Davies concludes liner market 'closely matches the requirements of extreme, ideal, perfectly contestable market.'

Franck and Bunel (1991) discuss there are two kinds of entries in container liner market - occasional entry and entry of long time stay, exist are not subjected to same condition. Entry and exit barriers for outsiders expecting long time stay is high, since they need to divert customers from incumbents while staying profitable. The characteristics of demand observed in liner shipping differ from those in airline industry where sunk costs are limited and it is easier for entrants to obtain new customers by cutting prices. The authors as such suggest liner shipping market is imperfectly contestable facing competition from large size outsiders.

Miyashita (1976, 1988, 2002 and 2009) conducts various studies in a broad spectrum of transportation sectors including shipping, airfreight and integrated logistics. The author (Miyashita 2002 p.209) analyses the East-West routes quarterly data during 1993 to 1996 and concludes that HHI has increasing effect on freight rate at 1% significance level in Asia Europe and Trans-Atlantic routes and at 20% level in Trans Pacific route. The author suggests market was contestable in Trans-Pacific route however oligopolistic in Asia Europe and Trans-Atlantic routes during that period.

Research on liner market contestability in alliance era has been scarce. Especially, none of previous research on quantification of container liner market contestability in alliance era has been observed.

2.2.2 Liner Market Concentration Level

Herfindahl-Hirschman Index (HHI) is adopted to test concentration level in container liner market. HHI is a commonly accepted measure of market concentration. The higher the HHI value, the more concentrated the industry and the greater the potential for market power. HHI is calculated by squaring the market share of each firm competing in a market, and then summing the resulting numbers.

The formula of HHI calculation is given as,

$$HHI = \sum_{i=1}^{n} Si^2 \qquad (2.1)$$

where Si is market share of firm i in market. Percent as whole number is used for calculation in this chapter.

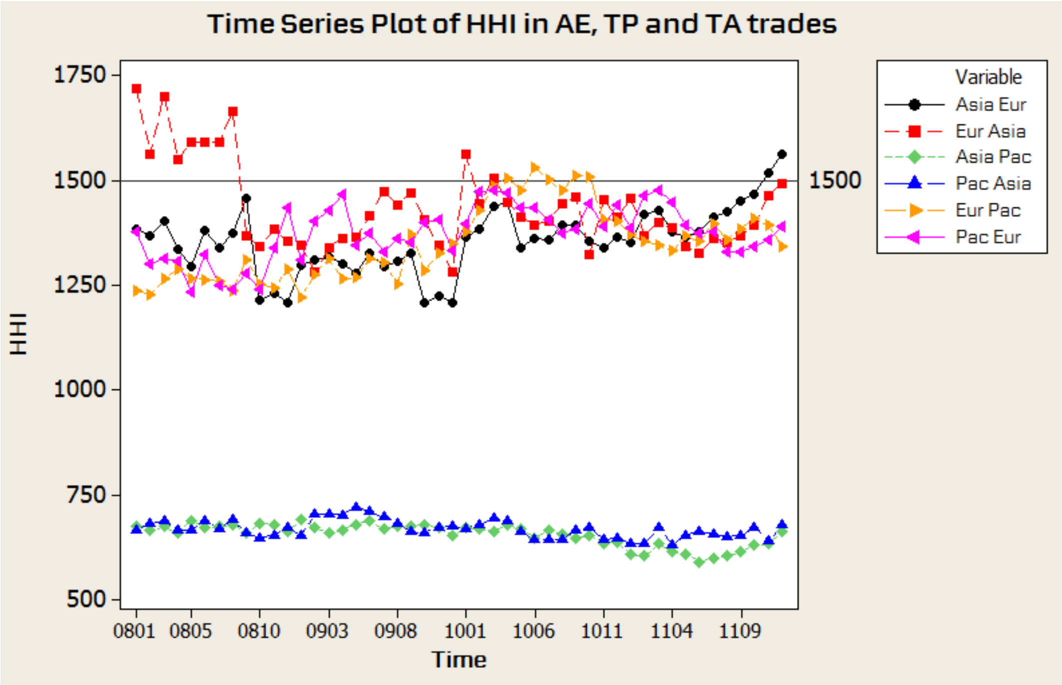
As per guidelines of U.S. Department of Justice and the Federal Trade Commission [13], markets are generally classified into three types: unconcentrated markets when HHI is below 1500 and highly concentrated markets when HHI is above 2500, else markets are moderately concentrated.

To obtain an overview on concentration level in container liner shipping market Liner market, concentration levels of the six East-West routes [Appendix V] during 2008 to 2011 are plotted (Figure 2.2). Taking consideration abolishment of FEFC in October 2008, the chart illustrates market concentration situation in post-conference era.

Except a few spots in Trans-Atlantic routes, HHI from 2009 onwards have all time been under 1500. It indicates liner market post conference era is considered as unconcentrated when evaluating on single carrier level.

Figure 2.2. HHI in East-West routes 2008 - 2011

Source: PIERS [14] and CTS [15]



Same analysis is conducted using market share on alliance basis. The market share is basis on alliance structure in 2014 (Figure 2.3).

Figure 2.3. HHI in East-West routes 2014

Source: Alphaliner[11]

Alliance based HHI

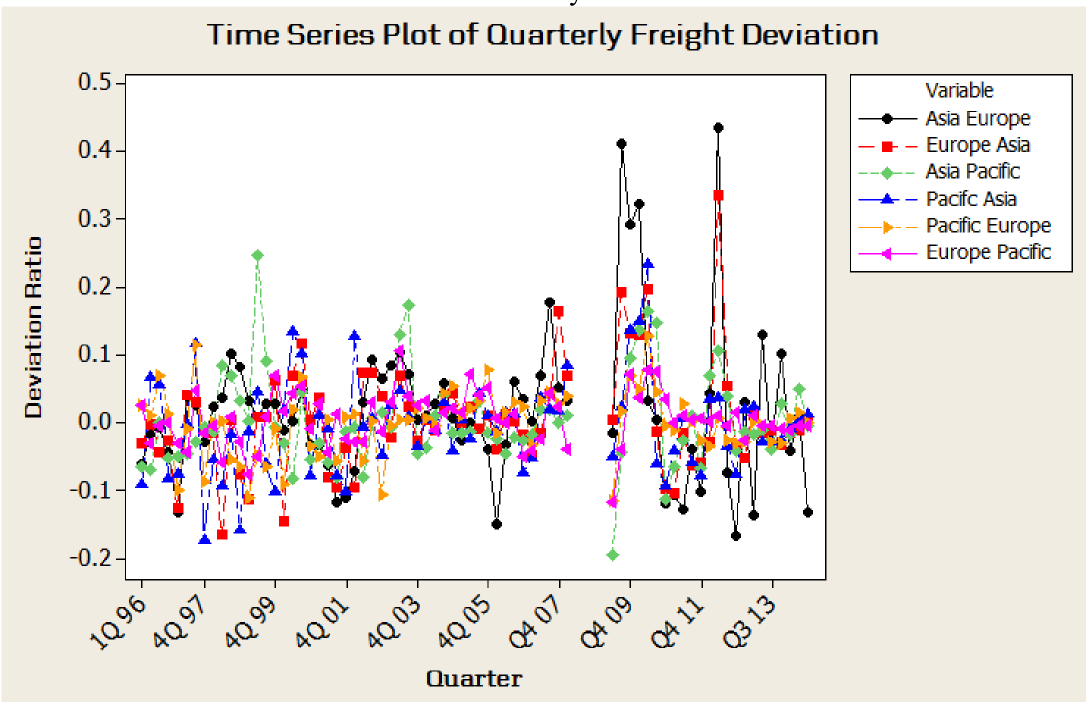
2014	Asia Europe	Trans Pacific	Trans Atlantic
HHI	2,494	2,556	3,240

All East-West routes are close to or higher than 2,500, which implies liner market is highly concentrated when evaluating on alliance basis. Existence of alliance does turn the market to be more concentrated.

2.2.3 Freight Rate Stability

Data used for analysis in this section are sourced from Drewry[16] and CTS for the period of 1996 – 2014[17] in the six East-West routes. To make data comparable, quarterly variation in percentage is applied to plot the movement (Figure 2.4).

Figure 2.4. Freight rate stability in 1996 - 2014
Source: Drewry and CTS



There are two intuitive conclusions from the chart. First, liners freight rates are more stable during 1996 – 2007 (conference era), and fluctuate in bigger range during 2009 – 2014 (post conference). Second, fluctuation from 2012 onwards becomes convergent. Noticing the fact that the first large alliance G6 formed in end 2011, large alliances seem to contribute to market stabilization. Overall freight rate fluctuation is relevantly small when larger alliances are present.

2.3 Empirical Model

The model applied in this study is derived from supply function.

The supply function is defined as,

$$\mathrm{Q} \ = \mathrm{a}_1 + \mathrm{b}_1\mathrm{P} + \mathrm{c}_1\mathrm{AS} + \mathrm{u}_1 \qquad (2.2)$$

The demand function is defined as,

$$Q = a_2 + b_2\mathrm{P} + c_2\mathrm{Fuel} + u_2 \qquad (2.3)$$

Where *Q* is quantity, *P* is price (freight rate), *AS* is the share of alliance member lines, and *Fuel* is the fuel cost.

Solve (2.1) and (2.2) to get the reduced-form equations,

$$P \ = \pi_1 + \pi_2 AS + \pi_3\mathrm{Fuel} + \upsilon_1 \qquad (2.3)$$

$$Q = \pi_4 + \pi_5 AS + \pi_6\mathrm{Fuel} + \upsilon_2 \qquad (2.4)$$

Introduce HHI (*HHI*), seasonality (*Seas*) and route control variables (*Route*), the model for estimation is given by,

$$P_{it} \ = \beta_0 + \beta_1 AS_{it} + \beta_2 Fuel_{it} + \beta_3 HHI_{it} + \sum_{i=1}^{5} \delta_i \, Route_i + \partial Seas + \varepsilon_{it} \qquad (2.5)$$

For *i*=1, …, 5 and *t*=1,…,35, ε_{ij} is the error term.

If container liner market in alliance era is contestable, market concentration level has no impact to liner freight rate, coefficient of HHI should be close to zero and statistically insignificant.

To increase robustness, model is power transformed using Box-Cox model. Both dependent and the set of independent variables are transformed in same way.

The transformed Box-Cox model has the following form,

$$P_{it}{}^{\lambda} = \alpha_0 + \alpha_1 AS_{it}{}^{\lambda} + \alpha_2 Fuel_{it}{}^{\lambda} + \alpha_3 HHI_{it}{}^{\lambda} + \sum_{i=1}^{5} \tau_i \, Route_i + \gamma Seas + \nu_{it} \quad (2.6)$$

2.4 Data and Variables

The data available for estimation are for a cross section panel of six East-West routes monthly data for the period of 2009 to 2011 (Table 2.2).

Table 2.2. Varaibles and data sources

Variable	Description	Source
P	Price indices	CTS [18]
HHI	Herfindahl-Hirschman Index, calculated basis on actual volumes each liner operator carried	PIERS[14] & CTS [16]
AS	Share of capacity supplied by alliance member lines	ComPair data
Fuel	Average bunker price of 380Cst/180Cst/MDO	Bunker World
$Route_i$ *(i=1, …,6)*	Route dummy for the six East and West routes	-
Seas	Seasonality control, factored by Christmas and Chinese New Year	-

2.4.1 Price (P)

CTS APIs (Aggregated Price Indices)[18] are applied. CTS APIs are weighted average of the sea freight rates including all surcharges and ancillary charges except inland haulage charges. It has 2008 price index value as 100.

2.4.2 HHI

Herfindahl-Hirschman Index, calculated by squaring the market share of each carrier, then summing the resulting numbers. Market shares are calculated basis on actual volumes each liner operator carried, sourced from PIERS for Trans-Pacific and Trans-Atlantic routes and CTS for Asia Europe Routes.

2.4.3 Alliance share (AS)

Percentage share of capacity provided by alliance member lines in each route. Capacity supply is Compair Data's estimate of TEU capacity that carriers assign to the trade route on a route. ComPair Data runs an algorithm to estimate what percentage of a service's capacity is allocated to a route.

2.4.4 Fuel

This variable represents bunker price. There are various types of fuel oils used in vessel operation. All types of fuel oils are referred as bunker. Average bunker prices of three major types of fuel oils (380Cst, 180Cst and MDO) are applied in the estimation.

2.4.5 Control variables ($Route_i$, seas)

The six East-West routes ($Route_i$) and seasonality (seas) are controlled to test the effects on freight rate.

The panel data have 210 observations for estimation (Table 2.3).

Table 2.3. Descriptive statistics of the regression variables

Name	Mean	St. Dev	Minimum	Maximum
Q	317.740	240.940	80.928	1122.700
P	86.796	16.279	42.000	121.000
HHI	1143.100	348.580	589.640	1563.900
AS	0.381	0.116	0.141	0.602
Fuel	566.870	147.320	286.670	800.000

2.5 Results

Table 2.4 reports the results estimated by OLS and BOX-COX models respectively. Out of total nine variables, eight variables in OLS model and seven variables in Box-Cox model are statistically significant at 1% or 5% level, which indicates the models are highly relevant.

Table 2.4. Estimate results (Dependent variable: *p*)

Variable	OLS	BOX-COX (λ=1.11)
HHI	-0.005 (0.012)	-0.009 (0.021)
AS	164.480*** (14.770)	267.430*** (20.970)
Fuel	-0.011 (0.007)	-0.018* (0.010)
Seas	-2.152 (1.889)	-3.652 (3.011)
R1(AEW)	10.345*** (2.934)	17.297*** (4.243)
R2 (AEE)	10.121*** (2.115)	16.622*** (4.275)
R3 (TPE)	-25.734** (10.10)	-42.238** (16.960)
R4 (TPW)	-19.663** (9.327)	-32.269* (16.550)
R5 (TAE)	17.246*** (1.759)	28.311*** (4.160)
Constant	38.360** (17.120)	49.568* (29.150)
R-squared adj.	0.567	0.563
Observations	210	210

(***denotes significance at the 1% level against two sided alternative. The estimated coefficients without a* are not statistically significant at a level lower than 10%. Standard errors in parenthesis. AEW/E=Asia Europe West/East Bound; TPE/W=Trans-Pacific East/West Bound; TAE=Trans-Atlantic East Bound.)

Adjusted R-squared in both models is relevantly lower, as some of variance has been explained by inclusion of seasonality and model transformation. Since all dependent variables are stationarised series, an R-squared of great than 25% is often considered good fit. Taking into account of all these factors, 56% level of adjusted R-squared indicates the empirical model is well explained.

As results reveal, null hypothesis that zero coefficient of HHI is zero cannot be rejected even at 10% of significant level. The impact of HHI on Price (liner freight rate) may be zero. Price (liner freight rate) has diminishing relationship with volume and increasing relationship with bunker price. One point change of HHI results price (liner freight rate) to move downward by 0.009 points; one point of change in bunker price results price (liner freight rate) to increase 0.018 points.

The coefficients of route dummies have both positive and negative value, which implies that liner market in the six East-West routes is of different nature. The conclusion comply with real business practices that the competition situation in the westbound markets are generally different from that in the eastbound markets.

Interestingly seasonality dummy coefficient has negative value, which indicates liner freight rate in peak season is lower than non-peak season. Shippers, when have large volume of cargo to ship, tend to have more bargaining power in freight rate discussion. One would not expect this kind of activity in oligopolistic market.

2.6 Summary

This chapter uses panel data on six East-West routes in container liner shipping to estimate the responsiveness of freight rate to the change of market concentration level, demand and bunker price. The estimation procedures accommodate heteroskedasticity and endogeneity.

The results indicate formation of large alliances does cause market to be more concentrated, however the impact of market concentration level on freight rate is statistically insignificant. Market concentration level has weak diminishing relationship with liner freight rate. Since alliance member lines offer homogenous products, carriers compete to gain market share, as a result, price (liner freight rate) goes down. Formation of alliances makes it easy for liner operators to entry into and exit from a competitive market, liner market in alliance era is highly contestable.

Fusillo (2013) studies market share stability to characterize whether oligopolistic suppliers operate as a cartel. The author suggest carriers are forced to behave more competitively in post conference era. Higher level of concentration does not necessarily lead to reduced competition. This study empirically proves Fusillo's conclusion.

This study also finds static equilibrium does not exist. Equilibrium is established when price (freight rate) is approximately equal to marginal cost (MC). Since formation of alliance allows member lines to have a lower marginal cost, those member lines are profitable. However, with new entrants joined, supply curve becomes more flat, new equilibrium is established at lower price level. When price is too low for most carriers to be break even, some carriers opt to reduce capacity or withdrawn from certain routes (markets), slop of supply curve comes deeper, which shifts the equilibrium point upwards. Some carriers become profitable again. Nonetheless, the situation will not last long - equilibrium point shifts again with the movements of industry average cost triggered by technology advance or reforming of alliance.

Advent of large alliances brings constant increase in vessel size, which leads to constant lowering of unit costs. However large alliance cannot bring the rates up, in the long term rates tempt to decline. In conclusion, alliance does not hamper competition, but is rather a solution to lower unit operational cost hence to sustain the industry.

Chapter 3 Demand Elasticity and Competitive Conduct in Container Liner Shipping Market

This chapter follows Shaffer's (1982, 1983) demonstration of P-R test for the relationship of competitive conduct and demand elasticity, or H = E+1, where H is H statistic of P-R test and E is the demand elasticity across the entire market or industry. The H-statistic for container liner shipping industry calculated basis on estimated demand elasticity ranges from 0.72 to 0.79. The empirical result suggests that container Liner Shipping industry can be described as displaying monopolistic competitive behaviour, and is consistent with results of literatures using different methods.

3.1 Introduction

Methods to assess competitive conditions can be divided into two main streams: structural and non-structural approaches (Bikker 2004). Structural methods are based on the structure-conduct-performance (SCP) paradigm of Mason (1939) and Bain (1951), which predicts that more concentrated markets are more collusive. In structural models, competition is proxied by measures of concentration, such as the Herfindahl-Hirschman Index. Non-structural methods are derived from profit maximizing equilibrium conditions. The two well-known non-structural models are the Panzar-Rosse (P-R) test and the Bresnahan-Lau method. This study applies the implications of P-R test.

Panzar and Rosse (1987) developed H-statistic to measure the competitive structure of an industry. H-statistic is estimated as the sum of the elasticities of the reduced form (equilibrium) revenues with respect to input prices. It is interpreted as that if $H \leq 0$ then the market is monopoly. With perfect competition, $H = 1$. When $0 < H < 1$, the market is in monopolistic competition.

P-R model offers an advantage that it is easy to estimate with few independent variables. However it is challenging to gather enough data to perform P-R test for container liner industry. The alternative way of obtaining P-R H statistic is proposed by Shaffer (1982, 1983). Shaffer demonstrates the relationship of competitive conduct and demand elasticity. This chapter will follow Shaffer's demonstration to obtain P-R H statistics for container liner industry.

The structure of the article is as follows. Section 3.2 provides an overview of theoretical methodology, which is devoted largely to the alternative way of obtaining P-R H statistic. Section 3.3 discusses statistical methodology to obtain short-run and long-run demand elasticities. Section 3.4 describes the data, Section 3.5 presents the estimate results, and Section 3.6 contains a summary.

3.2 Literature Review and Theoretical Framework

The P-R test has been applied in many industries to assess competitive conduct, often in specifications of controlling for firm scale or using a price equation. The approach developed by Rosse – Panzar (1977) and Panzar – Rosse (1982, 1987) is based on the estimation of the reduced form revenue equation of the market participants R (z, r, w), with z denoting exogenous variables shifting the firm's revenue function, r denoting exogenous variables shifting the firm's cost function and w representing factor prices. The reduced form equation is derived from marginal revenue and cost functions and the zero profit constraint in equilibrium. The gist of this approach is the estimation of the elasticities of total revenues of the individual firm with respect to the firm's input prices. P-R H statistics is the sum of the partial elasticisties.

The P-R model (Rosse and Panzar 1977) is defined as,

$$\mathrm{H} = \mathrm{w}R_w/R = R_q^2/\Pi_{qq}R \qquad (3.1)$$

where subscripts denote partial derivatives.

For certain specific models, Rosse and Panzar (1987) show:

- Monopoly Rent Hypothesis: Under monopoly, H is non-positive.
- Market Equilibrium: If firms maximize profits and there are market forces (entry) that drive profits to zero, $H \leq 1$.
- Competition Hypothesis: For firms in long-run competitive equilibrium with free entry, $H = 1$.

P-R test is mainly applied to study competitive environment in banking industry (Shaffer 1982, 1983, Nathan and Neave 1991, Yildirim and Philippatos 2007, Bikker et al 2012 etc.). Shaffer (1982, 1983) shows that H is negative for a conjectural variations oligopolist or short-run competitor; and equal to unity for a natural monopoly in a contestable market or for a firm that maximizes sales subject to a breakeven constraint (Table 3.1).

Table 3.1. Properties of P-R H-statistic

	Average cost curve	
Assumption	**U-shaped**	**Constant**
Market structure		
Monopoly	H<0	H<0
Oligopoly	H<0	H<0
Long-run competition	H=1	H<0 or 0<H<1
Short-run competition	H<0 but 0<H<1possible	
Monopolistic competition	0<H<1 but H<0 possible	

Source: summarized from Shaffer 1982, 1983, Nathan and Neave 1991, Bikker et al. 2012.

There are two P-R test related studies made to container shipping industry. Endo (2005) estimates H statistic for top three Japanese container carriers (NYK Line, MOL, K-Line) during 1986 – 2002. The author defines a logarithm linear model derived from inductive revenue function with capital costs, labour costs, operation costs and deflated GNP as independent variables. The result of H statistics value is 0.54 which indicates the top three Japanese container carriers were unable to act as cartel, but rather operated in monopolistic competitive condition during the period researched. Sys et al. (2011) investigate the competitive conditions in container liner market for the period 1999 to 2008 (the period before the abolishment of the conference in 2008) for a sample of 18 container liner carriers. The authors find the H-statistic during that period varies from 0.68 to 0.87, which indicates container liner shipping operates in a monopolistic competitive environment. No relevant research has been identified for the period from 2009 and onwards.

To conduct P-R test, one estimates a reduced-form revenue function and then calculates the test statistic, H, which is the sum of the elasticities of revenue with respect to each of the factor prices.

The biggest challenge to conduct P-R test is to gather enough data. Shaffer's (1982, 1983) demonstrated an alternative way of obtaining P-R H statistics. The brief calculation steps are as follows.

First for the case of single-output, profit maximizing firm in the absence of a zero-profit condition, the firm's profit function is,

$$\Pi(q;w) = R\big(q(w)\big) - C(q,w) \qquad (3.2)$$

Where R is the firm's revenue function equal to output price times output quantity while quantity itself if a function of input prices, C is the firm's cost function, q is the firm's output quantity, and w is vector of input prices. Profit maximizing first order condition requires,

$$\Pi_q = R_q - C_q = 0 \qquad (3.3)$$

By definition the firm's elasticity of demand is $e = (p/q)(\partial q/\partial p)$ and R=pq, as such,

$$R_q = p + q\left(\frac{\partial p}{\partial q}\right) = p(\frac{e+1}{e}) \tag{3.4}$$

Substitute (3.4) into (3.2) to get,

$$\Pi_q = p(\frac{e+1}{e}) - C_q = 0 \tag{3.5}$$

Take second order condition,

$$\Pi_{qq} = -\frac{p}{e^2}\frac{\partial e}{\partial q} + (\frac{e+1}{e})\frac{\partial p}{\partial q} - C_{qq} \tag{3.6}$$

For locally constant demand elasticity ($\partial e/\partial p = 0$) and the firm's cost curve is locally linear ($C_{qq} = 0$), then the expression reduces to,

$$\Pi_{qq} = \left(\frac{e+1}{e}\right)\frac{\partial p}{\partial q} = \frac{p}{q}\frac{e+1}{e^2} \tag{3.7}$$

Substituting (3.4) (3.7) into (3.1),

$$H = R_q^2/\Pi_{qq}R = p^2(\frac{e+1}{e})^2 /R\frac{p}{q}\frac{e+1}{e^2} = \frac{pq}{R}(e+1) \tag{3.8}$$

Since R=pq, the expression reduces to,

$$H = e + 1 \tag{3.9}$$

This study applies Shaffer's method of obtaining P-R H statistic. The focus is then to estimate the demand elasticity most effectively.

3.3 Demand Elasticity in Container Liner Industry

Figure 3.1 and 3.2 demonstrate the movements of freight rate index (price) and actual volume of containers (demand) in the six East-West routes during 2009 to 2014.

Figure 3.1. Freight rate index movements in 2009 - 2014
Source: CTS

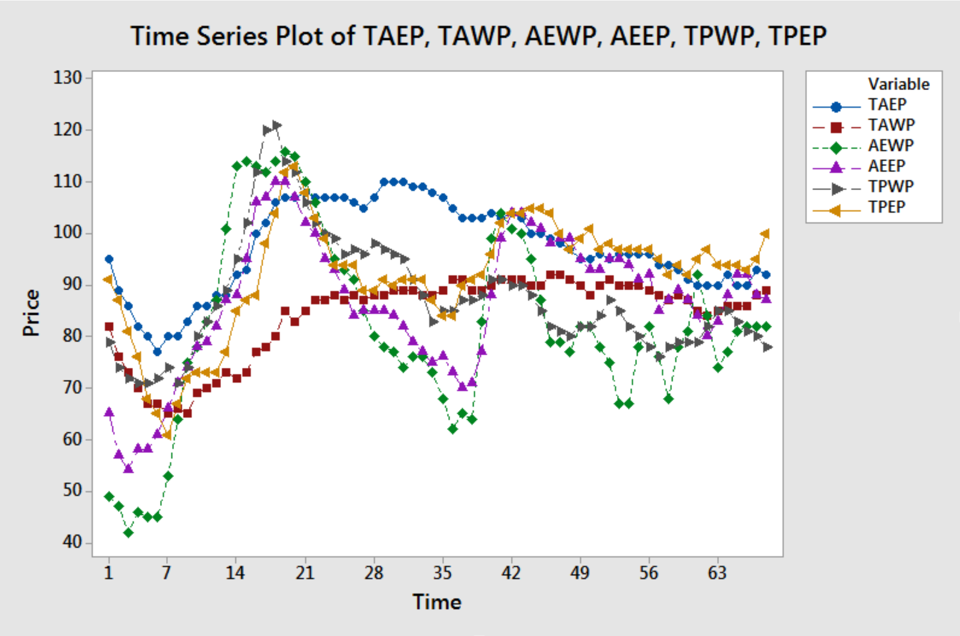
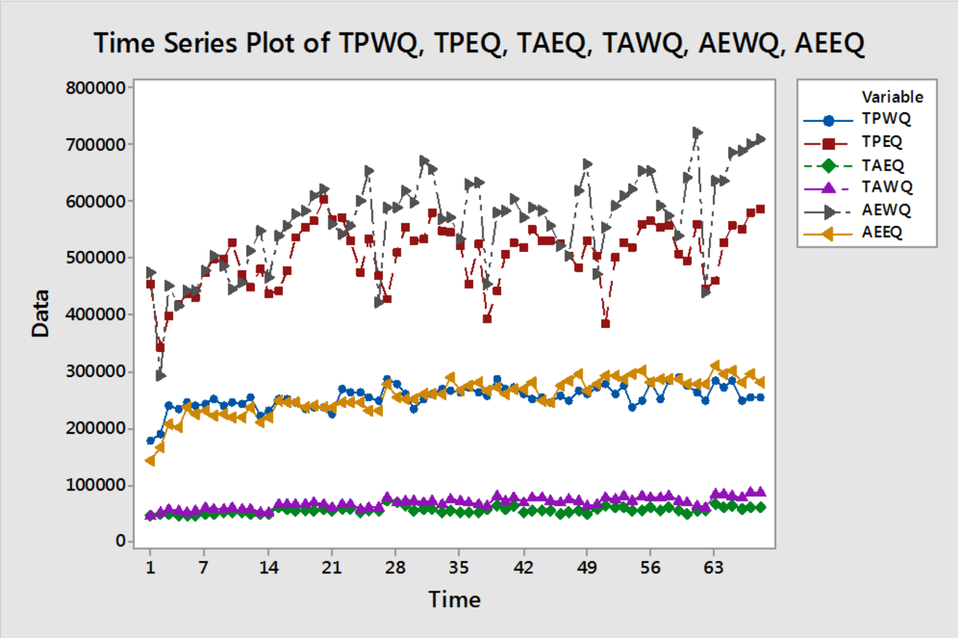


Figure 3.2. Demand movements in 2009 - 2014
Source: PIERS & CTS



Legends of figure 3.1 and 3.2:

TAEP: Trans-Atlantic Eastbound Price

TAEQ: Trans-Atlantic Eastbound Demand

TAWP: Trans-Atlantic Westbound Price

TAWQ: Trans-Atlantic Westbound Demand

AEWP: Asia Europe Westbound Price

AEWQ: Asia Europe Westbound Demand

AEEP: Asia Europe Eastbound Price

AEEQ: Asia Europe Eastbound Demand

TPWP: Trans-Pacific Westbound Price

TPWQ: Trans-Pacific Westbound Demand

TPEP: Trans-Pacific Eastbound Price

TPEQ: Trans-Pacific Eastbound Demand

The plots intuitively indicate different moving patterns in the six East-West routes over time. A static specification will not be sufficient, since it does not take into account the fact that behavioural change in response to changes in price may take time to come about. For example, movement towards equilibrium may be delayed due to imperfections in alternative transport markets, and stickiness in changes to loyalty contract. Thus, elasticity estimates from a static model only account for adjustments in the current time period and may actually produce short- or intermediate-run estimates.

To separate short-run and long-run responses in demand to a change in price, a dynamic model is applied in this study. There are several approaches to dynamic models (Oum et al. 1992, Maddala 1997, Graham et al. 2009) with varying lag specification nested. A simple Auto-regressive Distributed Lag (ADL) model is applied in this study to estimate the short-run and long-run elasticities.

First, define a basic double log model,

$$logD_t^* = b_0 + b_1\, logP_t + b_2\, logY_t + \nu_t \qquad (3.10)$$

where D_t^* is desired demand in FEUs (Forty-foot Equivalent Unit) at time t, P_t is real price. Y_t is GDP per capita and ν_t is an error term.

Since imperfection exists in container liner shipping market, adjustment of supply and costs agents cannot realize their desired holdings immediately. A partial adjustment model is applied to factor the delay of responses.

Since desired demand (D_t^*) is not observable, we cannot estimate the demand model directly. Denoting observed demand as D_t, the following equation holds,

$$logD_t - logD_{t-1} = \delta(logD_t^* - logD_{t-1}) \quad (\delta \leq 1) \qquad (3.11)$$

Where δ is the partial adjustment coefficient.

The partial adjustment hypotheses are,

$\delta = 1$ means observed changes are equal to desired changes in container capacity demand, or full adjustment.
$\delta < 1$ agents are only able to fulfil changes they desired partially.

Replace D_t^* and solve for D_t to get,

$$logD_t = \delta b_0 + \delta b_1\, logP_t + \delta\, b_2 log\, Y_t + (1-\delta)logD_{t-1} + \delta\nu_t \qquad (3.12)$$

This can be written as,

$$logD_t = \alpha + \beta\ logP_t + \theta\ logY_t + \gamma logD_{t-1} + \mu_t \qquad (3.13)$$

Where $\equiv\ b_0/\delta$, $\beta \equiv b_1/\delta$, $\theta \equiv\ b_2/\delta$, $\gamma \equiv 1-\delta$ and $\mu_t \equiv \nu_t/\delta$.

Increase P today in one unit will change D in β, which is the short-run effect.
In period t+1, D will continue to change, since past demand has an effect: γβ
In period t+2, another effect will be observed: $\gamma\gamma\beta = \gamma^2\beta$
……
Addition of all of these effects, or the long-run effect is then,

$$\beta + \beta\gamma + \beta\gamma^2 + \beta\gamma^3 + \cdots = \beta/(1-\gamma) \qquad (3.14)$$

Using panel data of six East-West routes, the model used for estimation in this chapter has the following form:

$$log\ D_{it} = \alpha + \beta log\ P_{it} + \theta logY_{it} + \gamma logD_{i,t-1} + \varepsilon_{it} \qquad (3.15)$$

Where *i*=1,…,6 (route subscript) and *t*=1,…,6 (year subscript).

β is the short-run price elasticity of demand and the long run elasticity equals to β/(1-γ).

3.4 Data and Variables

Table 3.2 summarises data sources and variable descriptions.

3.4.1 Demand (D)

Demand data (actual volumes of containers carried) for Trans-Pacific and Trans-Atlantic routes is sourced from PIERS. PIERS gathers raw data of waterborne cargo vessels that enter and exit ports in the United States, sourced by U.S. Customs and Border Protection. The raw data is subsequently verified, analysed, and synthesized with supplementary data sourced from The United Nations, United States Census and direct international country sources for use in PIERS trade intelligence tools. PIERS data is in FEU (Forty-foot Equivalent Unit).

Table 3.2. Variables and data sources

Variable	Description	Source
D	Demand, actual carried volumes in FEU	PIERS[14] & CTS[16]
P	Liner Freight Rate Indices	CTS [18]
Y	GDP per capita based on purchasing power parity (PPP) paper.	The World Bank

Demand data for Asia Europe routes is sourced from Container Trades Statistics (CTS). CTS database is derived from data supplied by many of the world's major container shipping lines. CTS uses the TEU (Twenty-foot Equivalent Unit) data provided to estimate total trade volumes for 447 global trades.

3.4.2 Price (P)

CTS APIs (Aggregated Price Indices) are applied. CTS APIs are weighted average of the sea freight rates including all surcharges and ancillary charges except inland haulage charges. It has 2008 price index value as 100.

3.4.3 GDP per capita (Y)

GDP per capita based on purchasing power parity (PPP) is sourced from the World Bank. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current international dollars based on the 2011 International Comparison Program (ICP) round.

Table 3.3 outlines the descriptive statistics of the regression variables.

Table 3.3. Descriptive statistics of the regression variables

Name	Mean	St. Dev	Minimum	Maximum
D	371750	371750	48018	1405900
P	88.34	11.13	60.00	109.00
Y	13582.00	969.55	12107.00	14923.00

3.5 Results

The short-run demand elasiticities for all of the six routes are statistically significant at 10% level against one-sided alternative (Table 3.4). The overall demand elasticities for the six East-West routes is statistically insignificant at a level lower than 10%, which may imply that levels of competition are different in the six routes.

Table 3.4. Regression results (Dependent varaible: $logD_t$)+

Variable	East-West Routes						
	TPW	TPE	TAE	TAW	AEW	AEE	ALL
$logP_t$ (β)	-0.626** (0.093)	-0.137** (0.012)	-0.213* (0.049)	-0.151** (0.017)	-0.572* (0.122)	-0.034* (0.010)	-0.263* (0.080)
$logY_t(\theta)$	-0.373* (0.078)	0.345* (0.087)	0.791* (0.234)	0.482* (0.127)	2.645* (0.601)	-0.098 (0.271)	0.665* (0.149)
$logD_{t-1}$ (γ)	-0.226 (0.128)	-0.364** (0.054)	-0.059 (0.106)	0.505** (0.062)	-1.044* (0.260)	0.728* (0.127)	-0.339 (0.123)
Constant (α)	21.643** (2.347)	15.269*** (0.301)	4.998* (1.077)	1.656* (0.497)	4.405 (2.033)	4.521* (1.062)	13.716** (1.308)
Durbin h-statistic	-0.904	-1.847	-1.383	-1.859	-1.715	-1.389	-1.143
R-squared adj.	0.899	0.435	0.125	0.992	0.285	0.966	0.712
Observations	42						

(***denotes significance at the 1% level against one-sided alternative. The estimated coefficients without a* are not statistically significant at a level lower than 10%. Standard errors in parenthesis. AEW/E=Asia Europe West/East Bound; TPE/W=Trans-Pacific East/West Bound; TAE/W=Trans-Atlantic East/West Bound.)

+ The results are estimated per route and bound without taking advantage of panel data. Due to low degree of freedom the implication has limitation. However, it clearly indicates different demand elasticity in east and west bound in each route.

Since lag variable of demand (D) is applied, Durbin h-test (appendix II) is applied to test autocorrelation between current D and lagged D. For a test of the null hypothesis of no autocorrelation against the two-sided alternative of autocorrelated errors, at a 5% level, the decision rule is if $-1.96 < h < 1.96$ the null hypothesis cannot be rejected. By applying this decision rule it can be seen that autocorrelation for the six routes cannot be rejected at 5% level of significance. At 10% significant level, the critical value is 1.645, in which circumstance autocorrelation in three routes TPE, TAW and AEW can be rejected. Taking a note that these three routes are the top three routes in terms of numbers of containers transported, the model is rather relevant.

There are a few possible causes for autocorrelation: (a) Durbin h-test is not accurate for small data samples like this case; (b) misspecification of model; (c) omitted variables and (d) systematic errors. Correcting autocorrelation is as such a potential future research area when large data sample becomes available.

Adjusted R-squared 0.712 is at high side in viewing to small sample size. All of the short-run and long-run P-R H-statistics are greater than zero and less than one (Table 3.5), which indicates container liner market is in monopolistic competitive condition.

Table 3.5. H-statistic for container liner industry

	E_{SR}	E_{LR}	H_{SR}	H_{LR}
TPW	-0.63	-0.51	0.37	0.49
TPE	-0.14	-0.10	0.86	0.90
TAE	-0.21	-0.20	0.79	0.90
TAW	-0.15	-0.31	0.85	0.69
AEW	-0.57	-0.28	0.43	0.72
AEE	-0.03	-0.12	0.97	0.88
The East West Routes	-0.28	-0.21	0.72	0.79

Notes:
E_{SR}: Short-run demand elasticity
E_{LR}: Longt-run demand elasticity
H_{SR}: Short-run P-R H statistic
H_{LR}: Long-run P-R H statistic

3.6 Summary

This chapter takes non-structural approach to test the short-run and long-run demand elasticities in container liner shipping industry during 2007 to 2014 in the six East-West routes. The degree of competition is further estimated following Shaffer's (1982, 1983) demonstration of the relationships between demand elasticity and P-R H statistic.

The empirical results suggest container liner shipping industry is in monopolistic competition. The outcome is consistent with previous studies for different periods made by Endo (2005) and Sys et al. (2011) that the container liner shipping market could be described as displaying monopolistic competitive behaviour.

Since CTS price indices have only been measured as of 2008, the study covers only 6 years period from 2009 to 2014, which is considered as relevantly short span in evaluating demand elasticities. Further research may be conducted to use alternative variables as proxies to study on longer time span.

There is a limitation in the study. As a matter of fact, many countries are involved in each route. For instance, cargoes transported in Asia Europe route could be trade between Asian countries, or between European countries, even some of African countries. The contribution of each country to the route can as such hardly be measured or weighed. Although world GDP per capita is applied in the model to absorb some of possible bias, measurement problem may still remain.

Chapter 4 The Effect of Container Liner Shipping on Economic Growth

In this chapter, unbalanced panel data are used to estimate how container liner shipping freight rate and liner connectivity influence economic growth for a sample of 31 countries over a seven-year period. The fixed and random effects are estimated by using the pooled ordinary least squares and feasible generalised least squares methods, respectively. The coefficients of both transport costs (using container liner freight rate as a proxy) and liner connectivity (liner shipping network integration level) are found to be statistically significant at the 5% level. Reducing transport costs do not contribute to GDP growth. Further, the estimated effect of liner connectivity on GDP growth is greater than that of container liner freight rate, which implies that an increase in liner connectivity could be more effective at stimulating trade growth. The main contribution of this study is thus quantifying the effects of the container liner shipping industry on economic growth.

4.1 Introduction

Liner container shipping has influenced global trade heavily over the past 50 years. Lower transport costs have allowed much lower value cargo to be traded as well as cargo from more remote areas to be sold in new markets. Consequently, container liner shipping industry has clearly contributed to trade growth in East Asia, notably in China. However, few studies have quantified these positive effects or explained their implications for the carriers and regulators in other regions.

Containerised transport has been a growing industry for the past 30 years. Between 1983 and 2006, world GDP growth was 4.8% per year, whereas container cargo growth averaged 10% per year (Stopford 2009). This trend has continued in recent years according to World Bank data with the exception of 2009 and 2011 when the industry suffered the effects of the global financial crisis. According to Alphaliner[11], global container volumes outstripped global GDP growth by 2.7 times during 2000 to 2009 and by 2.1 times in 2010 to 2012. This long history of rapid growth in containerised cargo has led to the expectation of continuous growth in the industry. However, the lengthy delivery time for newly built vessels of several years makes the market slow to adapt to increased demand, with subsequent huge fluctuations in revenues, as seen in the aftermath of the financial crisis in 2009.

This chapter uses unbalanced panel data for 31 countries over a seven-year period to estimate the relationships between container liner freight rate, liner connectivity, and economic growth. Estimating by using panel data offers a number of advantages. Firstly, such data provide a large number of observations on individuals and time, which makes the resulting estimates more efficient and asymptotically consistent. Secondly, panel data allow us to check the individual and time effects in a regression. This approach thus provides more variance than that contained in time series alone, allows for individual system-specific heterogeneity to address the problem of omitted variable bias, and can reduce the potential for multicollinearity and aid identification. However, crucially, for the purpose of this study, the key benefit of panel data is that they allow us to derive the consistent effect of liner shipping on economic growth despite missing time periods and unobserved effects. Hence, both the fixed effects (FE) and random effects (RE) of container liner freight rate and liner connectivity on economic growth are estimated. This statistical approach allows system-specific heterogeneity and accommodates endogenous regressors.

The rest of the chapter is organised as follows. Section 4.2 reviews the literature on line freight rate. Section 4.3 outlines the framework and model applied. Section 4.4 describes the data available for the estimation. Section 4.5 presents the results and the final section 4.6 concludes the chapter.

4.2 Literature Review and Theoretical Framework

Previous research has focused on the relationship between shipping and economic growth. Many scholars have pointed out that ocean freight rate plays an important role in economic growth. The contribution of shipping is often described as that it has significantly lowered transport costs. Ocean shipping makes it possible to transport large volumes to remote markets. The declining trend of ocean shipping costs up to World War I led to rapid growth in trade. Except during the collapse of the gold standard in the 1930s (Estevadeordal et al. 2002) and rapid development of air transport since the 1970s (Hummels 2007), ocean freight has shown a declining trend over time (North 1958, Hummels 2007). This declining cost of transportation has been critical to trade growth.

Several studies on the relationships of transport costs and economic growth are available. Sampson and Yeats (1977, 1978) assesse the incidence of international transport and tariff exports from Australia and the United Kingdom. The authors find that the trade barriers imposed by transport costs accentuated the role freight costs played in limiting international trade flows, which may indicate the importance of formulating measures to reduce transport costs in order to stimulate trade.

Radelet and Sachs (1998) propose a model that GDP growth is a function of shipping costs, ratio of coastal line to land area, openness and nature resource abundance. The authors find strong relationship between shipping costs and economic growth and suggest that geographic isolation and higher shipping costs may make it 'much more difficult if not impossible for relatively isolated countries to succeed in promoting manufactured exports'.

Raballand et al. (2005) explore the role of transportation costs in weakening trade between the European Union (EU) and Central Asia. The authors argue that transport costs play an important role in causing Central Asian countries to generate far less trade with the EU than their relative location would suggest.

Behar and Venables (2010) develop a model that trade as a function of income, policy and transport costs, where transport costs are determined by factors such as distance, geography, infrastructure, trade facilitation, technology, fuel costs. The authors suggest transport costs impact international trade and vice versa. Both are influenced by geography, technology, infrastructure, fuel costs and policy towards trade facilitation.

Bernhofen et al. (2013) suggest that containerisation stimulates trade in containerisable products (e.g. auto parts) and has complementary effects on non-containerisable products (e.g. automobiles). Research on modelling the relationship between GDP and liner transport costs has been scarce.

The framework applied in this chapter is derived from the macroeconomic identity. For any economy, GDP (Y) is the sum of consumption (C), investment (I), government spending (G), and net exports (NX). Hence, the following equations hold:

$$Y = C + I + G + NX \tag{4.1}$$

$$NX = EX - IM \tag{4.2}$$

where EX is exports and IM is imports. Since EX and IM are composed of commodity value (CV) and transport costs (TC), we write

$$EX = CV_e + TC_e \tag{4.3}$$

$$IM = CV_i + TC_i \tag{4.4}$$

By substituting (4.3) and (4.4) into (4.2), we have

$$NX = CV_e - CV_i + TC_e - TC_i \tag{4.5}$$

Since more than 75% of international transport is containerised (Notteboom and Rodrigue 2008), container liner freight rate index is used as a proxy of transport costs. Although there is a trade imbalance between inbound and outbound liner freight rates, they are proportional in the long-term. For instance, Asia/Europe eastbound freight rate is about 25% of westbound based on the World Container Index (WCI)[19]. Denote liner freight rate as *fr* and define it thus,

$$f(fr) = TC_e - TC_i \qquad (4.6)$$

By substituting (4.5) and (4.6) into (4.1), the below equation holds,

$$\mathrm{Y} = \mathrm{C} + \mathrm{I} + \mathrm{G} + CV_e - CV_i + f(fr) \qquad (4.7)$$

Equation (4.7) indicates the relationship between GDP and container liner freight rate (fr). It is then possible to measure the partial impact of liner freight rate on GDP.

4.3 Empirical Statistical Model

A few explanations need to be made to define the empirical model.

a) More than 75% of international transport is containerised (Notteboom and Rodrigue 2008).

b) Export transport costs and import transport costs are different and proportional in average, for instance, in average freight rate in Asia Europe eastbound route is about 25% of that in westbound route as per WCI.

c) The effects of the other factors (C, I, G, $\mathrm{CV_e}$, $\mathrm{CV_i}$)) are not measured in this model. GDP growth rate instead of GDP is applied in the model to eliminate omitted variable bias.

d) In addition, statistical measures are taken to control unobserved variable bias: control country factor in FE model and estimate with a RE model. (Wooldridge 2002).

The basic FE model as such can be written as,

$$gr_{it} = \gamma_0 + \gamma_1 fr_{it} + \theta_i \sum_{i=1}^{30} country_i + \varepsilon_{it} \quad (4.8)$$

Introducing another variable, namely liner service connectivity (*lcdi*, see the description in Section 4.3), controlling for bound (*bound*), country (*country*), and year (*yr*), and denoting GDP growth rate as *gr*, the estimated FE model has the following form:

$$gr_{it} = \gamma_0 + \gamma_1 fr_{it} + \gamma_2 lcdi_{it} + \eta bound + \theta_i \sum_{i=1}^{30} country_i + \tau_t \sum_{t=1}^{6} yr_t + \varepsilon_{it} \quad (4.9)$$

for *i* =1,…,30 and *t* =1,…,6 (*t* is the annual observation of country *i*), where ε_{it} is the error term. Because annual data are used, seasonal effects do not need to be modelled.

Since unbalanced panel data are used, a RE regression is performed to test whether the missing time periods are systematically related to the idiosyncratic errors. The RE model using the feasible generalised least squares (FGLS) estimation corrects serial correlation in the errors of multiple regressors (Wooldridge 2002, 2003). By using RE, one can thus efficiently account for any remaining serial correlation due to unobserved time-constant factors.

To derive the GLS transformation, first define a linear regression model with the composed error term,

$$y_{it} = \beta_0 + \beta_1 x_{it1} + \cdots + \beta_k x_{itk} + v_{it} \quad (4.10)$$

where $v_{it} = a_i + \mu_{it}$. Here, $a_i$is the unobserved effect fixed over time and μ_{it} is the idiosyncratic error serially correlated across time *t* and section *i*.

Under the RE assumptions,

$$Corr(v_{it}, v_{is}) = \sigma_\mu^2/(\sigma_\mu^2 + \sigma_\alpha^2), t \neq s \quad (4.11)$$

where $\sigma_u^2 = Var(u_{it})$, $\sigma_a^2 = Var(a_i)$.

Define,

$$\lambda = 1 - \left[\sigma_\mu^2/(\sigma_\mu^2 + T\sigma_\alpha^2)\right]^{1/2} \quad \text{[T=max(0, t)]} \quad (4.12)$$

which is between zero and one. Then, the transformed equation is written as

$$y_{it} - \lambda\bar{y_i} = \beta_0(1-\lambda) + \beta_1(x_{it1} - \lambda\bar{x}_{i1}) + \cdots + \beta_k(x_{itk} - \lambda\bar{x}_{ik}) + (v_{it} - \lambda\bar{v}_i) \quad (4.13)$$

where the overbar denotes the time averages. The RE transformation subtracts a proportion of that time average, where the proportion depends on $\sigma_u^2 = Var(u_{it})$, $\sigma_a^2 = Var(a_i)$, and the number of time periods.

The transformation in (4.13) allows for constant explanatory variables over time, which is one advantage of RE models over FE models. This is possible because RE assumes that the unobserved effect is uncorrelated with all the explanatory variables, whether fixed over time or not. If the full set of RE assumptions holds, the RE estimator is asymptotically more efficient than the FE one.

The autocorrelation AR(1) is applied to obtain the value of parameter $\hat{\lambda}$. The RE estimator is the GLS estimator that uses $\hat{\lambda}$ instead of λ.

Finally, Hausman (1978) specification test (Appendix I) is applied to test the difference between the RE and FE estimates. This study also uses Hausman's method to test the exogeneity of the variables.

4.4 Data and Variables

Table 4.1 summarises data sources and variable description.

Table 4.1. Variables and data sources

Variable	Description	Source
gr	GDP growth at market prices	The World Bank
fr	Container Liner Freight Rate Index	Drewry [19]
lcdi	Liner Service Connectivity Index	UNCTAD

4.4.1 GDP Growth (gr)

GDP growth is sourced from the World Bank. It is calculated as the annual percentage growth rate of GDP at market prices based on a constant local currency. Aggregates are based on constant 2005 U.S. dollars. No deductions for the depreciation of fabricated assets or for the depletion and degradation of natural resources are made. As noted earlier, GDP growth rate instead of GDP or GDP per capita is adopted in the models to eliminate possible unobserved variable bias.

4.4.2 Container Liner Freight Rate Index (fr)

This variable is measured with the freight rate index reported by Drewry's WCI for the period of 2007 to 2013. This reports the actual spot container freight rates for the major East–West trade routes. The indices are reported in USD per 40 feet container, while WCI rates are reported on a container yard to container yard basis inclusive of surcharges associated with the transport of goods.

In common practice, container liner freight rate is offered based on the main ports (MP) concept. For instance, the rates per 40 feet dry container from East Asian MP to North European MP are typically the same. By contrast, rates to non-MP or outports are often offered with a standard add-on to MP rates and fluctuate in line with the MP rate. Hence, all available container freight rate indices report fluctuations in the MP rate. Of the 11 route-specific indices reported by the WCI, four MP-based routes of larger volumes are chosen. The fours routes are from Shanghai to Rotterdam (one of the MP in North Europe), to Genoa (one of the MP in the Mediterranean), to Los Angeles (one of the MP on the West Coast of the United States), and to New York (one of the MP on the East Coast of the United States).

4.4.3 Liner Service Connectivity Index (lcdi)

This index captures the extent to which countries are connected to global shipping networks. It is computed by UNCTAD based on five components of the maritime transport sector: (a) the number of ships; (b) the total container-carrying capacity of those ships; (c) the maximum vessel size; (d) the number of services; and (e) the number of companies that deploy container ships on services from and to a country's ports. For each component, a country's value is divided by the maximum value of each component in 2004. The five components are then averaged for each country, and the average is divided by the maximum average for 2004 and multiplied by 100. The index generates a value of 100 for the country with the highest average index in 2004.

Assuming that higher liner connectivity stimulates trade activities, the coefficient of *lcdi* is expected to be positive. Basis on the routes selected, the countries involved are China, where the load port Shanghai is located, and 30 other countries (Appendix III) in Europe and North America where the destination ports are located.

4.4.4 Control Variables: year (yr), country (country) and bound (bound) dummies

Country is controlled in the FE model to eliminate possible bias caused by omitted variable. Taking account of liner freight rate cycles (Stopford 2009, Wijnolst and Wergeland 2009), *year* is further controlled to test the potential time impact.

In container liner shipping market, the trade nature is different for inbound (import) and outbound (export) market. As such, *bound* dummy variable is controlled to test the effect of the trade imbalance on economic growth. The *bound* dummy has a value of zero if the country's outbound freight rate level is higher than its inbound freight rate level (or the export containerised volume is greater than the import containerised volume) and one otherwise.

The data available (Table 4.2) for the estimation are for 2007–2013 for 22 countries in Europe and eight countries in North America, in addition to China where the port of loading is located.

Table 4.2. Descriptive Statistics of the Regression Variables

Name	Mean	St. Dev	Minimum	Maximum
gr	1.14	4.39	-17.96	14.16
fr	40.52	35.57	2.40	157.51
lcdi	2495.00	652.51	1362.00	3321.00

4.5 Results

The Hausman statistic (Appendix I) for *fr and lcdi* is 6.16 distributed chi-square with a 1 degree of freedom. Given that the 5% critical value is 3.84, the two variables are thus exogenous. Our models are therefore consistent.

The feasible GLS parameter obtained by using AR(1) is 0.496. Since OLS and FGLS are different estimation procedures, the parameters in the estimation results vary. The Hausman statistic for the OLS and FGLS estimates is 0.837 distributed chi-square with 9 degrees of freedom. Hence, the null hypothesis holds at 1% significance level, which indicates that both models are consistent and that the FGLS estimate is more efficient. The FGLS estimator is thus preferred to the OLS estimator since it has a smaller standard deviation and the FGLS test statistics are asymptotically valid. The RE results estimated by FGLS suggest *fr* (liner freight rate) is statistically significant at the 5% level, ceteris paribus one percentage point increase in *fr* increases *gr* (GDP growth) by approximately 0.0014 percentage points (Table 4.3). The full estimate results are listed in Appendix IV.

Table 4.3. Regression results (Dependent variable: *gr*)

Variable	FE OLS	RE Feasible GLS(λ=0.496)
Fr	0.0026*** (0.001)	0.0014** (0.001)
Lcdi	-0.0333 (0.045)	0.0187** (0.009)
Bound	2.9531*** (1.100)	4.1502*** (0.831)
yr08	-1.9067** (0.764)	-2.3440*** (0.602)
yr09	-4.9628*** (1.539)	-6.9051*** (1.198)
yr10	-2.6944*** (0.730)	-2.7116*** (0.749)
yr11	1.2401 (1.266)	-0.2998 (1.069)
yr12	-2.7726*** (0.949)	-3.8731*** (0.870)
yr13	-1.6537 (1.176)	-3.2079*** (1.010)
Constant	-2.6782 (3.196)	-1.0809 (2.084)
R-squared adj.	0.499	0.435
Observations	217	217

***denotes significance at the 1% level against the two-sided alternative. The estimated coefficients without a* are not statistically significant at a level lower than 10%. Standard errors in parentheses.

The RE regression results also show that *lcdi* (liner connectivity) are statistically significant at the 5% level. Ceteris paribus one point increase in *lcdi* increases *gr* (GDP growth) by 0.0187 percentage points. Moreover, the coefficients of the *bound* dummy in both models are statistically significant at the 1% level. The effect of inbound volumes have on GDP growth is about four times of that the outbound volumes.

Compared with 2007, except 2011, the impacts of the other years are less than that of 2007. This finding concurs with the occurrence of the global financial crisis in 2008 and Eurozone meltdown in 2011.

Interestingly the coefficient of *lcdi* has opposite sign in the FE and RE models. Globalisation raises the incentive for manufacturers to produce in countries with relevant low-cost access. This trend impacts GDP growth rate in all countries involved. The non-positive relationship of *lcdi* and *gr* (GDP growth) in the FE model reflects the impact of globalisation on trade growth. The positive coefficient of *lcdi* in the RE model matches the expectation on the relationship of the two variables as addressed in section 4.4.4.

The test results for the trade imbalance suggest that inbound (import) trade volumes have a larger impact on economic growth than outbound (export) trade volumes. This finding may be explained that in addition to the effect of logistics flows on GDP, the domestic consumption of import goods promotes economic growth. The main contribution of this study is thus quantifying the relationship between liner shipping and economic growth in terms of liner transport costs and liner connectivity.

4.6 Summary

This study uses unbalanced panel data on container liner freight rate and liner service connectivity to estimate the responsiveness of GDP growth to changes in liner shipping factors. An unbalanced panel estimation accommodates individual system-specific heterogeneity, endogenous regressors, and measurement error. Therefore, compared with the FE model, the results from the RE model are more efficient.

The empirical results reveal that the effect of liner freight rate on GDP growth is statistically significant at the 5% level and that the effect of liner freight rate (transport costs) is non-negative in contrast to the conclusions of the studies reviewed in Section 2. This non-decreasing relationship suggests that reducing transport costs does not contribute to GDP growth. Further, the coefficient of liner connectivity is statistically significant, positive, and substantially higher than that of liner freight rate. The implication of this finding is that an increase in liner connectivity may be more effective at stimulating economic growth.

This study also finds that import and export has different level of impact on GDP growth. Import trade volumes have a larger impact on economic growth than export trade volumes. In addition, globalisation of product manufacturing has impact on the growth rate of GDP in countries involved.

This study has two limitations. First, the freight rate data used are container liner freight rate indices for the Shanghai–Europe and Shanghai–US routes published by Drewry. The choice of these routes is limited by data availability. Although acknowledging that outport rates are formed as the MP rate plus an add-on, the choice may still lead to bias or measurement problems because sample countries do not have similar proportions of import and export trade on these routes. Second, country-level data is used without considering the trade volume of each country, which may bias the conclusions drawn. Future research may thus aim to deflate the weighting of a country’s trade volume in the model as well as identify more independent variables.

Chapter 5 Conclusion and Future Research

Ocean shipping since its birth has significantly contributed to world trade growth. Invention of container ship further reduces transport cost through cargo containerisation. More than 75% of world trade volumes are carried in containers (Notteboom and Rodrigue 2008). Container liner shipping industry is undoubtedly one of the most important sectors in world transport. It is of great value to study market structure of contemporary container liner industry as well as its impact to economic growth.

This dissertation contributes to above subject, applying to both industrial statistics and academic theories. It contains three studies. The first research tests the effect of market concentration level on container liner freight rates. The result suggests contemporary container liner market is contestable. The second research taking non-structural approach explores the degree of competition in container liner market. The degree of competition measured by P-R H statistic ranges from 0.72 to 0.79, which implies container liner market is in oligopolistic competition. The conclusion is consistent with that in previous research. The last research quantifies the contribution of container liner shipping to economic growth. The empirical results imply that reduction of liner freight rate does not contribute to trade growth. With majority of trade volumes containerised, and overall decreasing trend of transport costs during the entire ocean shipping history, transport costs have reached to a valley point. Further reduction of transport costs would not contribute to trade growth.

5.1 Method and Major Outcome

One of the major outcomes is to empirically prove that container liner shipping market is competitive during the period researched. The result reveals that formation of large alliance does not hamper competition. Instead, it offers a solution to carriers to lower unit operational cost hence to survive deteriorated freight rate market. The conclusion offers insights to policy maker, since market structure is important information for policy-making. The conclusion also offers great reference to carriers, since market structure determines carrier's behaviour in the market.

The second major outcome is to find that static equilibrium does not exist in contemporary container liner shipping market. Formation of alliance allows member lines to enjoy lower level of marginal cost, until new entrants joined. When price is too low for most carriers to be break even, some carriers opt to reduce capacity or withdrawn from certain markets (routes). As such, equilibrium point shifts with the movements of industry average cost triggered by technology advance or reforming of alliance.

The third major outcome is to estimate the short-run and long-run demand elasticity and the degree of competition in latest container liner shipping market. Research on demand elasticity of container liner shipping sector has been scarce. This study does not only provide a preliminary research of demand elasticity for container industry, but also separates short-run and long-run effects. The empirical results suggest that container Liner Shipping industry could be described as displaying monopolistic competitive behaviour. Comparing with conclusions from previous research, an increasing trend of P-R H statistic in the industry, which may be interpreted as that container liner industry encounters increasing degree of competitiveness.

The final major outcome is to quantify the effects of container liner industry on economic growth. Different from conclusions in relevant previous research literature, this study indicated reducing transport costs do not contribute to trade growth.

5.2 Originality and Impacts of Study

All of the three studies in the dissertation apply data for container liner shipping market in last seven years. Methods applied in the research differs from those used in previous literature in two perspectives. First, the dynamic model applied in chapter 3 separates short-run and long-run demand elasticities. Second, the macroeconomic that approach applied in chapter 4 that quantify the relationship of liner freight and GDP growth. To the best of my knowledge, this series of studies in the dissertation are the only ones that quantify container liner shipping market during the corresponding period.

The study also contributes to new way of evaluation to the effect of container liner industry on economic growth. The conclusion drawn from chapter 4 differs from those in previous study. Transport costs have been overall declining over entire ocean shipping history, except in 1930s during the collapse of gold standard and in 1970s when the aviation industry developed rapidly. Current market has little room for transport costs to further decline. Instead increasing of transport cost concurs with a country's economy growth.

5.3 Limitations of Study

The limitations are twofold. First, the data available for estimation is for the period from 2008 onwards when the container liner freight rate indices have been measured. Six to seven years of time span is relevantly short in evaluating the market behaviours in container liner shipping industry.

The second limitation is missing measurement of country specific effect. The studies focus on each market (route) in container liner shipping industry. During to existence of transhipment cargo, unspecified countries may contribute to the transport in the market. There is no effective way available to deflate each country's contribution. Unobserved country effects are partially absorbed by including country dummies in chapter 4 and applying world average GDP per capita in chapter 3, nonetheless the solution may still cause statistic bias or measurement problems.

5.4 Future Prospects

More than 75% of world transport has been containerised (Notteboom and Rodrigue 2008), and the trend is expected to increase with advancement of technology. Containers are invented to carry goods in temperate as low as minus 60 Celsius degree or with air supply for live fishes. The increasing ratio of containerisation calls for thorough study to the industry in depth. The knowledge gap between industrial professionals and academic scholars needs to be constantly narrowed.

The scope of future study is expected to investigate the container liner freight rate structure and to elicit the role of container liner shipping industry for economy. The potential topics for further study include:

a. Identification and quantification of factors influencing liner freight rate movements.

b. Forecast of container liner freight rate market and shipping cycles.

c. Continuous investigation on the role of container liner shipping industry to economic growth.

Notes

[1]Shanghai Container Freight Index (SFCI) has officially been measured as of October 16th 2009. http://en.sse.net.cn/indices/ccfinew.jsp

[2]Greg Knowler, 2015, CMA CGM signs exclusivity deal for NOL acquisition. http://www.joc.com/maritime-news/container-lines/cma-cgm/cma-cgm-signs-exclusivity-deal-nol-acquisition_20151122.html

[3]EUROPEAN LINERS AFFAIRS ASSOCIATION, 2003, The European Commission Consultation Paper on the Review of Council Regulation (EEC) 4056/86 of 22nd December 1986.

[4]The Code was adopted in Geneva in April 1974, to become effective six months after ratification by at least 24 nations controlling 25% of the world's tonnage. UNCTAD, United Nations Conference of Plenipotentiaries on a Code of Conduct for Liner Conferences, vol. II, Final Act(including the Convention and resolutions) and tonnage requirements Annex I (Art. 49) at 18, U.N.Doe. TD/CODE/13/Add. 1 (1975) [http://unctad.org/en/PublicationsLibrary/tdcode13add.1_en.pdf]. This was accomplished in April 1983, when 58 countries representing 28.6% of the world's liner tonnage (measured in 1974) had ratified the UNCTAD Code. For a list of signatories see, 22 Int'l Leg. Mat. 1227.

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[11]http://www.alphaliner.com/

[12]Source: Compare data & carrier websites.

[13]U.S. Department of Justice and the Federal Trade Commission, 2010. Horizontal Merger Guidelines. http://www.justice.gov/atr/public/guidelines/hmg-2010.html#5c

[14]http://www.joc.com/group/joc-group/piers

[15]http://www.drewry.co.uk/publications/view_publication.php?id=358

[16]https://www.containerstatistics.com/

[17]Data for 2008 is not available.

[18]CTS APIs (Aggregated Price Indices) are weighted average of the sea freight rates including all surcharges and ancillary charges except inland haulage charges. Price index: 2008 =100. https://www.containerstatistics.com/faq#api1

[19]The World Container Index assessed by Drewry reports actual spot container freight rates for major East West trade routes. http://www.worldcontainerindex.com/index.php?mode=staticContent&id=methodology

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Appendices

I. Hausman Specification Test

In the empirical model if the causal relationship between HHI and Q exists, the OLS estimation would be biased. To test exogeneity of the two variables, Hausman (1978) specification test is applied by comparing instrumental variable (IV) estimates to ordinary least squares (OLS) estimates. The Hausman specification test compares the difference between the two estimators. Under the null hypotheses, IV and OLS converge to the same value, but OLS will be more efficient. Under the alternate hypothesis, they will converge to different value.

To apply Hausman inspection test, first define an IV model with Z representing the function of Q and HHI, where HHI is an instrument variable:

$$logP = \beta_0 + \beta_1 Z + \varepsilon \qquad \text{(App.1)}$$

Then define the OLS model as:

$$logP = \alpha_0 + \alpha_1 logQ + \upsilon \qquad \text{(App.2)}$$

Next use Hausman specification test to decide whether the instrument improves the estimation as following equation (App.2) distributed chi-square with 1 degree of freedom.

$$H = \frac{(\hat{\beta}_1 - \hat{\alpha}_1)^2}{var(\hat{\alpha}_1) - var(\hat{\alpha}_1)} \sim \chi_1^2 \qquad \text{(App.3)}$$

Where $\hat{\beta}_1$ and $\hat{\beta}_1$ are the coefficients of the IV and OLS model respectively. Under the null hypothesis, the two variables Q and HHI are exogenous. But under the alternative hypothesis the two variables are endogenous and OLS will be biased and inconsistent.

II. Durbin h-test

The most popular test for autocorrelation is the Durbin-Watson (DW) test. DW test is only applicable to first order Autoregressive systems. If there is a lagged endogenous variable, Durbin h-test should be applied instead.

Durbin h-test is calculated basis on DW-test. First for DW test, consider a model,

$$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \varepsilon_t \qquad \text{(App.4)}$$

And suppose,

$$\varepsilon_t = \rho\, \varepsilon_{t-1} + v_t \qquad \text{where,} \qquad |\rho| \leq 1 \qquad \text{(App.5)}$$

where ρ is the autocorrelation coefficient and v_t is a random error.

The null hypothesis Ho: $\rho = 0$ (no serial correlation)

The alternative hypothesis Ha: $\rho \neq 0$

To test the hypothesis DW calculates an estimate of ρ from the regression residuals:

$$DW = \frac{\sum_{t=2}^{N} (\hat{\varepsilon}_t - \hat{\varepsilon}_{t-1})^2}{\sum_{t=1}^{N} \hat{\varepsilon}_t^2} \qquad \text{(App.6)}$$

The DW statistics lies in the range zero to 4.

$0 \leq DW \leq 4$.

It can be shown that,

$$DW \approx 2(1-\hat{\rho}) \quad \text{(App.7)}$$

When $\hat{\rho}=0$ (no serial correlation) DW = 2

When $\hat{\rho}$ tends to 1 (perfect positive first order serial correlation) DW = 0

When $\hat{\rho}$ tends to -1 (perfect negative first order serial correlation) DW = 4

Durbin h-statistic can be obtained in following manner:

Estimate a model with OLS:

$$Y_t = \alpha + \gamma X_t + \beta Y_{t-1} + \varepsilon_t \quad \text{(App.8)}$$

The Durbin h-statistic is defined as:

$$h = \hat{\rho}\sqrt{\frac{T}{1-T[Var(\hat{\beta})]}} \quad \text{(App.9)}$$

T = the number of observations

$\hat{\rho}$ = the estimated correlation coefficient of the residuals, that is the autocorrelation coefficient of the residuals

$Var(\hat{\beta})$ = the variance of the coefficient on the lagged dependent variable

Solving for $\hat{\rho}$ and substituting, the Durbin **h-**statistic can be written as:

$$h = \left(1-\frac{DW}{2}\right)\sqrt{\frac{T}{1-T[Var(\hat{\beta})]}} \quad \text{(App.10)}$$

Durbin h-statistic is approximately normally distributed with a unit variance, hence the test for first order serial correlation can be done using the standard normal distribution. However, as it well self-explains, that if $T[Var(\hat{\beta})]$ is greater than one, then the ratio with the square root becomes negative and this test cannot be applied.

III. List of countries (Chapter 4)

CONTINENT	COUNTRY	CONTINENT	COUNTRY
North America	Antigua and Barbuda	Europe	Germany
North America	Bahamas	Europe	Greece
North America	Belize	Europe	Ireland
North America	Canada	Europe	Italy
North America	Honduras	Europe	Latvia
North America	Panama	Europe	Lithuania
North America	St Vincent and the Grenadines	Europe	Malta
North America	United States	Europe	Netherlands
Europe	Belgium	Europe	Poland
Europe	Bulgaria	Europe	Portugal
Europe	Cyprus	Europe	Romania
Europe	Denmark	Europe	Slovenia
Europe	Estonia	Europe	Spain
Europe	Finland	Europe	Sweden
Europe	France	Europe	United Kingdom

IV. Full estimation results (Chapter 4)

GDP Growth	Fixed Effects (OLS)		Random Effects (Feasible GLS)	
Variable	Coef.	SE	Coef.	SE
p	0.0026***	0.0009	0.0014**	0.0006
lcdi	-0.0333	0.0445	0.0187**	0.0093
bound	2.9531***	1.0999	4.1502***	0.8312
yr08	-1.9067**	0.7645	-2.3440***	0.6022
yr09	-4.9628***	1.5394	-6.9051***	1.1984
yr10	-2.6944***	0.7304	-2.7116***	0.7486
yr11	1.2401	1.2664	-0.2998	1.0694
yr12	-2.7726***	0.9491	-3.8731***	0.8699
yr13	-1.6537	1.1760	-3.2079***	1.0103
cn2	5.8325***	1.8088	-	-
cn3	6.8483***	1.4818	-	-
cn4	7.8721***	2.2536	-	-
cn5	7.6088***	1.5080	-	-
cn6	12.6105***	2.2750	-	-
cn7	2.2347	1.4759	-	-
cn8	8.8797**	4.0005	-	-
cn9	9.6429**	3.7770	-	-
cn10	7.9783***	1.5263	-	-
cn11	17.6712***	6.5783	-	-
cn12	6.7615***	1.6144	-	-
cn13	6.6371***	1.9362	-	-
cn14	6.9892***	1.5269	-	-
cn15	6.5353***	1.5566	-	-
cn16	9.0464***	3.3270	-	-
cn17	10.0612**	4.1156	-	-
cn18	3.6824**	2.1212	-	-
cn19	6.1658***	1.5440	-	-
cn20	7.2423**	3.0925	-	-
cn21	8.1329***	1.5376	-	-
cn22	6.5440***	1.5259	-	-

GDP Growth	Fixed Effects (OLS)		Random Effects (Feasible GLS)	
Variable	**Coef.**	**SE**	**Coef.**	**SE**
cn23	9.5438***	2.1816	-	-
cn24	9.5383**	4.0774	-	-
cn25	10.5356***	1.7545	-	-
cn26	6.5696***	2.0680	-	-
cn27	8.6463***	1.7429	-	-
cn28	6.8295***	1.6731	-	-
cn29	8.1333**	3.4121	-	-
cn30	8.3191***	2.0466	-	-
cn31	9.4452**	3.8823	-	-
constant	-10.5021***	3.0230	-1.0809	2.0837

***denotes significance at the 1% level against the two-sided alternative. The estimated coefficients without a* are not statistically significant at a level lower than 10%. Standard errors in parentheses.

V. Abbreviations of liner carriers, conference and shipping alliances

APL	American President Lines, Ltd. (merged into NOL in 1997)
ChoYang	Cho Yang Shipping Co. Ltd.
COSCO	China Ocean Shipping Company
CSG	China Shipping Group
DSR/Senator	DSR/Senator Lines, GmbH
Evergreen	Evergreen Marine Corp. (Taiwan) Ltd.
E-W routes	Six East-West routes are Asia Europe Westbound (AEW) and Eastbound (AEE), Trans-Pacific Eastbound (TPE) and Westbound (TPW), Trans-Atlantic Eastbound (TAE) and Westbound (TAW)
Hanjin	Hanjin Shipping Company Ltd.
Hapag Lloyd	Hapag-Lloyd Containerlinie GmbH
HYMM	Hyundai Merchant Marine Co., Ltd.
K-Line	Kawasaki Kisen Kaish Ltd.
Maersk	A. P. Moller-Maersk, also known as APMM
MSC	Mediterranean Shipping Co. SA
MOL	Mitsui-OSK Lines Ltd.
Nedlloyd	Nedlloyd Lines
NOL	Neptune Orient Lines Ltd. (Acquired APL in 1997)
NYK	Nippon Yusen Kaisha
OOCL	Orient Overseas Container Line
P&O	P&O Containers Ltd. (Acquired by APMM in 2005)
UASC	United Arab Shipping Company
Sealand	Sea-Land Service, Inc. (Merged by APMM in 1999)
Yang Ming	Yang Ming Marine Transport Corp.

FEFC	Far Eastern Freight Conference
2M	Alliance consists of carrier Maersk Line and MSC
CKYHE	Alliance consists of COSCO, K-Line, Yang Ming, Hanjin, Evergreen
G6	Alliance consists of six carriers namely NYK, Hapag, OOCL, APL, HYMM, MOL
O3	Alliance consists of three carriers namely CMA, CSG, UASC

Appendix VI Ranking of top 20 container liner carriers

Source: Alphaliner 2015

Rank	Operator	TEU	Ships	% Share
1	APM-Maersk	2,959,743	609	16.0%
2	Mediterranean Shg Co	2,546,719	499	13.8%
3	CMA CGM Group	1,713,852	457	9.3%
4	Evergreen Line	963,214	202	5.2%
5	Hapag-Lloyd	956,883	181	5.2%
6	COSCO Container L.	826,470	164	4.5%
7	CSCL	715,733	142	3.9%
8	Hanjin Shipping	626,533	101	3.4%
9	MOL	603,966	111	3.3%
10	Hamburg Süd Group	576,073	121	3.1%
11	OOCL	546,405	102	3.0%
12	APL	546,100	89	3.0%
13	NYK Line	498,808	106	2.7%
14	Yang Ming Marine Transport Corp.	463,329	96	2.5%
15	UASC	410,104	56	2.2%
16	K Line	398,963	77	2.2%
17	Hyundai M.M.	377,060	57	2.0%
18	PIL (Pacific Int. Line)	358,082	153	1.9%
19	Zim	325,439	75	1.8%
20	Wan Hai Lines	202,067	87	1.1%