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Research on formation of strategic alliance and its effect on container lines' efficiency

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DECLARATION

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

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

(Signature): ………………………….

(Date):…………………………..

Supervised by

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ABSTRACT

Title of Research paper: **Research on formation of strategic alliance and its effect on container lines' efficiency**

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Shipping lines operate their fleets under circumstances of various uncertainties. To achieve diverse objectives including maximizing operating profit and minimizing operating costs in this unpredictable liner market, shipping lines have made use of collaboration strategy by forming or joining strategic alliances rather than competing with rival lines over the last two decades. These strategic alliances have an enormous influence on the liner market as well as on the performance of liner businesses. However, the actual benefits of a strategic alliance group toward its member companies are unclear. In this regard, this paper measured two types of relative efficiencies, which are financial and operational efficiencies for six shipping lines, COSCO, K Line, Yang Ming Line, Hanjin Shipping, Evergreen Line, and Maersk Line from 2010 to 2015. The researcher uses Data Envelopment Analysis (DEA) to assess the efficiencies. In particular, the output-oriented Charnes, Cooper and Rhodes (CCR), and Banker, Charnes and Cooper (BCC) models are used to attain technical efficiency, pure technical efficiency, and scale efficiency. To evaluate the financial efficiency, two inputs (total fixed assets and operating costs) are used as and two outputs (gross revenues and operating incomes) are employed. For measuring operational performance, two inputs (operating capacity and number of vessels) are chosen and two outputs (net revenue and total handled volume) are applied. The study showed that Maersk Line is the most efficient line financially and COSCO and K Line are the most efficient in their fleet operations of the six lines. In addition, joining a strategic alliance had a negative influence on Evergreen Line's financial and operational efficiency. This paper also deals with the overview of the restructuring strategic alliances, which are 2M, OCEAN and THE Alliance, with comparisons among three alliances.

KEYWORDS: Liner shipping industry, strategic alliance, data envelopment analysis (DEA), financial efficiency, operational efficiency

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LIST OF ABBREVIATIONS

APL	American President Lines
BCC	Bancker, Charnes and Cooper
BCC-O	Output-oriented Bancker, Charnes and Cooper model
BIMCO	Baltic and International Maritime Council
CCR	Charnes, Cooper and Rhrodes
CCR-O	Output-oriented Charnes, Cooper and Rhrodesmodel
CKY alliance	COSCO, K Line, and Yang Ming
CKYH alliance	COSCO, K Line, Yang Ming, and Hanjin
CKYHE alliance	COSCO, K Line, Yang Ming, Hanjin, and Evergreen
CMA CGM	Maritime Freighting Company – General Maritime Company
CNY	Chinese Yuan
COSCO	China Ocean Shipping Corporation
CRS	Constant Returns-to-Scale
CSCL	China Shipping Container Lines
DEA	Data Envelopment Analysis
DKK	Danish Krone
DMUs	Decision Making Units
DRS	Decreasing Returns-to-Scale
E.U	European Union
GAAP	General Accepted Accounting Principles
GDP	Gross Domestic Product
HMM	Hyundai Merchant Marine
IFO	Intermediate Fuel Oil
IFRS	International Financial Reporting Standards
IRS	Increasing Returns-to-Scale
JPY	Japanese Yen
JVOC	Joint Vessel Operating Centre
KRW	South Korean Won
LP	Linear Programming
MISC	Malaysia International Shipping Company

MOFCOM	China's Ministry of Commerce
MOL	Mitsui O.S.K Lines
MSC	Mediterranean Shipping Company
NOL	Neptune Orient Lines
NYK	Nippon Yusen Kaisha
OECD	Organization for Economic Cooperation and Development
OOCL	Orient Overseas Container Line
OSRA	Ocean Shipping Reform Act
P&O	Peninsular and Oriental Steam Navigation Company
PTE	Pure Technical Efficiency
RTS	Returns-To-Scale
SE	Scale Efficiency
TE	Technical Efficiency
TEU	Twenty-Foot Equivalent Unit
TWD	Taiwan New Dollar
UASC	United Arab Shipping Company
UNCTAD	United Nations Conference of Trade and Development
USD	United States Dollar
VRS	Variable Returns-to-Scale
2M	Maersk Line and Mediterranean Shipping Company

Chapter 1 Introduction

1.1 Background

The shipping industry plays an important role in the growth of international trades, which leads to developments on national economies around the world. Remarkably, the proliferation of global trade and the growth of the world economy are directly related to the advance of liner services by shipping companies with maintaining competitiveness while providing efficient and effective transportation to various customers. Stopford (2009) gives a definition of the liner business.

> A liner service is a fleet of ships, with a common ownership or management, which provide a fixed service, at regular intervals, between named ports, and offer transport to any goods in the catchment area served by those ports and ready for transit by their sailing dates. A fixed itinerary, inclusion in a regular service, and the obligation to accept cargo from all comers and to sail, whether filled or not, on the date fixed by a published schedule are what distinguish the liner from the tramp.

The amount of cargo volume traded by shipping lines has been grown along with the global economy. According to Notteboom (2012), the shipping industry has witnessed spectacular growth in container trade, fueled by the globalization process and the large-scale adoption of the container.This situation has causedlines to extend their market coverage globally as well asto escalatetheir fleets. Because of this, container shipping companies have burdens to satisfy diverse customers with the fact that offering new service routes and deploying more vessels are needed, which both cost a lot of money. In addition to this circumstance, there is huge competition between lines. All of this makes it difficult for the shipping companies to follow the customers' requirements and make a profit in the severe business place.

Container shipping is a very capital-intensive industry, in which some assets are owned and others leased and there exists a wide variability in cost bases (Brooks, 2000). As mentioned above, to satisfy customers, lines should invest in ships. Therefore, asset management is a key part of container shipping companies for operational and commercial success. Container shipping lines are particularly challenged to develop an effective asset management program, which includes the procurement, acquisition, deployment, and disposal of container vessels (Notteboom, 2012). Once linesinvest in fleet expansion and liner service networks, there is pressure to fill the ships with containerized cargo because the unused capacity on them cannot be stored and used in the future. Moreover, volatile revenues caused by trade imbalances and seasonal cycles also make it difficult for lines to manage their operating incomes.

Shipping companies often cooperate with each other in order to cope with various problems, including the aforementioned things. The first steps along the path of cooperation are taken in the form of loose operational agreements. Depending on the degree of collaboration, these can be classified into five broad groups: space purchase, space exchange, cost pooling, revenue pooling, and revenue and marketing pools (Packard, 1995). In the 1990s, strategic alliances were initially formedby lines, and they substituted conferences, which were used for freight rate unity to secure lines' profit because of the declining antitrust immunity. Trade agreements in the form of liner conferences were very common until the European Commission outlawed these forms of cooperation in October 2008 (Notteboom, 2012). Strategic alliancesoffers container shipping companies various benefits such as risk sharing, investment sharing, wider geographical scope, and entry into new markets. Majorliner shipping firms, which provide global services, have formed or joined the strategic alliances since they appeared in the liner industry. Presently, there are four major alliances: 2M, Ocean three(O3), CKYHE, and G6, whose membership consists of sixteen of the twenty largest shipping firms by capacity, collectively controlling 75 percent of the global shipping capacity (Bockrath and Arnord, 2015). Likewise, the groups of strategic alliances have an enormous influence on the international liner service market as well as shipping lines' financial and operational strategies. Of course, there is a negative point of view toward the strategic alliances for reasons such as market domination by oligopolistic behaviors. However, it is quite important for lines to make use of the alliance as a strategy to increase profits and reduce costs. The groups of alliances are taking a significant position in liner society because most major lines are willing to stay within the boundaries of strategic alliances; these days, the restructuring of the strategic alliances is becoming a hot issue in the shipping industry. Two new groups of strategic alliances will enter liner market next year, and it can be expected that the liner service market will be changed tremendously by the three strategic alliances.

1.2 Purpose of research

This research will identify whether joining or forming a strategic alliance in liner shipping industry can improve the productivity and profitability of the member companies. According to Farrell (1957), firms' productivity can be measured by the ratio of outputs to inputs. A firm can improve its productivity by increasing outputs, decreasing inputs, or doing both, and many research papers mentioned that a strategic alliance helps the member companies to reduce the number of inputs through sharing resources, and to increase outputs through synergy and cooperation among members. This implies that shipping lines are able to attain better productivity and profitability after joining a strategic alliance. So as to identify the influence of a strategic alliance on the member companies, I will measure an alteration of efficiency for six shipping lines, which are COSCO, K Line, Yang Ming, Hanjin, Evergreen, and Maersk,from 2010 to 2015. Among the six firms, COSCO, K Line, Yang Ming, and Hanjin were members of CKYH alliance until 2013, and with one more line, Evergreen, they were formed CKYHE alliance in 2014. Maersk was the biggest international liner service company in terms of operating capacity throughout the whole test period.

Evergreen Line used to have a go-it-alone strategy. However, in 2014, the company changed its management strategy towardworking together with other competitors toform strategic alliances like other major lines. It is not strange consideringsixteen of the twenty largest shipping firms by capacity operate their fleet with other lines by cooperating as members of a strategic alliance, and they control 75% of the global shipping capacity. In this regard, I will examine some motivations for joining or forming strategic alliances. In addition, I will examine thetransition of lines' efficiency before and after joining or forming strategic alliance.

Strategic alliances have been changed theirstructure by shuffling of member firms through newly forming or dissolving alliances. This means that the strategic alliances are not permanent cooperative groups. Nowadays, shipping lines announce that they will form and operate their fleets under the groups of new strategic alliances. In this regard, I will review the latest changes of the liner industry along with the restructure of strategic alliances.

To achieve these purposes, in the next chapter, I will review literature that is related to the subject of strategic alliance and the methodology, which will be utilized to measure shipping lines' efficiency. In chapter 3, this dissertation will cover the general characteristics of the international liner shipping industry, and it will contain a brief history of the formation of strategic alliances by dividing the whole period into four generations. Next, in chapter 4, I will investigate the strategic alliance itself, in detail, such as the definition, various objections to choose to form or join strategic alliances from the lines' point of views, and some drawbacks of the alliance. In addition, I will look into Evergreen Line regarding operating strategies and history of cooperation with other firms as a case study. In chapter 5, I will measure the two types of efficiencies of six lines, which are financial and operational efficiency for the period from 2010 to 2015 by data envelopment analysis (DEA). The results of the analysis will be included in chapter 6. The next chapter, will contain a general overview on restructuring of strategic alliances and a general analysis on three alliances (2M, OCEAN alliance, and THE alliance). Finally, I will end this research with a conclusion in chapter 8.

1.3 Methodology

The main purpose of this research paper is to measure the efficiencies of six lines. Generally, for assessment efficiency, an equation of output variable divided by input variable is applied. However, calculating the efficiencies is complex for shipping lines with more than one input and output variable. In this regard, the Data Envelopment Analysis (DEA) tool has drawn researchers' attentions because it is a non-parametric technique used in operating research and econometrics for multivariate frontier estimation and ranking, which can be used for calculating apparent efficiency levels within a group of organizations (Panayies et al, 2009). It can be exploited to analyze relative efficiency with multiple input and output variables. Therefore, I will adapt DEA to assess the relative efficiency among the six shipping lines. To do so, I will use the input and output variables as follows.

- Input variable for DEA

1) Fixed asset
2) Operating cost
3) Total operating capacity
4) Number of vessels

- Output variable for DEA

1) Gross revenue
2) Operating income
3) Handled volume of cargo
4) Net revenue

Chapter 2 Literature review

The objective of this chapter is to review research papers in the past related to a topic of strategic alliance in liner shipping industry and non-shipping industry, and to look through how the data envelopment analysis tool was used for research in shipping and non-shipping industry. The literature reviews will be categorized into two parts. One part will be regarding strategic alliance which is the key topic in my research paper, the other will be about the methodology, data envelopment analysis, used to measure the efficiency and performance for both the shipping industry and Non-shipping industry.

2.1 Previous research into strategic alliance

2.1.1 Liner shipping industry

Bockrath (2015) examined how changes in the liner shipping sector's market structure have impacted the global trading system. The author did the research by empirically examining how shipping alliances have impacted bilateral trade flows from January 2011 to February 2015 by identifying the alliance behavior on a route level and a trade level. To examine the relationship between liner shipping alliances and trade flows, this researcher used a gravity model, which integrating variables to measure the intensity of alliance activity. The empirical results suggested that shipping alliances appears to be inhibiting bilateral trade in a manner consistent with the exercise of market power, although this negative result does not hold for every alliance. Analysis of the major alliances revealed that they do not substantially vary in their commercial behavior but did substantially vary in how frequently alliance members deviate from the alliance structure, suggesting this result was being driven by differences in how effectively an alliance can control its members.

Tan and Thai (2014) studied the knowledge sharing mechanisms presented within liner shipping alliances, and identified how knowledge sharing positively impact on the firm's performance using the qualitative method of face to face in-depth interviews.

Gao, Yoshida and Choi (2014) investigated the effect of alliance onprofit rate in the Japanese liner shipping industry by Porter's five forces analysis and empirical analysis with data in 1990, 2000, and 2010. They found that alliances pull down the freight rate, which is not caused by changing the market concentration, but by the worsening of the supply and demand balance and reducing costs by the development of large-sized ships. They contributed to providing evidence for the effect of the alliance on the profit rate in the liner shipping industry. However, this empirical study only focuses on two Japanese shipping companies, NYK and MOL.

Song and Panayides (2002) applied cooperative game theory to analyze cooperation among members of liner shipping strategic alliance. In addition, they included in their research paper various objectives of forming global shipping strategic alliances and methods to have alliance stability and efficiency. The authors proved two thing using cooperative game theory in this paper. One is whether the shipping lines will have the cooperative strategy by forming strategic alliance or having go-it-alone strategy. The other one is why the shipping alliances tend to be unstable.

Huang and Yoshida (2013) reviewed important academic journals for the past decade regarding to the most important reasons to form the alliances. The authors explained the motive of alliances and details of shipping cooperation. They identified strategic alliance restructure in four different perspectives, which were the service quality perspective, the management perspective, the market structure perspective, and the strategic perspective, in the major carrier's view point to survive in the harsh market.

They also empirically investigated the key service quality requirements improved through alliances by using quality function deployment (QFD). The results were that the top four service quality requirements improved are business reputation, less transit time, intermodal service and cheaper service.

Das (2011) identified and tested specific factors (synergy type, nature of resources, redundant resources, market uncertainty, and market competition) that influence liner shipping firms in their strategic choice between partnerships and acquisitions. Cox regressions were used for the analysis, results are that two factors, the extent of redundant resources and the intensity of competition, increase the likelihood of the choice of acquisition, while a third factor, the nature of resources, affects the likelihood of acquisition in an inverted-U shaped manner. In addition, the home region of a firm and prior acquisition experience increases the probability of acquisitions while prior partnership experience decrease it. The level of synergy and degree of market uncertainty do not affect the mode of alliance choice.

Slack, Comtois, Mccalla and Slack (2002) examined developments in liner shipping in terms of the formation of strategic alliances by the leading companies. They focused on the transformation of services, the evolution of the fleet, and the adjustments made to the ports of call to examine container shipping development in the three specific years, 1989, 1994, and 1999.

Chen and Yahalom (2013) studied slot co-allocation planning for a joint fleet in a round trip for a shipping alliance in the liner shipping industry. A large-scale integer programming model is formulated to guide carriers in an alliance in pursuing an optimal slot co-allocation strategy. For this model application, a joint fleet of two shipping lines, COSCO and Hanjin Shipping, at an Asia-Europe trade route was used as a case study. They found that the slot co-allocation model outcome is consistent with the shipping alliance performance outcomes.

Ryoo and Thanopoulou (1999) suggests that alliances are a distinct form of cooperation for Asian carriers, which they can benefit from, in order to face the challenges by the changes on the demand side of container trades. They said alliance, as all cooperation forms, can prove powerful tool for adapting to the changing circumstances of the Asian Trades, and coordination and adaptation to changing volumes and required frequency is optimized as the number of vessels inside the cooperation is increased. Also, they mentioned that alliance participation may also prove not only a more flexible but also a quicker tool for adapting to market conditions in changing times. The empirical evidence based on a survey was only about the perception of alliances and of the benefits of alliance participation by only a specific group of Asian carriers sharing a common geographical origin.

Midoro and Pitto (2000) examined the key reasons why shipping companies join at strategic alliances and argued that their current structure may prove inherently inadequate to remain stability. Organizational complexity of the alliance and establishment of an intra-alliance competition were the key forces driving the strategic alliance unstable. Two authors explained building stable alliances that were reduction in number of partners, differentiation in their roles and contribution and coordination of sales and marketing activities. Authors expected more mergers and take-overs realized until a new generation of more efficient and stable alliance will be made.

Ding (2009) applied the modified extent analysis method of fuzzy AHP approach for selecting suitable partners of strategic alliance for a liner shipping company. To find out the most appropriate company for selecting the partner of strategic alliance based on the proposed fuzzy AHP algorithm, the author studied an empirical survey of lines. To facilitate the selecting a partner, the author developed a hierarchical structure of partner selection for a liner shipping company with seven criteria, thirty-two sub criteria and three alternatives.

Panayides and Wiedmer (2011) examined the structure and conduct of strategic alliances, Grand Alliance, New World Alliance and CKYH Alliance, in container liner shipping with the service characteristics of the top 20 container shipping in 2010. In addition, authors identified the motives for the formation of alliances in liner shipping by examining over a ten-year period the announcements of companies forming or agreeing the alliance partnership and the reason that the companies themselves provide as motive for its formation.

2.1.2 Non-shipping industry

Xu and Ruan (2012) discussed the construction of Shapley Value and its economy implication, on which the rent of alliance, and the benefit of alliance system was studied. The result proved that the member of alliance with competitive resource could gain the most individual rent of enterprise alliance.

Lin (2013) used data envelopment analysis and stochastic frontier analysis to assess the airlines' technical efficiency, while panel regression analysis for airline productivity and profitability. The author focused on 20 international airlines between 1995 and 2005 periods from two main categories: allied airlines, which included three global airline strategic alliances, and non-allied airlines. The author found that joining an airline strategic alliance group generally will have positive effects on its member airlines' technical efficiency, productivity and profitability. However, the results was not statistically significant, which meant that the effects of an airline alliance group are practically unimportant to the airline performance during the study period. Also, the author suggested that the number of alliance member do not always have a positive impact on the airline performance, size of the alliance should be considered.

2.2 Previous research using Data Envelopment Analysis

2.2.1 Shipping industry

Chou and Lee (2007) applied a performance index to the evaluation of shipping alliance competitiveness using Multidimensional Scale Method (MDS), which include DEA'S strength that is in simultaneously considering multiple inputs and outputs without any need for a priori assignment of weight. They used data for five shipping alliances and two operation zones in 1999. They wrote in this paper that with these performance indices, shipping alliances can identify their strength and weakness as well as competitive positions by the output/input by aggregating the performance indices.

Bang, Kang, Martin and Woo (2012) examined the impact of operational and strategic management on financial and operational efficiency using a two-stage DEA approach, which combined the DEA and Tobit regression. To measure the operational efficiency, the authors used the number of ships and fleet capacity in TEUs as inputs and capacity in TEUs carried by lines as an output variable for DEA analysis. To calculate the finance efficiency, they had total assets and capital expenditure as input variables and revenues and operating profits as output variables. Using the DEA tool, they showed the efficiency scores of financial and operational models for 14 lines out of top 20 container lines in terms of fleet capacity in 2008. The results from the Tobit regression were that the firm size, ship size, the ratio of chartered vessels, use of new vessels, and the formation of alliances all make a positive contribution to the financial performance of shipping lines. Ship age and ship type did not show a significant contribution to the financial performance and for the operational performance.

Panayides el al (2011) measured the relative efficiency for shipping companies in the dry bulk, wet bulk and container sectors using Data Envelopment Analysis and Stochastic Frontier Analysis. The research paper showed that productivity and market efficiency are two different measures of performance efficiency. The results showed that some companies or sectors may be highly productivity efficient but not market efficient in the same level, or vice versa.

Hsu, Chung, Lee and Sherman (2013) measured the performance of seven tramp shipping companies using network data envelopment analysis and balance score cards. To check the efficiency of the tramp shipping companies, they used 10 variables of inputs and outputs, which are fixed assets, current assets, operating costs, non-operating expenses, total assets turnover, cash flow ratio, operating revenue, non-operating revenue, earnings per share and net income.

Bang and Kang (2011) evaluated performances for 12 ocean carriers by data envelopment analysis. Static-efficiency analysis is adapted to assess financial and operational performance with 3 inputs and 3 outputs in 2007, and dynamic-efficiency analysis are used to show the stability and trend of efficiency by DEA-Window model between 2004 and 2007.

Lee and Kim (2006) measured the relative efficiency of 50 Korean shipping companies using data envelopment analysis. They applied CCR-O and BCC-O models to evaluate the efficiency in 2004. Number of employee, fixed assets and total capital are used as inputs variables, and total revenue, operating income and net income are utilized as output variable. In addition, they applied DEA-Window model to assess the trend and stability of 12 shipping companies for the period from 1995 to 2004.

2.2.2 Non-shipping industry

Panayides, Maxoulis, Wang and Ng (2009) identified certain limitations in the application of DEA for seaport efficiency measurement. A key issue identified in the paper was the need for researchers to decide on the number of inputs and outputs to be used in the model in relation to sample size. Authors mentioned that greater number of inputs/outputs is desirable in order to capture the complexity of port production, however, the sample size must be adequate otherwise results may be biased. They also highlighted the limitations of using cross-sectional data.

Somogyi, R, M. (2011) examined how the DEA method is applied in the transport sector such as airports, ports, railways and airlines. The author collected 69 cases with DEA applications and classified 69 cases into inputs and outputs variables.

Bhagavath, V. (2006) investigated technical efficiency for 44 of state road transport undertakings in India using a variable retune to scale model of data envelopment analysis. Fleet size, average kilometers traveled per bus per day and cost per bus per day were used as input variables, and revenue per bus per day was used as output variable.

Chapter 3 Liner shipping industry

3.1 General characteristics of container shipping industry

The container shipping is a kind of maritime transport similar to train or bus as means of transportation with fixed schedules, designated ports of call and named ships, which it has the core activity the delivery of unitized container boxes. The first modern container vessel, Ideal X, was launched by Malcolm McLean who developed the modern intermodal shipping container, half-century ago. This time was considered the beginning of container shipping era. The containership was rarely used in the early period of liner shipping, however, in the mid of 1960s, the container shipping industry developed drastically because of the introduction of standard container sizes resulted from an economic motivation for higher productivity and the awareness of the shipping lines about the benefits of using containerships like saving a lot of time of loading and discharging cargos by container boxes.

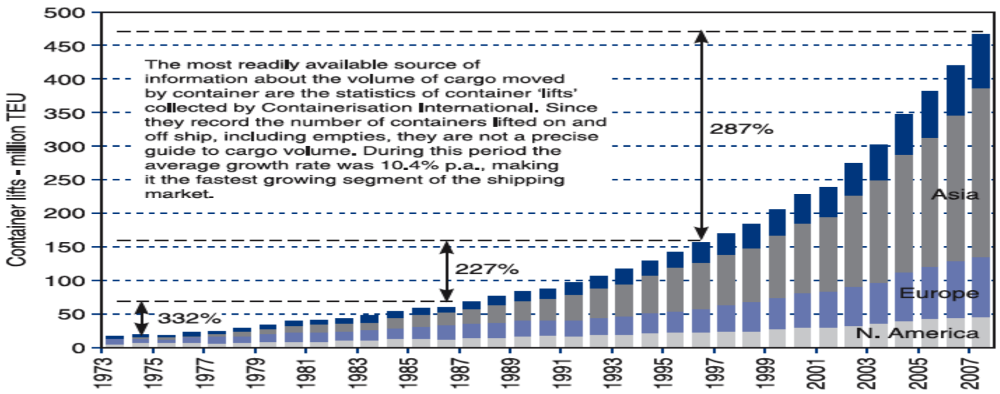


Figure 1Growth of liner trade, 1973 ~ 2007

Source: Stopford (2009)

The amount of containerized cargo grew rapidly from 1975 to 2007 in Figure 1. It started from 14.1 million TEU, the number of container lifted, in 1975, and it reached to about 470 million TEU for 32 years. The average growth rate between 1990 and 2007 is 10.4 percentage year by year.

The increasing world GDP rate due to the economic growth of developing countries is one of the driving forces increasing the amount of merchandise trade and the world seaborne trade. More and more economic growth for nations, people want to have more stuff for better living condition. This kinds of the economic activities of countries have expended foreign trade among countries, it affects demand of the maritime transports such as bulk carriers, gas carrier and oil carrier. The increasing demand for container shipping is also affected by the requirement to carry particular kinds of goods.

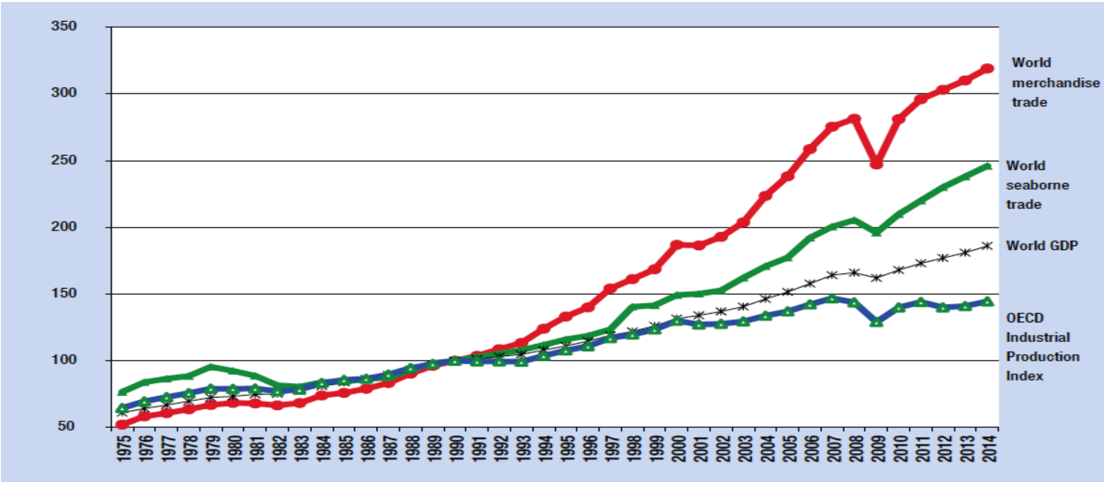
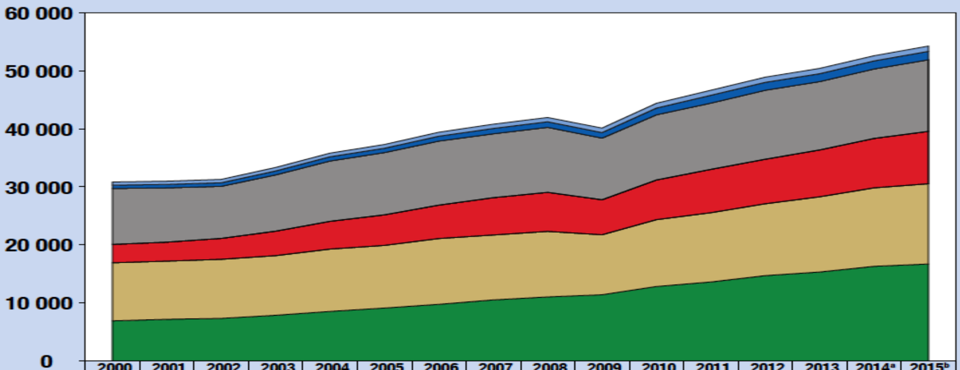


Figure 2Merchandise trade and seaborne shipments, 1975 – 2014 (1990 = 100)

Source: UNCTAD (2015) Review of maritime transport 2015

The diagram, Figure 2, shows four kinds of index, which are world merchandise trade, world seaborne trade, world GDP and OECD industrial production between 1975 and 2014. The trend for all indices are similar that they mostly indicate going-up trend except the years from 1979 to 1982 and from 2007 to 2009. This means that increasing the world GDP and the OECD industrial production played the key role on growing for world merchandise trade and world seaborne trade.

With increasing demand for international trade, the amount of various cargoes delivered by maritime transportation has been increased as well. The ton-mile unit offers a more accurate measure of demand for shipping services and tonnage as it takes into account distance, which determines ships' transportation capacity over time (UNCTAD, 2015). Figure 3 represents the phenomenon of international ocean trade in terms of ton-miles by cargo types from 2000 to 2015. It shows that the numbers of ton-miles for containerized cargo as well as the other type of cargos are rising over the whole period except the year of 2009, which the financial crisis hugely affected the world economic negatively and the trade amount by the maritime transportation was diminished.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014[a]	2015[b]
Chemicals	552	562	593	606	625	651	689	724	736	765	824	864	889	908	899	912
Gas	576	591	611	662	719	736	833	913	956	958	1 147	1 344	1 346	1 347	1 382	1 444
Oil	9 631	9 352	8 971	9 698	10 393	10 729	11 036	11 011	11 200	10 621	11 237	11 417	11 890	11 779	11 969	12 339
Container	3 170	3 271	3 601	4 216	4 785	5 269	5 757	6 422	6 734	6 030	6 833	7 469	7 673	8 076	8 514	9 024
Other (minor bulks & other)	9 998	10 023	10 167	10 275	10 729	10 782	11 330	11 186	11 272	10 325	11 504	11 927	12 375	12 952	13 514	13 833
Five main dry bulks	6 896	7 158	7 331	7 852	8 527	9 107	9 745	10 503	11 028	11 400	12 824	13 596	14 691	15 312	16 294	16 685

Figure 3World seaborne trade in cargo ton-mile by cargo type (billions of ton-miles)

Source: UNCTAD (2015) Review of maritime transport 2015

The growth rate of demand for delivery of containerized cargo has been faster than that of the other types of cargo, shipping lines have been applied various operational strategies over time from go-it-alone strategy, which denotes doing things alone independently, to cooperation between rival companies through types of formation from conferences to strategic alliance. Especially, topics related to the strategic alliance in liner shipping industry draw public attention nowadays because a number of shipping lines, which have high market shares in markets, are involved in the strategic alliances as members, and it has been said that they influence on the competitiveness and the financial performance of container shipping companies. Through this research paper, I will examine some reasons and motivations on forming or banding of strategic alliances and how much they will affect the companies' operational and financial performances. Before going further, I will explain distinct characteristics that make shipping lines co-operate with rival firms firstly.

3.1.1 Globalization

Since the Second World War, world trade has grown much more rapidly than the world production has. A main reason is that trade barriers to the free flow of goods, services and capital among countries have generally been diminishing after the 1960's and the rapid and continuous development of transport and telecommunication technology. Especially, the development of new transport technology and the continuous decrease of transport cost due to improved productivities have led to the formation of the global integrated market place (Shuo, 2015). This trends have an effects on the formation of globalization. Globalization does not entail only a dispersal of the production process to various geographic locations to take advantage of differences in cost and quality of productive factors, but also converging consumer tastes and preferences, leading to the emergence of global brands (Midoro and Pitto, 2000). The globalization has played a critical role on change of companies' operational strategies in line with transformation of thinking toward the world as one huge market and that competitions in liner shipping industries are international. The result of the conversion of ideas by the globalization alter the container shipping firms to satisfy their customers based on over the world. This means that the shipping lines need to increase and expand their services in terms of frequency, schedule reliability, global coverage of services and appropriate rate setting. Brooks (2000) mentioned that the liner shipping industry has witnessed enormous changes due to the globalization, which affected variously such as new logistics needs by shippers and higher requirements for operational flexibility as well as for an expanded geographical coverage of trading service routes. According to Ryoo and Thanopoulou (1999), as the globalization of the modern economy has become a common phenomenon, so the pressure for cooperation that can reduce costs, share the risk of over committing capital, add to market coverage and increase market control through the combined activities of what would have been individual competitors.

3.1.2 Economies of scale

While there may be several reasons for cooperation among shipping lines, the main reason for collaboration with rival firms is to achieve economies of scale.

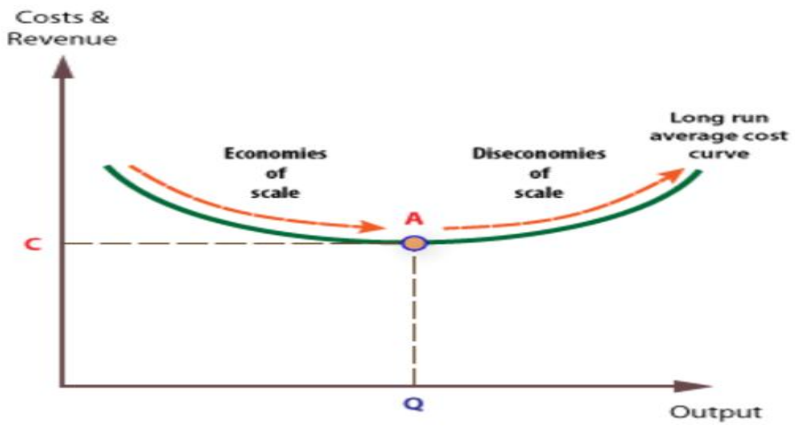


Figure 4Long run average cost curve

Source: www.economicsonline.co.uk

The first left part of green line from dot A in Figure 4 shows the economies of scales, which it exists when a production cost (cost & revenue, vertical axis) of a product decreases when the number of units (output, horizontal axis) produced increases. To make most use of the scale economies for companies in the liner shipping industry, two methods can be taken, which are by adaptation of intrinsic and extrinsic strategies.

(1) Extrinsic strategy

After beginning with the containerization revolution in the 1950s, innovation has brought about important changes to the shipping sector. The scope for reaching economies of scale has led the major trends for shipping lines, which it regarded as a main characteristics of container shipping industry, ranging from looser agreements of slot chartering to more integrated cooperation such as strategic alliance, consolidation, and merger and acquisition, which they can be called horizontal integration. It refers to cooperation between two or more companies competing in the same sector or market (Hill et al, 2014). In addition, shipping lines try to exploit scale economies by vertical integration, which it refers consolidation of supply chain. The major liner shipping players such as Maersk Line, Hanjin Shipping, and COSCO are making use of the scale economy by horizontal and vertical integrations.

The horizontal integration in liner shipping can be divided two parts, which are cooperation on rates and cooperation on operational matters. The former type of horizontal integration is that for the purpose of regulating and restricting competition in order to achieve relative stability on rates, and offer regular and reasonable frequency of sailings. The conference system can be categorized into this type of horizontal integration. The latter type integration is the cooperation among container shipping companies in order to have benefits such as cost reduction and global coverage of liner services without price-fixing. Slot chartering agreement, vessel sharing agreement, consortia, strategic alliances and merger and acquisition are included into this type of horizontal integration. There are some advantages and disadvantages of horizontal cooperation with rival company below.

- Advantages of horizontal cooperation of liner shipping industry
  1) Monopolistically competitive market economies of scale
  2) Cost control: slot sharing, terminal sharing, improvement of utilization
  3) Expansion by lower capital investment
  4) Alternative method to upgrade fleet-optimal age, optimal size, optimal structure
  5) More clients and network
  6) Stronger bargaining power
- Disadvantages of horizontal cooperation

1) Anti-trust by authorities

2) Business overlap

3) Lack of flexibility

4) Loss of corporate independence

On the other hands, the vertical integration in shipping lines is differently approached by extending the shipping services to port terminals, storage and inland transport. Purchasing a container leasing company by a shipping line or buying a shipping companies by a freight forwarder can be examples of vertical integration. Figure 5 shows the process of integration levels. The circles indicate logistic chain in each process for cargo flow from a sender to a final customer. The level of integration among entities are increasing from top to bottom. With an increasing level of integration intermediate steps in the transport chains are removed. The highest integration level is seen in the bottom, which indicate the mega carrier developed by merge and acquisition. This is the highest scale economies.

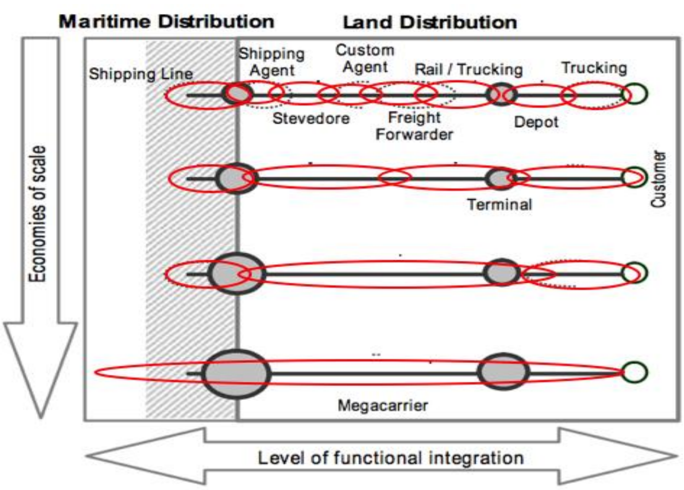


Figure 5Freight integration in supply chains

Source: Notteboom and Rodrigue (2004)

There are some pros and cons of vertical consolidation through supply change.

- Benefits of vertical integration

1) Cost reduction

2) Value added

3) Larger market coverage

4) Increased consumer network

5) Economies of scale and scope

6) Exchange of knowledge

➢ Drawbacks of vertical integration

1) Conflict in business orientation

2) Conflict in business structure

3) Competition distortion

4) Loss of corporate identity

5) Lack of flexibility

6) Administrative expenses

The vertical integration has been exercised as a strategy in order to create added value or to generate revenue or to increase margins. Also, it can be used as a complementary strategy to integration along the logistic chain, and it can be sustainable way of differentiating business over rival companies. The biggest scale of liner shipping company, Maersk Line, is a good example that it makes use of the vertical integrations with sub-companies such as Maersk Line, APM terminal and logistic service company through their supply chain.

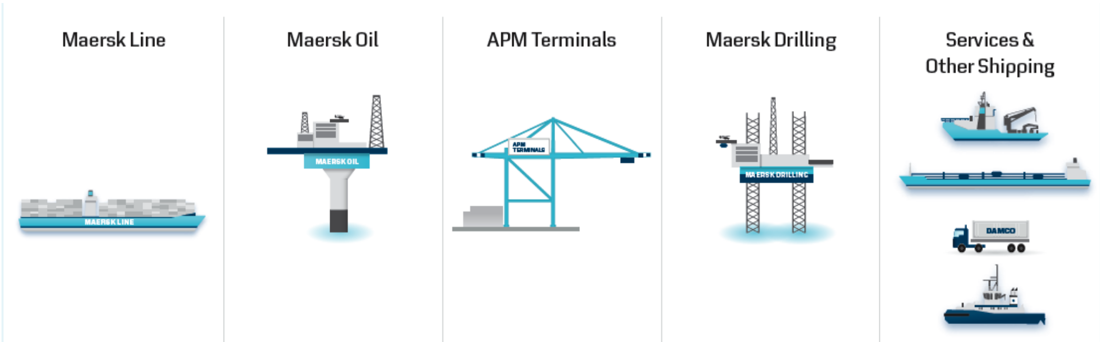


Figure 6Core business units, Maersk Line

Source: Maersk group, annual report 2013

(2) Intrinsic strategy

Figure 7 shows the container fleet development by ship size in TEU. Left side graph presents containership development between 8,000 TEU and 12,000 TEU from 1996 to 2016, while right side indicates containership growth over 12,000 TEU between 2003 and 2016. According to the graphs, the container carriers ranged over 8000 TEU and below 12,000 TEU sizes revealed to market since 1997, and the scale of these types of vessels have raised always for the period of time. Similarly, ships, which can load more than 12,000 TEU, introduced since 2005, and the number of the vessel has risen for the whole period.

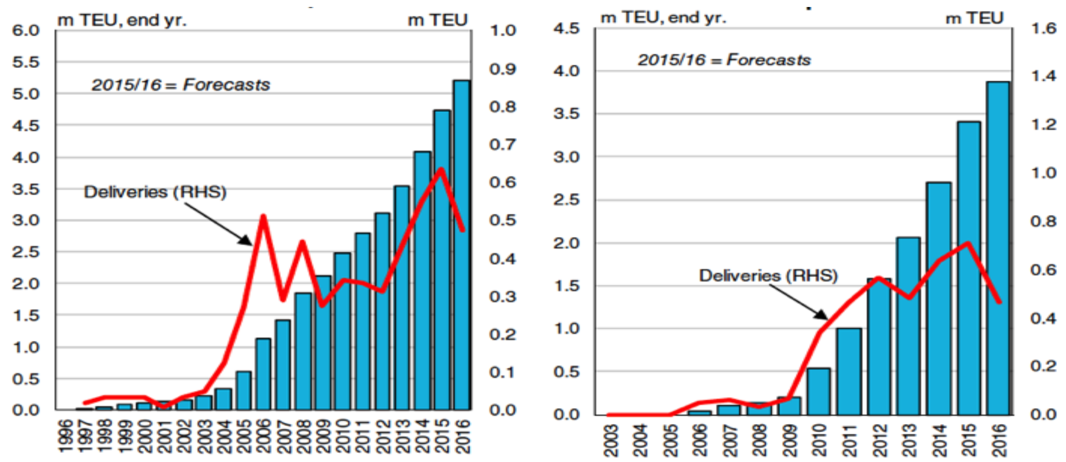


Figure 7Containership fleet development, 8,000-12,000 TEU and over 12,000 TEU

Source: Clarkson Research Services

Likewise, shipping lines have exploited scale economies by purchasing and deploying big size vessels to reduce unit costs of transportation as well as to satisfy shipper’s demand with low freight rates.

3.1.3 Capital intensity

Container shipping is a very capital intensive industry where some assets are owned and others leased and there exists a wide variability in cost bases (Brooks, 2000). To provide liner services to customers in an era of globalization, container shipping companies need to be required huge investment. According to Alphaliner (Figure 8), most lines in the world top 20 in terms of operating fleets capacity chartered a lot of vessels and made order to buy new ships to provide more service routes with frequent time interval with the objective to take higher market shares than rival firms. However, operating profits for shipping lines is historically low these days with relative low freight rates compared than operating cost. The rates on major trade routes have dropped more than the gains in productivity. This prolonged unsatisfactory financial performance in container shipping industry is one of forces inducing shipping lines collaborating and forming various types of alliance to minimize operating costs.

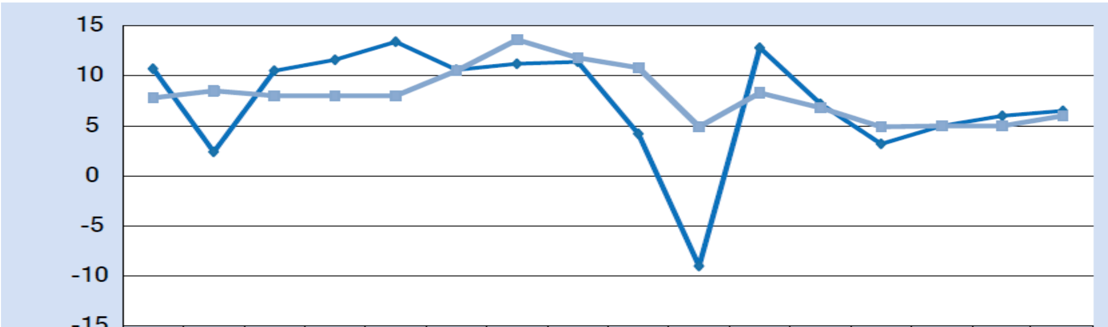
		TOTAL		Owned		Chartered			Orderbook		
Rnk	Operator	TEU	Ships	TEU	Ships	TEU	Ships	% Chart	TEU	Ships	% existing
1	APM-Maersk	3,148,741	621	1,754,664	262	1,394,077	359	44.3%	387,150	29	12.3%
2	Mediterranean Shg Co	2,773,110	499	1,055,632	190	1,717,478	309	61.9%	466,135	34	16.8%
3	CMA CGM Group	2,330,687	530	1,011,684	140	1,319,003	390	56.6%	235,624	24	10.1%
4	COSCO Container Line	1,573,498	290	483,717	87	1,089,781	203	69.3%	560,888	35	35.6%
5	Evergreen Line	963,777	190	557,365	107	406,412	83	42.2%	367,062	39	38.1%
6	Hapag-Lloyd	923,782	169	506,011	70	417,771	99	45.2%	52,500	5	5.7%
7	Hamburg Süd Group	641,923	126	292,311	44	349,612	82	54.5%	30,400	8	4.7%
8	Hanjin Shipping	625,416	101	274,078	37	351,338	64	56.2%			
9	OOCL	601,693	108	397,531	53	204,162	55	33.9%	126,600	6	21.0%
10	Yang Ming Marine Trar	578,514	104	203,810	43	374,704	61	64.8%	112,594	8	19.5%
11	UASC	541,146	56	419,203	38	121,943	18	22.5%	29,986	2	5.5%
12	MOL	529,490	86	151,316	22	378,174	64	71.4%	120,900	6	22.8%
13	NYK Line	503,343	98	267,544	45	235,799	53	46.8%	182,000	13	36.2%
14	Hyundai M.M.	400,257	56	165,080	22	235,177	34	58.8%	20,162	2	5.0%
15	K Line	391,700	69	80,150	12	311,550	57	79.5%	69,350	5	17.7%
16	Zim	357,910	80	32,053	7	325,857	73	91.0%			
17	PIL (Pacific Int. Line)	346,123	135	296,643	120	49,480	15	14.3%	141,600	12	40.9%
18	Wan Hai Lines	240,023	95	170,328	72	69,695	23	29.0%	15,200	8	6.3%
19	X-Press Feeders Grour	143,967	94	27,441	22	116,526	72	80.9%			
20	KMTC	120,061	60	41,987	25	78,074	35	65.0%	7,200	4	6.0%

Figure 8Operated fleets of container shipping companies on 26 June 2016

Source: www.alpahliner.com/top100/

3.1.4 Volatility

According to Stopford (2009), both volatility and cyclical patterns are due to an inherent mismatch between demand and supply of shipping. In particular, the problem is that while demand for shipping may change even in short time, as a result of alteration in local, regional or world economy and trade, sea cargo carrier companies cannot control it. For example, a liner shipping company want to add new capacity immediately in response to an increasing in demand for cargo, however, it takes time to buy and operate new ships. For this reason, the tonnage availability is delayed from the time when it would be needed by various shippers. This in turn causes surplus in supply when demand is low, which consequently makes freight rates decrease. From shipping companies' point of view, this situation is very risky. When demand is peak, companies should invest a high amount of capital resource in deploying new capacity, when facing the perilous situation, which demand and freight rates are dropping continually, it makes the shipping companies troublesome to recover the invested capital resource. When the duration of low demand and freight are expected for a long time, carriers want to dispose their unused capacity by selling through a second-hand vessel market or by scraping, or by laying up the ships. However, it is not straightforward to eliminate overcapacity in a low demand market condition. It is unlikely to find a buyer for ships when owners still pay part of expenses for the unused vessels.' Figure 9 shows the differences between demand and supply in container shipping from 2000 to 2015. Only 4 years (2005, 2007, 2011, and 2013) out of 16 years are same or similar rates between two indices.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015 (estimated)
Demand	10.7	2.4	10.5	11.6	13.4	10.6	11.2	11.4	4.2	-9.0	12.8	7.2	3.2	5.0	6.0	6.5
Supply	7.8	8.5	8.0	8.0	8.0	10.5	13.6	11.8	10.8	4.9	8.3	6.8	4.9	5.0	5.0	6.0

Figure 9Growth of demand and supply in container shipping, 2000-2015

Source: UNCTAD. (2015). Review of maritime transport 2015

In addition to above, there are a lot of volatility in liner shipping market such as freight rates (Figure 10), exchange currency, time charter rates (Figure 11), bunker prices (Figure 12), and global economic situation. These are driving forces to push containership companies toward formation of alliances among them to gain the comparative advantages.

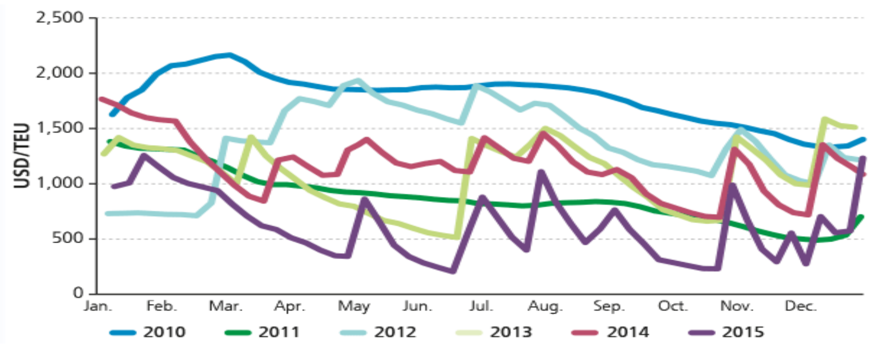
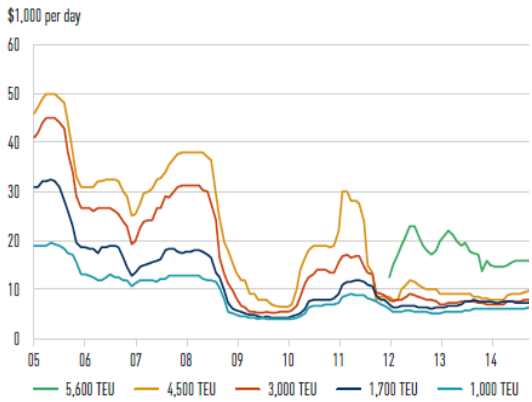


Figure 10Freight rates from Shanghai to Europe, 2010 - 2015

Source: BIMCO, Shanghai Shipping Exchange



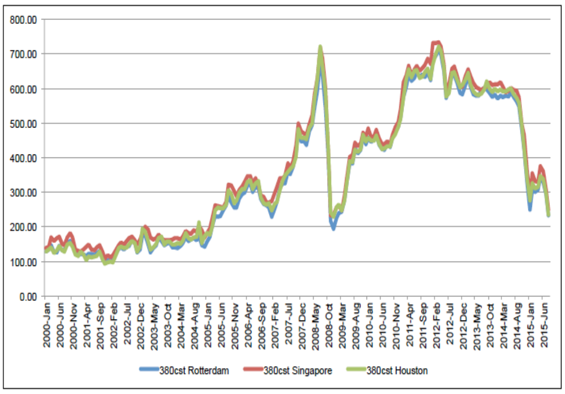


Figure 11T/C rates for container ships, 2005-2014

Source: RS Platou. (2015). The Platou Report 2015

Figure 12Price fluctuation for bunker fuel (IFO 380), 2000-2015

Source: Clarksons Research Studies

3.2 Overview of strategic alliance in liner market

3.2.1 Origin of cooperation

The history of the container shipping industry has been various formations of organizational cooperation. In 1875, the first conference was formed to limit the competition among rival companies and to control the freight rates in the market. Clarke (1997) mentioned that the shipping lines were historically organized in conferences, which like carters that set price schedules for their members, restricted output, and engaged in price or quantity wars with outside entrants. The primary goal of liner conferences is to stabilize the freight level by regulating the capacity and/or applying conference tariffs (Shuo, 2015).

Most nations at that time granted the companies in the shipping sector antitrust immunity for the sake of protecting the nation’s maritime influence. Many researchers argued that the conferences played a vital role in cartels to get high profit and inhibited the development of the global economic. Others include Sjostrom (2004) believed that the conferences were a necessary evil since container shipping companies suffered from an empty core, which means that there is no competitive equilibrium and it could be an effective check against the inherent instability that would plague the market in a purely competitive situation. Even though, there was controversial against cooperation as conferences, however, it remained for more than a century. This is because of the believing that the fluctuation of demand and supply for maritime transportation, a secured income was important for the shipping lines to maintain and operate services in the capital-intensive market, and shipper also could be got benefit by the remained services.

However, the regulatory changes have directly ended the conferences among shipping lines. In 1998, the United States passed the “Ocean Shipping Reform Act (OSRA)”, which required conference to allow their member firms to confidentially deviate from the conference system (Lewis and Vellenga, 2000). In 2006, the Europe Nations when further and outright stripped conferences of any anti-trust immunity (Bockrath, 2015). These changes of laws in the major economic areas made the traditional co-operational groups, the conferences, unacceptable.

3.2.2 Advent of consortia

After the containerization revolution, new form of cooperation, called as consortia, introduced to container shipping industry. The first stage of liner consortia started in the early 1970s with some features such as limitation to the vessel, space sharing and tonnage control. The second but last stage of consortia were more integrated among member companies, which it involved not only operational and technical collaboration, but also commercial and financial decision. Due to slow decision process and structural problem, which they were disadvantages toward independent companies, the first stage of consortia started to fall in the1980s. And also, the second stage of consortia became out of date because the two giant governments, U.S. and E.U., were unfavorable toward the freight control and capacity management.

3.2.3Appearance of strategic alliance

The emergence of global markets with world economic growth, the increased service of shipping companies in non-conference but in a fierce and capital intensive market, and the considered illegal under anti-trust laws were contributed to the restructuring of the liner shipping industry. This has led to a traditional conference disappear and a tremendous increase in efficiency-enhancing operating agreements. At the end of the conference system, shipping lines were looking for the other type of cooperation, strategic alliance.

Alliances very widely in their organizational structure, but broadly speaking an alliance is composed of a set of individual firms that co-operate their vessel deployments and share space on their vessels, allowing them to reach a wider range of destinations and customers (Brooks, 2000). Compared to conferences, alliances are less restrictive in their actions, as they are barred from directly setting prices and allow independent competition amongst their members. In addition, alliances are much larger in scale than the traditional conferences, as many alliances collectively span the globe and the combined membership of some alliances control substantial portions of the global shipping market (Bockrath, 2015). The shipping companies in the strategic alliances were not involved in price-setting but in the rationalization of capacity through the operating cooperation among member companies in alliance such as sharing vessel, terminal and equipment, joint- scheduling, and slot chartering.

(1) First generation (1994 – 1996)

In 1994, the new type of cooperation group, called strategic alliance, was emerged to the shipping market by four carriers: namely, APL, OOCL, MOL and Royal Nedlloyd Lines. The ‘Global Alliance’ was the name for the first strategic alliance and it had an objective to establish an integrated Europe – Far East service route. The Grand Alliance of Hapag-Lloyd, NYK, NOL and P&O was formed in 1996. In addition, Maersk and Sealand agreed to cooperate in a same strategic alliance, Maerck-Sealand. The first generation for the period between 1994 and 1996, the international liner shipping markets were dominated by the three alliances, which were Global Alliance, Grand Alliance and Maersk & Sea-Land, and independents major container shipping companies such as CMA, CGM and Evergreen Line.

(2) Second generation (1997 – 2000)

The second generation of strategic alliance was formed by the global mergers and acquisitions from 1997 to 2000. There was an Asian financial crisis in 1997, which was started by the financial collapse in Thailand, it affected the imbalance of vessels' capacity on supply and demand. In response, the major shipping lines changed their market structure by mergers and acquisitions with rival and cooperation lines to reduce operating cost and to solve the problems came from the initial organization of global alliance such as overlapped business and complexity of strategic alliance. Through this period, P&OCL merged with Nedlloyd, NOL merged with APL and Hanjin took the DSR-Senator. And the CMA acquired the CGM and CP Ships gained CAST, Lykes Line and Contship. In 1999, Maersk Line got Sea-Land and it became the biggest liner shipping company as named Maersk-Sealand. P&ON, MISC and OOCL became a member of the Grand Alliance in 1998. Moreover, HMM and the other companies, APL-NOL and MOL, changed the Global Alliance to New World Alliance, and Hanjin made United Alliance with DSR-Senator and Cho Yang Shipping. Also, CKY Alliance was formed by COSCO, K-Line and Yang Ming. Therefore, there were four strategic alliances, which are the Grand Alliance, New World Alliance, United Alliance and CKY Alliance, two giant independent shipping lines, Maersk-Sealand and Evergreen-Lloyd Triestino, and minor companies in second generation period.

(3) Third generation (2001 – 2010)

In the mid of 1990s, an estimated 60% of total global liner capacity was accounted for by alliances (Agarwal and Ergun, 2010). Likewise, the formation of liner shipping strategic alliances has been a dominant form of cooperation among lines since the early 1990s. In 2002, the United Alliance was disbanded and the Hanjin, former member of the United Alliance, joined CKY Alliance, as a result, CKYH Alliance emerged. The Maersk-Sealand took the P&ON and became a Maersk Line in 2005. After these changes, the liner shipping markets were operated by three strategic alliances, which are the New World Alliance, Grand Alliance and CKYH Alliance, two giant shipping lines, Maersk Line and Evergreen Line, which they provide global liner services, and big scale companies such as CMA-CGM, CSCL and MSC.

(4) Fourth generation (2011 – 2016)

The period of fourth generation was started by the consolidation with two alliances, the New World Alliance and Grand Alliance, and they became a G6 Alliance in 2011. After two years, the world’s three largest container shipping lines, Maersk, MSC, and CMA CGM, announced an operational alliance on three of the world busiest trade routes, Asia/North America, Asia/Europe, and Transatlantic with a name of P3 Alliance. A unique selling point for P3 is its Joint Vessel Operating Centre (JVOC) aimed at delivering maximum cost efficiency. The companies assure that the alliance can deliver more stable, frequent and flexible services, with CMA CGM citing the P3 network's capacity to offer 8 weekly sailing between Asia and Northern Europe. Despite this unified approach, each company was still set to have fully independent sales, pricing, marketing, and customer service functions.On June, 2014, China's Ministry of Commerce (MOFCOM), following a review under China's merger control rules, refused approval for the proposed P3 joint venture despite approval from the U.S. and the E.U. competition authorities. The reason for the refusal is that the proposed arrangement would integrate the market power of the parties and consolidate their operating network, eliminating effective competition between major competitors and raising entry barriers to the market. After that, COSCO, K-Line, Yang Ming, Hanjin and Evergreen Line announced they agreed to establish a shipping alliance, and CMA-CGM, CSCL and UASC also reported to make a new alliance, named Ocean 3 Alliance in the same year. In 2015, Maersk Line and MSC formed 2M Alliance, and the COSCO and CSCL announced to be integrated and to reshape as one company.

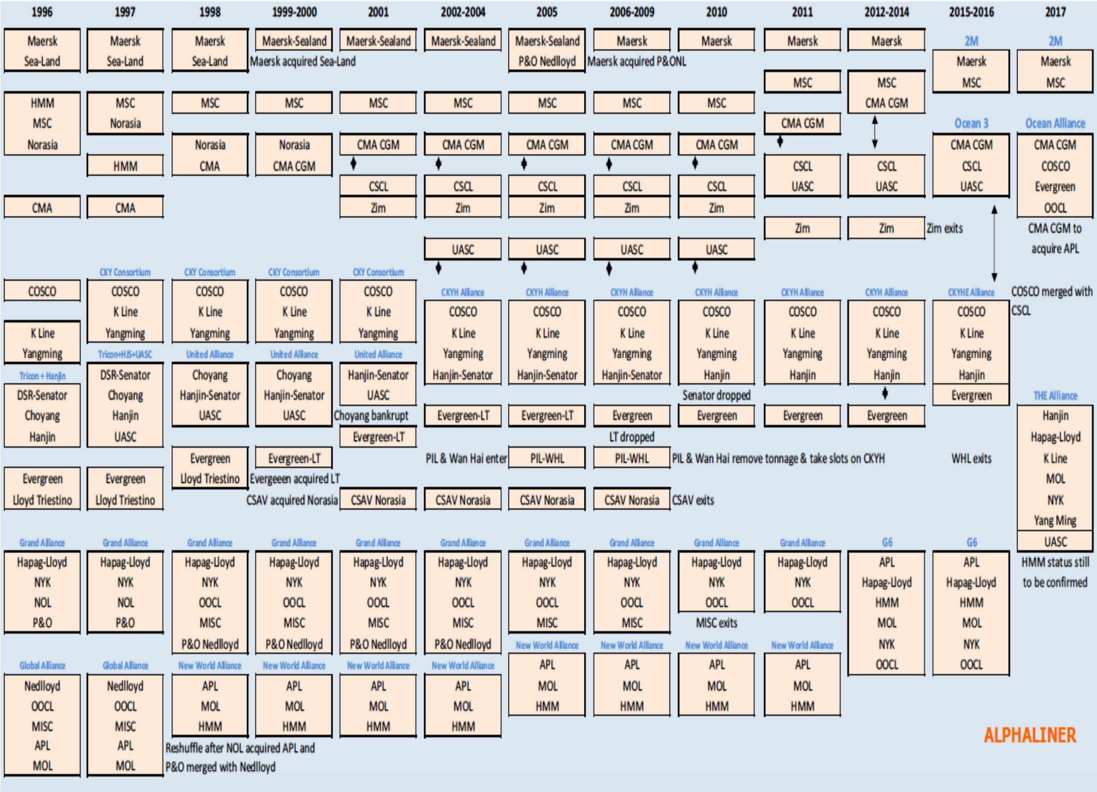


Figure 13Development of alliances on the Far East – North Europe route

Source: Alphaliner Weekly Review, volume 2016 issue 2

Chapter 4 Strategic alliance

4.1 Definition of strategic alliance

Initially, the term strategic alliance was used to describe a contractual relationship between a firm with a marketable technology and one with the capability to produce the product and/or bring it to market and its application to the transport industry has been much later than in other industry sectors (Brooks, 2000). Today, the terms strategic alliance is used to describe a wide range of organizational structures in which two or more businesses cooperate for mutual benefit and ideally share common goals; the relationship is symbiotic and voluntary (Brooks, 2000). Yao (2003) mentioned that Hopland and Nigel proposed the concept of strategic alliances in the end of the 1970s and they defined the strategic alliance as an agreement involving two or more organizations for achieving joint strategic goals in order to meet their business needs.

4.2 Objectives of forming or joining strategic alliance

Container shipping companies have been facing intense competition and there are huge threats in a constantly changing and globalization of world markets with low financial performance. In order to improve competitiveness and survive in this fierce and rigid business environment, it has been considered and implemented to join or form strategic alliances amongst at least two organizations with similar structure and compatible objectives to achieve objections. Song and Panayides (2002) said that in order to examine the underlying reasons that have induced strategic alliance formation in liner shipping, it is important to consider the objectives pursued by contemporary shipping lines. The objective modern shipping lines can be classified into three classes generally, which are financial, commercial and operational objectives. It can be argued that formation, dissolution and destruction of strategic alliances are motivated by the need to get the three objectives. And I sum up the researchers' finding of objections against forming strategic alliance among container shipping firms below (Table 1). I collected information from four research papers, Gardiner (1997), Song and Panayides (2002), Panayides and Wiedmer (2011), and one class handout, Shuo (2015), and then I reorganized them into three categories depends on my classification method.

Table 1Researcher's finding regarding objections of forming strategic alliances

Consideration	Yen (1994)	Gardiner (1997)	Song and Panayides (2002)	Panayides and Wiedmer (2011)	Shuo (2015)
	Objections				
Financial purpose	1. reduce and share capital costs	1. risk and investment sharing	1. profit maximization	1. economies of scope	1. economies of scale
	2. reduce maintenance and operation of ships	2. economies of scale	2. increase in shareholder wealth	2. rationalize capacity	2. profit margin
	3. economies of scale		3. capital investment sharing	3. economies of scale	3. operating cost
	4. minimize unit costs		4. financial risk reduction		
			5. cost reduction		
			6. economies of scale		
Commercial purpose	1. explore new markets	1. entry in new markets	1. entry in new markets	1. respective strengths	1. market coverage
	2. enhance global share	2. increase in purchasing power	2. wider geographical scope	2. competitive advantages	2. service frequency
		3. wider geographical scope	3. increase in purchasing power	3. market power	3. market capability
			4. satisfy customer requirements	4. cost control	4. cost control
			5. better or higher frequency		
			6. flexibility reliability		
			7. variety of routes and destination		
Operational purpose	1. improve the utilization of infrastructure and marine terminals	1. increase in frequency of services	1. increase in frequency of services	1. service frequencies	1. vessel space utilization
	2. high frequency of services		2. vessel planning and coordination on global scale		2. container deployment
	3. reduce imbalance in trade				3. operational know-how
	4. better utilization of ship's capacity				

Source: Yen (1994), Gardiner (1997), Song and Panayides (2002), Panayides and Wiedmer (2011) and Shuo (2015)

4.2.1 Financial consideration

In order to increase companies' profit, they have two options to achieve; one is by increasing revenue and the other is by reducing operating cost. A container carrier can increase its revenue by increasing the quantity of its product sold or the price the product. However, both are hard to achieve and are not feasible in practice. The liner shipping industry is very price sensitive and most lines provide almost same services to customers. In this situation, if one liner service company increase their product price, cargo delivery service, customers may look for other shipping lines with providing cheaper delivery service. As a result, the line will be loosed their market share. Therefore, reducing operating costs will be the only option to get better profit for shipping lines.

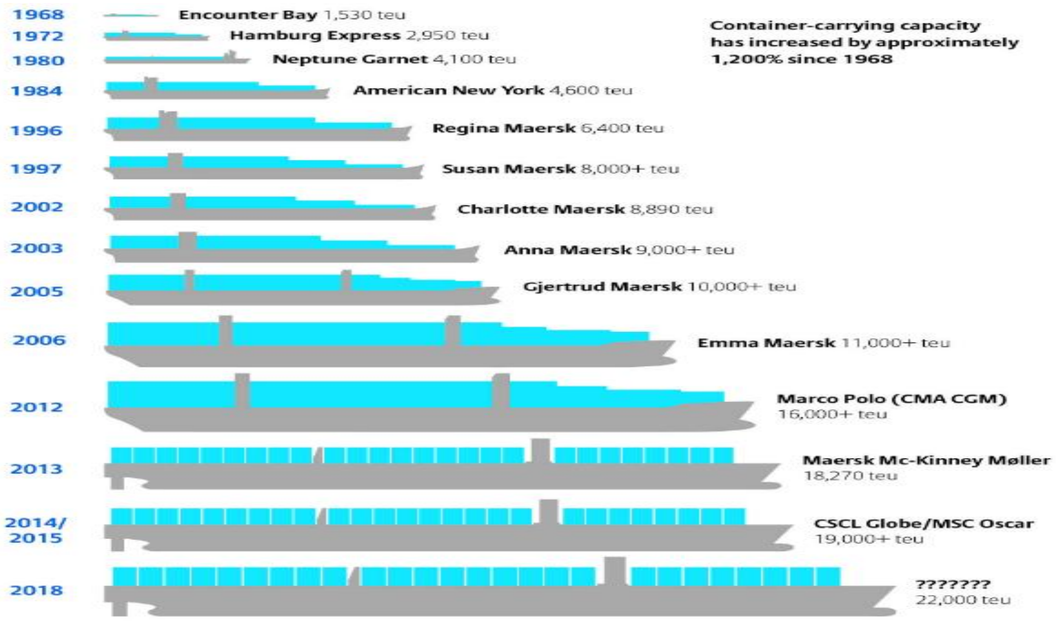


Figure 14Container ship growth for 50 years

Source: www.worldshipping.org/about-the-industry/liner-ships/container-ship-design

In addition, container shipping companies have invested to purchase big capacity vessels more and more (Figure 14). The reason why they have done that it is well known that deploying and operating bigger ships can reduce and minimize the unit cost of the vessels because some ship-costs such as capital costs, operating expenses, and bunker costs for container ships do not increase as growing of the ship size. This means that firms want to make use of scale economies to minimize unit cost by operating fleet under the strategic alliance.

The economies of scale can be achieved by the three main factors of the ship-costs, which are capital costs, operating expenses and bunker costs. Seafarers hire, insurance, stores, maintenance and administration constitute the operating expenses. According to Stopford (2009), Administration, stores and crew generally do not increase very much as the ship gets bigger, however, insurance and maintenance costs are likely to increase in line with the capital cost of the ship, though by less than the transport capacity of the ship. Capital costs are subject to economies of scale because big ships cost less per container slot than small ones (Stopford, 2009). The fuel consumption decline as the size of ship getting bigger.

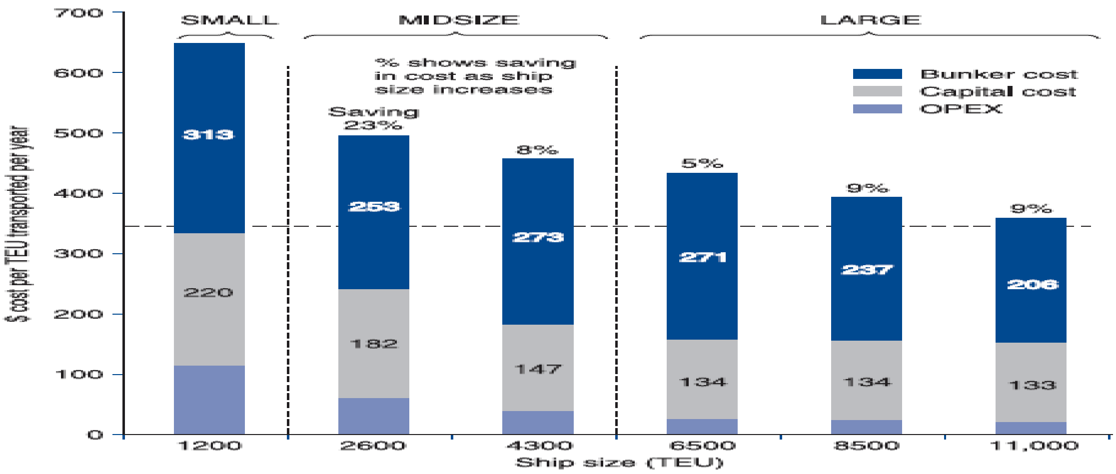


Figure 15Container ship per TEU transported

Source: Stopford (2009)

Figure15 shows cost, which denominated in dollar, per TEU transported in a year by the ship sizes. The cost of about 650 dollars per TEU for a 1200 TEU container ship decreases distinctly to near 500 dollars per TEU for a vessel of 2600 TEU. And approximately 450 dollars per TEU for 4300TEU size ship, a little bit lower cost for 6500 TEU ship and about 400 dollars per TEU for 8500 TEU ship, and almost 360 dollars per TEU for 11000 TEU containership are shown. As you can see, the bigger the size, the lower the cost per TEU.

In conclusion, shipping lines have formed and joined strategic alliances with objections related financial considerations such as operating cost reduction, profit maximization, having economies of scale, sharing risk and capital cost with other container shipping companies.

4.2.2 Commercial consideration

Porter (1980) mentioned that the alliance group can increase the bargaining power through the purchase together of the items such as equipment, spare parts, and bunker. Container shipping companies highly depend on services from third parties such as ship agent service companies and bunker supply companies. The generated cost from the services provided from the third parties comprise the operating cost for container shipping companies, and relative low the cost can be the competitiveness of liner shipping firms. Of course, scale economies play a crucial role on lowering the costs. Major container delivery service companies like Maersk Line, Evergreen Line, and COSCO invest or purchase on dedicated terminals or sometimes acquire their bunker supply company. However, it is not feasible strategy to invest the third party company from the point of view of not big enough companies, even though, if there are major companies, they cannot buy all of the third party service companies in the world. In this regard, strategic alliance can provide the benefit of cost down of services and material for shipping lines as well as the down the cost per unit of container handling, intermodal and feeder services for shippers by combining volumes of purchasing and cargoes for delivery through the enlarging the purchasing and negotiating power.

In addition to this, alliances help carriers to enter new markets and reinforce their global market share. The strategic alliance allowed member of companies to extend their services to new destinations this enhancing their role in those regions and generating new opportunities for mutual growth. As the world become a one nation by the help of containerization, globalization and deregulation the trade barrier among countries. This means that the companies should be ready to compete with firms in same nation as well as firms located over the border. It is understandable the fact that shipper prefer to choose a partner in maritime sector whose has services to connect globally than that of offering services limited areas or countries. In addition, shippers are looking for the cheap transportation as well. To satisfy the both, offering global delivery services and cheap transportation services, shipping lines try to co-operate by forming strategic alliance as a realistic method to enhance global market share (Figure 16).

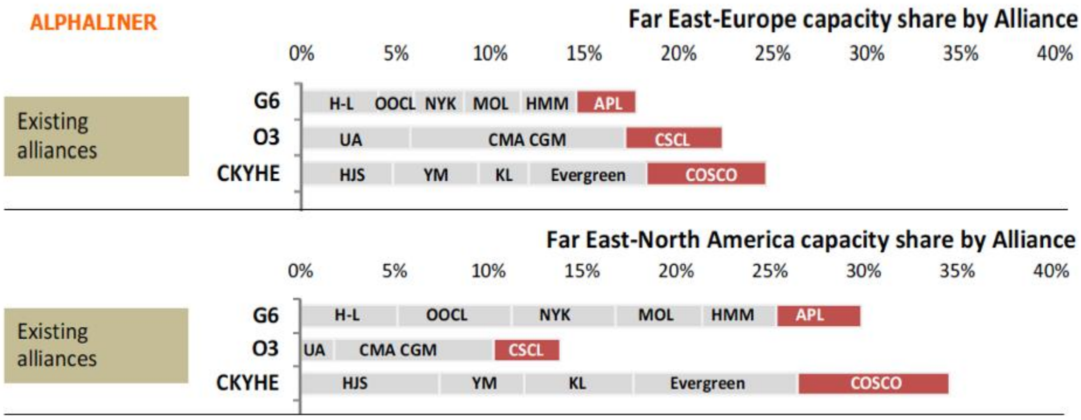


Figure 16Market share by three groups of strategic alliances

Source: Alphaliner Weekly Newsletter, Volume 2015, issue 51

Producing high frequency of delivery services is one of objections for creation of strategic alliances in liner shipping industry. In the past, shippers did not think about daily service from carriers. Sometimes, a few days of service delay were accepted. However, this story is not existed at present. Providing timely and frequent transportation services to customer than rival companies is considered to get higher market share and competitive advantage. Today, on the world's main maritime liner shipping routes, a monthly service supplier will be out of the market, a fortnightly service is too long, a 10-day calling interval is not good enough, and a fixed-day weekly has become the standard norm (Shuo, 2015). Deploying similar vessels together in as many route as they can with members of strategic alliance not only enable the weekly services for satisfying various customers, but also operate fleets economically. Shuo also mentioned that more and more shippers today are expecting to have a liner service twice a week, or even three or four times a week on some selected traffic routes, and to offer high frequency service, shipping lines have to work together.

4.2.3 Operational consideration

The advent of global strategic alliances can be considered as a substantial breakthrough in the industry's co-operative practice since they are not limited to a single trade lane, but aim to cover every major route as well as a number of relevant north-south trades and regional/feeder links. At the same time, these strategic alliances extend their sea of influence well beyond vessel operations towards the shared use of terminals, joint equipment management, inland transport and logistics, joint purchasing and procurement (Midoro and Pitto, 2000).

The trend of today in liner shipping industry is that companies purchase big size vessels and deploy them to reduce the operating cost as much as possible in the situation of low freight rates. The problem caused by the trend is that it is not east to sell the whole space in containerships in line with the volatility of demand of maritime transportation. The capacity on the ship is perishable. Once the ship leaves the loading port whether the vessel's capacity used or not, the unsold capacity cannot be stored to make a profit and it becomes useless until the ship arrive at loading ports, however, the operating costs such as crew, stores, lubricants, repair, maintenance, insurance, administration, and etc. are charged to shipping companies. Therefore, lines try their best to secure cargoes to make good use of their vessels. Strategic alliance helps member companies to have maximize utilization of vessels by sharing vessel space.

Technical and operational know-how may be a valid motive for shipping co-operations (Shuo, 2015). Some container shipping companies have competitiveness toward owning vessels or accessing specific markets monopolistically, however, they have not enough expertise to operating their fleets effectively. In this case, the shipping lines can learn to increase operating capability by joining strategic alliance. This is a kind of the win-win strategy by give-and-take their competitive things among members, which share the market access instead of getting fleet operating knowledge.

Likewise, operational arrangements such as improving the utilization of ship's space and getting operational know-how among firms on same strategic alliance can be regarded one of objections in liner shipping industry.

4.3 Disadvantages of strategic alliance

Major lines make use most of strategic alliance in their fleet operation to achieve their objections, however, there are some problems existed as well. First of all, the instability among the member companies of strategic alliance is the representative weakness. According to the Song and Panayides (2002), individual organizational objectives, the number of partners in an alliance, the nature of the members' role and contribution to the alliance, and the level of mutual trust and the complexity of the task play an important role in alliance instability. This cause the malfunction of the operational strategies through the strategic alliance.

Secondly, according to Agarwal (2007), alliances lead to many large scale problems at the tactical and the operational planning level such as managing al large pool of ships, as contributed by the members of the alliance, and designing a large scale network to satisfy multiple demands due to various carriers. He also mentioned that the members of an alliance should decide on a set of routes to operate their fleet together, and they need to decide how to realize these lanes and how the different members of the alliance should assign their vessels to the designated routes. In addition, the member lines of strategic alliance should settle the problem of how to share the profits in an acceptable method to inspire them.

Thirdly, Ryoo and Thanopoulou (1999) stated another drawback as follow, when common marketing is involved, flexibility of entry and exit can be jeopardized, not only by the sunk marketing costs involved but also by the potential loss of access to common marketing networks, involving a potential loss of customers over a transitory period of time.

Chapter 5 Shipping alliance's effect on the efficiency of container lines

The meaning of high efficiency can be defined that when a better outcome is achieved with same resources or efforts or when an equivalent result is attained using smaller resources than others. There are two types of efficiencies, which are absolute efficiency and relative efficiency. The former one means the ratio between input and output, and the latter indicates the comparison of efficiencies with the best efficiency in the specific group of the efficiency. For example, if we check the two efficiencies of three clothes factories related the amount of production over the number of employee, the absolute efficiency can be calculated total amount of clothes produced divide by the total number of worker and the relative efficiency can be obtained by observation how much distinct the two factories of efficiencies from the one highest efficiency of factory. In this research paper, I will calculate the relative efficiency of shipping lines.

5.1 Data Envelopment Analysis (DEA)

5.1.1 Definition of DEA

An efficiency can be measured output divide by input simply. This formula has a limitation to check the efficiency with only one input and output variable. However, when we usually examine efficiency of some companies, we need to think about more than one inputs and outputs as relative factors that influence on the efficiency results. DEA is a mathematical model that measure the relative efficiency among a set of Decision Making Units (DMUs) with capability of dealing with multiple output and input variables. In DEA model, the relative efficiency of each DMU can be earned through the calculation that a weighted sum of outputs divided by the weighted sum of inputs.

The origins of DEA may trace back to Farrell (1957) who introduced, in the methodology of making evaluations from realized deviations from an idealized production frontier isoquant, an approach based on developing a piecewise linear envelopment of the data in order to determine the frontier (Panayides at el., 2009). After that, researchers include Charnes introduced a linear programming methodology, DEA-CCR model. DEA, first proposed by Charnes et al. (1978), is a non-parametric linear programming based technique used to measure the efficiency of operating units, referred to as DMU by comparing their use of multiple inputs to produce multiple outputs (Hsu, Chung, Lee and Sherman, 2013). One of the strong points of DEA is its non-parametric character, which means that only the consumption values of the observed inputs and output production amounts are needed in order to assess the relative efficiencies of the DMU properly (Lin, 2013). There are two types of statistical procedure, which are the parametric and nonparametric statistics. The former one depend on suppositions about the shape of the distribution in the inherent population and about the form or parameters such as means, median and standard deviations of the expected distribution, while the latter one consider no or few guess about the shape or parameters of the population distribution from which the sample was drawn. This means that if the collected data are deviated highly from the expectation of a parametric procedure, the non-parametric test should be carried out rather than using parametric test to avoid incorrect results.

DEA makes use of frontier line to measure the relative efficiency with an efficiency frontier, which represents the best observed performance in the data set. DEA measures the efficiency of an organization within a group relative to observed best practice within that group (Bhagavath, 2006). The observed best practice is indicated as the efficiency frontier like the curve in Figure 17. The red curve represents the group of DMUs, which are statue of best efficiency, and the blue line shows the predicted average behavior of collected DMUs. There are three ways to be a best efficiency for DMUs, which are not located in the red efficiency frontier curve by reducing the input, increasing the output or both.

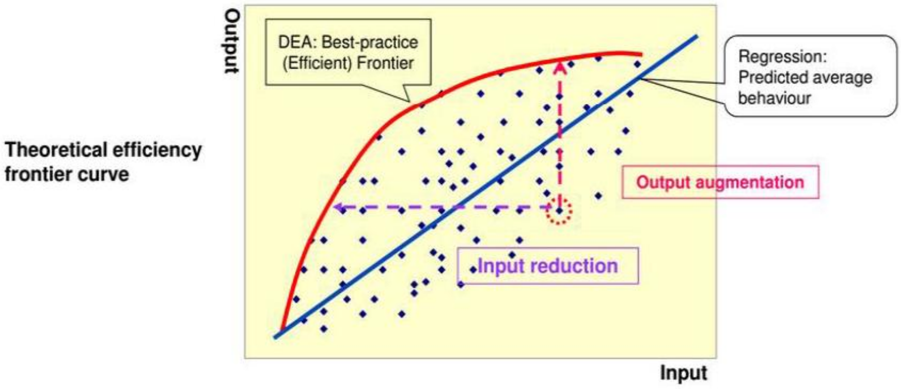


Figure 17Theoretical efficiency frontier curve

Source: Park, A, R. (2014). A port marketing strategy in the wake of new shipping alliance: a case study of Busan port, World Maritime University Dissertation, paper 460.

DEA uses variable weights, which are derived directly from the data with the result that the numerous a priori assumptions and computations involved in fixed weight choices are avoided (Cooper, Seiford and Tone, 2007). This means that it does not need an a priori production function to specify how to aggregate the data observed. Cooper et al. (2007) also mentioned that in addition to avoiding a need for a priori choices of weights, DEA does not require specifying the form of the relation between inputs and outputs in, and it does not require these relations to be the same for each DMU.

One of the main purpose of a DEA study is to project the inefficient DMUs onto the production frontiers. There are three directions, on called input-oriented that aims at reducing the input amounts by as much as possible while keeping at least the present output levels, and the other called output-oriented, maximizes output levels under at most the present input consumption (Cooper et al., 2007). The last one treat the input excesses and output shortfalls simultaneously in a way that jointly maximizes both.

5.1.2 Concepts of efficiency

Typically, using linear programming, DEA measures the efficiency of an organization within a group relative to observed best practice within that group. According to Bhagavath (2006), there are different concepts of efficiency below.

- Technical efficiency

  It is the conversion of physical inputs such as the services of employees and machines into outputs relative to best practice. Managerial practices and the scale or size of operations affects technical efficiency.

- Allocative efficiency

  It refers to whether inputs, for a given level of output and set of input prices, are chosen to minimize the cost of production, assuming that the organization being examined is already fully technically efficient.

- Cost efficiency

  It refers to the combination of technical and allocative efficiency. An organization will only be cost efficient if it is both technically and allocative efficient. Cost efficiency is calculated as the product of the technical and allocative efficiency scores, which expressed as a percentage.

5.1.3 CCR Model

The CCR model was initially proposed by Charnes, Cooper and Rhodes in 1978. It considered the constant return to scale (Figure 18), which assumes proportionality between input and output variables. There are two type of models, input-oriented CCR model and output-oriented CCR model. The former model is to purpose reducing the input amounts by as much as possible while keeping at least the present output levels, and the latter model is to target maximizing output levels under at most the present input consumption (Cooper at el., 2007).

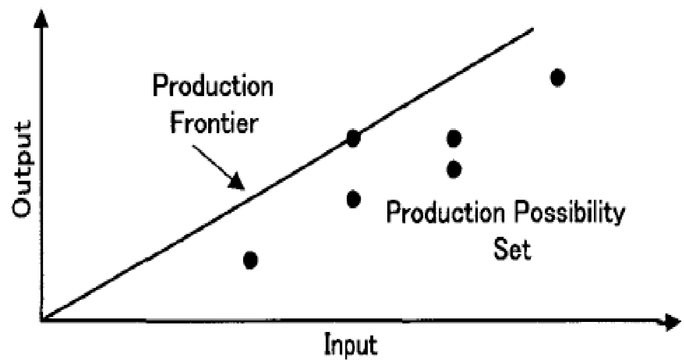


Figure 18Production frontier of the CCR Model

Source: Cooper at el. (2007). Data Envelopment Analysis

In CCR model, the efficiency is the ratio between the sum of multiple inputs and outputs, and the ratio should not exceed 1 for every DMU because the purpose is to obtain weights for each input and output to maximize the ratio. In addition, the all weights should be greater than zero as a non-negativity constraint. The CCR-O model to assess the efficiency of DMU can be indicated to the linear program model as below (1).

$$\underset{\eta,\mu}{Max}\ \eta \qquad (1)$$

Subject to

$$x_0 - X\mu \geq 0$$
$$\eta y_0 - Y\mu \leq 0$$
$$\mu \geq 0$$

The η always has an amount of more than 1, CCR-efficiency can be measured through the calculation of $\theta_{CCR} = \frac{1}{\eta}$. CCR-efficiency score of 1 for a DMU means efficient, and score of below 1 implies inefficient.

5.1.4 BCC Model

The BCC model was initially proposed by Banker, Charnes and Cooper in 1984. According to Cooper at el (2007), the BCC model has its production frontiers spanned by the convex hull of the existing DMUs, and the frontier have piecewise linear and concave characteristics which leads to variable return to scales (Figure 19) characteristics with increasing returns-to-scale, decreasing returns-to-scale and constant returns-to-scale. BCC model also have two type of models, which are input-oriented BCC model and output-oriented BCC model.

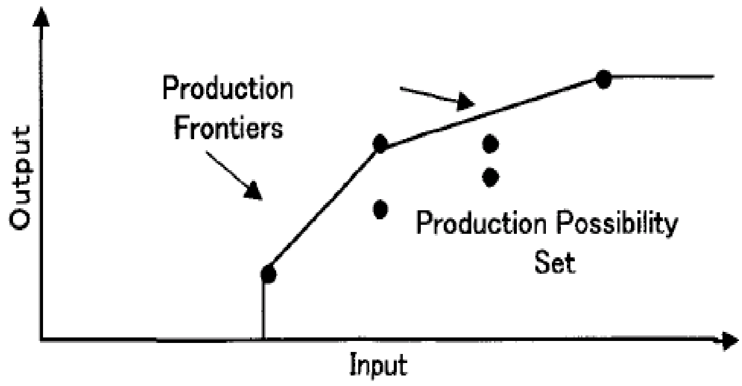


Figure 19Production frontier of the BCC Model

Source: Cooper at el. (2007). Data Envelopment Analysis

The BCC model differs from the CCR model only in the adjunction of the condition $\sum_{j=1}^{n} \lambda = 1$ which we also write $e\lambda = 1$ where **e** is a row vector with all elements unity and λ is a column vector with all elements non-negative (Cooper at el, 2007). Following is the BCC-O model, which represent to linear program model (2).

$$\max_{\eta_B, \lambda} \ \eta_B \qquad (2)$$

$$\text{Subject to} \quad \begin{aligned} & X\lambda \leq x_0 \\ & \lambda_B y_0 - Y\lambda \leq 0 \\ & e\lambda = 1 \\ & \lambda \geq 0 \end{aligned}$$

The BCC-efficiency can be indicated to $\theta_{BCC} = \frac{1}{\eta_B}$, and scale efficiency (SE) can be measured by the calculation of $SE = \frac{\theta_{CCR}}{\theta_{BCC}}$. CCR-efficiency called as technical efficiency (TE) because it assumes constant returns-to-scale, whereas BCC-efficiency is regarded as pure technical efficiency (PTE) since it supposes variable returns-to-scale of DMUs. Through this definition, a quotation below can be attained (3).

❖ Technical Efficiency (TE) = Pure Technical Efficiency (PTE) × Scale Efficiency (SE) (3)

5.2 Application of DEA model

In my research, the efficiency of six major shipping lines is measured with DEA. They are COSCO, K Line, Yang Ming, Hanjin Shipping, Evergreen Line and Maersk Line. The first five firms are member of CKYHE Alliance, and the last firm is the largest liner service company in terms of TEU in the world. There are five steps to apply the DEA model.

- Step 1. Selection of input and output variables
- Step 2. Selection of decision making units (DMUs)
- Step 3. Data collection
- Step 4. Selection of models for analysis
- Step 5. Efficiency analysis

5.2.1 Selection of Input and output variables

The first and the most important stage is to choose input and output variables to evaluate the efficiencies of DMUs (shipping lines). In my research, I plan to assess two types of efficiencies, which are financial efficiency and operational efficiency. Thus, I divide two groups of inputs and outputs (Table 2). To assess the financial performance for six lines, total fixed assets and operating costs are used as input variables, and gross revenues and operating incomes are employed as output variables, while for measuring operational performance, operating capacity in TEUs and number of vessels including quantity of owned ships and chartered ships are chosen as input variables, and revenue from the result of liner business and total handled volume during a year are used as output variables.

Table 2 Inputs and outputs for the research

	Financial efficiency	**Operational efficiency**
Inputs	*1) Fixed assets (Property ,plant and equipment)*	*1) Total operating capacity in TEUs*
	2) Operating cost	*2) Number of ship (owned + chartered)*
Outputs	*1) Revenue*	*1) Net revenue (liner service business)*
	2) Operating income	*2) Total handled volume in TEUs*

5.2.2 Selection of decision making units (DMUs)

Throughout my research paper, I want to find out how much the strategic alliance affects its member companies in terms of financial and operational efficiency.I expect that if I manage to compare the efficiency of relevant companies before and after their joining the strategic alliance, I could find out the transition of efficiency as well as the influence by the result of the joining a strategic alliance. In this regard, I choose five shipping lines, which are members of CKYHE alliance, to examine efficiencies. Presently, except the CKYHE alliance, there are three more strategic alliances, which are 2M (Maersk and MSC), Ocean 3 (CMA CGM, CSCL, and UASC), and G6 (APL, Hapag-Lloyd, HMM, MOL, NYK, and OOCL). However, I select the five shipping lines of CKYHE alliance is due to Evergreen, which is joined the strategic alliance most recently, in 2014, and before then it never joined a strategic alliance. So, I am able to achieve my objection of this research with up-to-date data. After this, I added one more company, Maersk Line, that is the largest liner service company and the most profitable company in the world. The reason why I put one more firm to my experiment is because the DEA assesses the relative efficiency among the experimental group, DMUs, not the absolute efficiency. Actually, this characteristic is one of strengths for DEA method. However, I wanted to know further how different between the five companies, member of CKYHE Alliance, and the first rank company, Maersk Line, in the containership industry in terms of efficiency. Therefore, finally, there are six DMUs in my test.

Table 3 Decision Making Units

No.	DMU	Rank	Share
1	*Cosco Container Line*	*4*	*7.60%*
2	*"K" Line*	*15*	*1.90%*
3	*Yang Ming Line*	*10*	*2.80%*
4	*Hanjin Shipping Line*	*8*	*3.00%*
5	*Evergreen Line*	*5*	*4.70%*
6	*Maersk Line*	*1*	*15.20%*

* Source: www.alphaliner.com/top100/inex/php

5.2.3 Data collection[1]

The data used in my research are mainly collected from open resources freely such as annual reports, financial statements, companies' websites, and shipping news websites (Tradewinds, Lloyd's List), and some data are from shipping research reports like Clarkson Shipping Intelligence quarterly reports. The period of data is for six years from 2010 to 2015. Those Tables from 4 to 9 show statistics for variables used in DEA, which are maximum value, minimum value, average value, and standard deviations.

Table 4 Statistics of variables, 2010 (Units: USD million, TEU thousand)

2010	Asset	Cost	Fleet, TEU	Fleet, NO	Revenue	Net revenue	Income	Volume
Max	43,343	40,255	2,166	560	45,559	24,022	10,083	14,554
Min	1,559	2,906	319	77	3,472	3,324	404	2,697
Average	11,405	12,684	737	186	14,459	8,099	2,227	5,579
SD	14,549	12,773	648	170	14,406	7,208	3,521	4,175

Table 5 Statistics of variables, 2011 (Units: USD million, TEU thousand)

2011	Asset	Cost	Fleet, TEU	Fleet, NO	Revenue	Net revenue	Income	Volume
Max	47,577	45,848	2,521	645	49,917	25,108	9,144	16,222
Min	1,941	3,246	343	80	3,241	3,082	-1,592	3,165
Average	12,887	14,492	826	204	15,043	7,999	1,018	6,189
SD	15,836	14,549	767	200	16,048	7,732	3,663	4,668

Table 6 Statistics of variables, 2012 (Units: USD million, TEU thousand)

2012	Asset	Cost	Fleet, TEU	Fleet, NO	Revenue	Net revenue	Income	Volume
Max	42,824	38,160	2,625	596	49,491	27,117	7,694	16,986
Min	1,958	4,384	338	70	4,444	4,178	-1,286	3,244
Average	12,546	13,429	887	200	15,461	9,367	1,061	6,725
SD	13,998	11,511	793	182	15,589	8,039	3,004	4,850

[1] See Appendix 1 for detail data for six DMUs

Table 7 Statistics of variables, 2013 (Units: USD million, TEU thousand)

2013	Asset	Cost	Fleet, TEU	Fleet, NO	Revenue	Net revenue	Income	Volume
Max	41,293	36,261	2,631	574	47,386	26,196	7,336	17,678
Min	2,564	4,140	357	69	4,001	3,698	-436	3,016
Average	12,226	12,687	937	204	14,629	8,961	1,126	6,978
SD	13,459	10,908	778	171	14,961	7,820	2,786	5,127

Table 8 Statistics of variables, 2014 (Units: USD million, TEU thousand)

2014	Asset	Cost	Fleet, TEU	Fleet, NO	Revenue	Net revenue	Income	Volume
Max	44,671	35,633	2,946	610	47,569	27,351	5,917	18,884
Min	1,199	1,797	355	68	1,877	1,764	-20	3,142
Average	11,943	11,495	1,012	204	13,851	8,513	1,102	7,356
SD	15,151	11,429	889	187	15,624	8,741	2,159	5,547

Table 9 Statistics of variables, 2015 (Units: USD million, TEU thousand)

2015	Asset	Cost	Fleet, TEU	Fleet, NO	Revenue	Net revenue	Income	Volume
Max	43,999	31,265	2,962	590	40,308	23,729	1,870	19,044
Min	2,850	4,039	378	68	4,014	3,772	-203	3,149
Average	12,263	10,744	1,052	204	12,453	8,051	360	7,461
SD	14,626	9,412	875	178	12,669	7,099	713	5,621

Next, from Table 10 to Table 15 presents correlation coefficients among variables from 2010 to 2015. All input and output variables through the whole period have a positive significant amongst them. Panayides et al (2011) mentioned that the positive significant between variables is a necessary and basic hypothesis of DEA approach, which is known as “isotonicity”, which makes sure that when input variables increase, the output variables will be risen as well, and this result justify the model selection.

Table 10 Correlation coefficients, 2010

2010	Asset	Cost	Fleet, TEU	Fleet, NO	Revenue	Net revenue	Income	Volume
Asset	1.000							
Cost	0.997	1.000						
Fleet, TEU	0.968	0.950	1.000					
Fleet, NO	0.965	0.946	0.999	1.000				
Revenue	0.997	1.000	0.950	0.946	1.000			
Net revenue	0.998	0.992	0.975	0.970	0.992	1.000		
Income	0.992	0.979	0.986	0.983	0.979	0.995	1.000	
Volume	0.988	0.984	0.959	0.957	0.984	0.988	0.977	1.000

Table 11 Correlation coefficients, 2011

2011	Asset	Cost	Fleet, TEU	Fleet, NO	Revenue	Net revenue	Income	Volume
Asset	1.000							
Cost	0.997	1.000						
Fleet, TEU	0.977	0.959	1.000					
Fleet, NO	0.968	0.948	0.999	1.000				
Revenue	0.998	0.999	0.964	0.955	1.000			
Net revenue	0.998	0.991	0.984	0.977	0.994	1.000		
Income	0.949	0.929	0.970	0.974	0.941	0.965	1.000	
Volume	0.985	0.975	0.977	0.966	0.973	0.983	0.920	1.000

Table 12 Correlation coefficients, 2012

2012	Asset	Cost	Fleet, TEU	Fleet, NO	Revenue	Net revenue	Income	Volume
Asset	1.000							
Cost	0.990	1.000						
Fleet, TEU	0.958	0.938	1.000					
Fleet, NO	0.944	0.921	0.998	1.000				
Revenue	0.987	0.997	0.950	0.936	1.000			
Net revenue	0.994	0.990	0.973	0.962	0.995	1.000		
Income	0.926	0.936	0.950	0.946	0.959	0.961	1.000	
Volume	0.977	0.939	0.968	0.960	0.937	0.965	0.883	1.000

Table 13 Correlation coefficients, 2013

2013	Asset	Cost	Fleet, TEU	Fleet, NO	Revenue	Net revenue	Income	Volume
Asset	1.000							
Cost	0.987	1.000						
Fleet, TEU	0.958	0.938	1.000					
Fleet, NO	0.941	0.917	0.997	1.000				
Revenue	0.984	0.998	0.947	0.930	1.000			
Net revenue	0.995	0.991	0.972	0.958	0.994	1.000		
Income	0.960	0.969	0.963	0.957	0.982	0.982	1.000	
Volume	0.980	0.937	0.963	0.953	0.935	0.966	0.918	1.000

Table 14 Correlation coefficients, 2014

2014	Asset	Cost	Fleet, TEU	Fleet, NO	Revenue	Net revenue	Income	Volume
Asset	1.000							
Cost	0.979	1.000						
Fleet, TEU	0.952	0.900	1.000					
Fleet, NO	0.946	0.891	0.998	1.000				
Revenue	0.985	0.997	0.923	0.916	1.000			
Net revenue	0.996	0.993	0.936	0.927	0.996	1.000		
Income	0.970	0.958	0.964	0.963	0.976	0.971	1.000	
Volume	0.978	0.918	0.949	0.946	0.927	0.955	0.924	1.000

Table 15 Correlation coefficients, 2015

2015	Asset	Cost	Fleet, TEU	Fleet, NO	Revenue	Net revenue	Income	Volume
Asset	1.000							
Cost	0.979	1.000						
Fleet, TEU	0.966	0.935	1.000					
Fleet, NO	0.958	0.925	0.999	1.000				
Revenue	0.980	0.999	0.946	0.936	1.000			
Net revenue	0.995	0.991	0.969	0.961	0.993	1.000		
Income	0.995	0.978	0.943	0.933	0.975	0.986	1.000	
Volume	0.984	0.929	0.945	0.936	0.929	0.962	0.982	1.000

5.2.4 Selection of analysis models

This study will be adapted data envelopment analysis (DEA) to assess financial and operational efficiency of six DMUs. Especially, I will employ output-oriented CCR and BCC model that aims to maximize outputs without adding input values because it is better idea to increase outputs such as handled total volume of container, operating income and profit using firm's assets like ships, container and cranes rather than minimizing input elements in container shipping industry.

The CCR-O model measures technical efficiency for DMUs. However, the CCR model has a drawback that cannot evaluate pure technical efficiency because it assumes that all observed DMUs operate at an optimal scale. Bang at el, (2012) mentioned that in a real world, in liner service industry, there are situations which limit operation at the optimal scale such as imperfect competition, conference systems, cabotage rules, and regulatory exemptions from anti-trust laws. Because I want to make up for this weakness, I will also use the BCC-O model. With technical efficiency and pure technical efficiency by the CCR-O and BCC-O model respectively, I will have one more efficiency, scale efficiency for DMUs.

5.2.5 Efficiency analysis

To measure the efficiencies of CCR-O and BCC-O models, I will utilize aDEA-SOLVER (Learning version 8.0)[2], which is an Excel based software.

I will introduce basic procedure to calculate efficiencies with the DEA-SOLVER through an example. Table 16 presents the data of 2 inputs (asset and cost) and 2 outputs (revenue and income) for six DMUs (C, K, Y, H, E, and M).

Table 16 Data for operational efficiency analysis with 2 inputs and 2 outputs

DMU	(I)Asset	(I)Cost	(O)Revenue	(O)Income
C	9,911	12,426	14,252	1,130
K	6,648	9,817	11,219	667
Y	2,311	3,457	4,145	484
H	4,662	7,240	8,104	593
E	1,559	2,906	3,472	404
M	43,343	40,255	45,559	10,083

This table can be conversion into 2x6 matrix with X (inputs) and Y (outputs) through Table 17.

[2] See Appendix 2 for finding steps of using DEA-SOLVER

Table 17 Conversion table

DMU	(I)Asset	(I)Cost	(O)Revenue	(O)Income
C	X11	X21	Y11	Y21
K	X12	X22	Y12	Y22
Y	X13	X23	Y13	Y23
H	X14	X24	Y14	Y24
E	X15	X25	Y15	Y25
M	X16	X26	Y16	Y26

(1) 2 x 6 matrix

$$X = \begin{pmatrix} x_{11} & x_{12} & x_{13} & x_{14} & x_{15} & x_{16} \\ \hline x_{21} & x_{22} & x_{23} & x_{24} & x_{25} & x_{26} \end{pmatrix}, \quad Y = \begin{pmatrix} y_{11} & y_{12} & y_{13} & y_{14} & y_{15} & y_{16} \\ \hline y_{21} & y_{22} & y_{23} & y_{24} & y_{25} & y_{26} \end{pmatrix}$$

There are some assumption to measure the efficiency (θ). The “μ” and ”ν” indicate weight factor for Y and X respectively.

(2) Assumptions

$$Max\,\theta = \mu_1 y_{1o} + \mu_2 y_{2o}$$

Subject to

(1) $\nu_1 x_{1o} + \nu_2 x_{2o} = 1$

(2) $\mu_1 y_{11} + \ldots + \mu_1 y_{16} + \mu_2 y_{21} + \ldots + \mu_2 y_{26} \leq \nu_1 x_{11} + \ldots + \nu_1 x_{16} + \nu_2 x_{21} + \ldots + \nu_2 x_{26}$

(3) $\nu_1, \nu_2 \geq 0$

(4) $\mu_1, \mu_2 \geq 0$

To evaluate the efficiency, the linear program (LP) for DMU C is indicated below.

(3) LP for DMU C

$$Max\,\theta = \mu_1 y_{11} + \mu_2 y_{21}$$

Subject to

$$\mu_1 y_{11} + \mu_2 y_{21} \le v_1 x_{11} + v_2 x_{21}(C),\ \mu_1 y_{12} + \mu_2 y_{22} \le v_1 x_{12} + v_2 x_{22}(K)$$
$$\mu_1 y_{13} + \mu_2 y_{23} \le v_1 x_{13} + v_2 x_{23}(Y),\ \mu_1 y_{14} + \mu_2 y_{24} \le v_1 x_{14} + v_2 x_{24}(H)$$
$$\mu_1 y_{15} + \mu_2 y_{25} \le v_1 x_{15} + v_2 x_{25}(E),\ \mu_1 y_{16} + \mu_2 y_{26} \le v_1 x_{16} + v_2 x_{26}(M)$$

The optimal solution of "μ_1" and "v_1" for DMU C can be gained by the DEA-SOLVER, and weight vectors are shown in Table 18.

Table 18 Optimal weight vectors

DMU	v(1)	v(2)	u(1)	u(2)
C	0	8.41E-05	7.02E-05	0
K	0	1.07E-04	8.91E-05	0
Y	8.13E-06	2.84E-04	2.22E-04	1.65E-04
H	3.86E-06	1.45E-04	1.23E-04	0
E	6.42E-04	0	2.88E-04	0
M	2.05E-05	2.80E-06	0	9.92E-05

(4) Optimal weight factors , "μ" and "v"

- $\mu_1 = 8.41E-0.5,\ \mu_2 = 0$

- $v_1 = 0,\ v_2 = 8.41E-05$

Withthese weight factors, I could calculate the efficiency for DMU C.

(5) Efficiency (outputs / inputs)

$$\frac{\mu_1 y_{11} + \mu_2 y_{21}}{v_1 x_{11} + v_2 x_{21}} = 0.96$$

These (1) to (5) sequence are used to measure the operational and financial efficiency scores in CCR-O and BCC-O models as a basic DEA model.

Chapter 6 Analysis of results

This chapter shows the results of analyzing the financial efficiency and operational efficiency, which were obtained with DEA-SOLVER (Learning version 8.0) for six years, from 2010 to 2015. There are three types of efficiency scores, which are: technical efficiency calculated by CCR-O model, pure technical efficiency measured by BCC-O model, and scale efficiency (SE). The SE scores are calculated by dividing the technical efficiency score by the pure efficiency score. Returns-to-scale characteristics, which are increasing returns-to-scale (IRS), constant returns-to-scale (CRS), and decreasing returns-to-scale (DRS), are presented as well.

6.1 Interpretation of DEA

It is important to notice that the DEA model furnishes outcomes that only consider the relative efficiency of DMUs in the collection. For example, the efficiency scores of the six lines in my research represent each line's efficiency relative to the other five lines' efficiency, and its efficiency cannot represent the absolute efficiency of the entire group ofshipping lines.

There are seven cases of results by DEA using CCR-O model and BCC-O model.

- Case 1: The case in which, a company is CCR-efficient and BCC-efficient.
- Case 2: The case in which, a company is BCC-efficient but CCR-inefficient. The company can improve CCR-efficiency by increasing its scale (input variables).
- Case 3: The case in which a company is BCC-efficient but CCR-inefficient. The company can improve CCR-efficiency by decreasing its scale (input variables).
- Case 4: The case in which a company is CCR-inefficient and BCC-inefficient. The company can improve CCR-efficiency by increasing its scale (input variables).

- Case 5: The case in which a company is CCR-inefficient and BCC-inefficient. The company can improve CCR-efficiency by decreasing its scale (input variables).

- Case 6: The case in which a company is CCR-inefficient and BCC-inefficient with relatively high scale efficiency. This implies it is helped by its scale even though the company is inefficiently operated. The company can improve CCR-efficiency by increasing its scale (input variables).

- Case 7: The case in which a company is CCR-inefficient and BCC-inefficient with relatively high scale efficiency. This impliesthat it is helped by its scale even though the company is inefficiently operated. This company can improve CCR-efficiency by decreasing its scale (input variables).

Table 19 Seven cases of results

	TE (CCR)	PTE (BCC)	SE (CCR/BCC)	RTS
Case 1	1	1	1	CRS
Case 2	Below 1	1	below 1	IRS
Case 3	Below 1	1	below 1	DRS
Case 4	Below 1	below 1	below 1	IRS
Case 5	Below 1	below 1	below 1	DRS
Case 6	Below 1	below 1	close to 1	IRS
Case 7	Below 1	below 1	close to 1	DRS

Source: Author's own work

6.2 Financial efficiency[3]

6.2.1 Technical efficiency

Figure 20 shows the results of financial efficiency scores in CCR-O model for six container shipping firms during six years. Maersk is efficient for the whole period. K

[3] See Appendix 3 for results of financial efficiency for each year between 2010 and 2015

Line is efficient for four years and inefficient for two years (2010 and 2012), even though the efficiency scores are close to 1 for both years. Efficiency scores for the Yang Ming and Hanjin lines fluctuated during six years, with the lowest value of around 0.83 for both. COSCO experienced high variation for six years, from the highest score of about 0.73 in 2012 to the lowest score of around 0.97 in 2015. Evergreen had high efficiency scores before joining the strategic alliance in 2014, with an efficiency score of 1 for three consecutive years since 2010 and close to 1 in 2013. However, 2014 and 2015 witnessed lower efficiency scores than before. This is quite an interesting result, which is opposite from my expectation. I assumed that if a liner shipping company cooperates with other companies in forming a strategic alliance, the company would gain financial benefits with the help of scale economies.

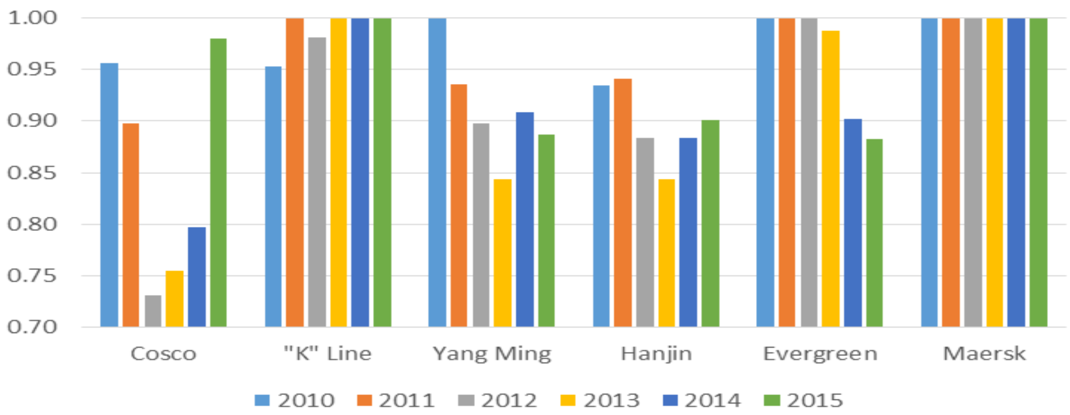


Figure 20Results of financial efficiency, CCR-O model

Source: Author's own work based on results

To analyze in more detail, I use another histogram (Figure 21), which indicates average financial efficiency by members of the CKYH alliance from 2010 to 2013 and the CKYHE alliance in 2014 and 2015. In addition, I included financial efficiency scores for Evergreen (indicated as "E" in the graph) and Maersk (indicated as "M" in the graph) in the graph to compare with the average scores. Evergreen's efficiency score is higher than average scores of the four firms that were members of the CKYH alliance for the first three years. The average score for the four firms is a little bit ahead of the score for Evergreen in 2013. In the following year, the efficiency score for Evergreen dropped to approximately 0.9. In 2015, the score for Evergreen decreased further than the previous year, while an average efficiency score of five lines, which were members of the CKYHE alliance escalated from the score of 2014.

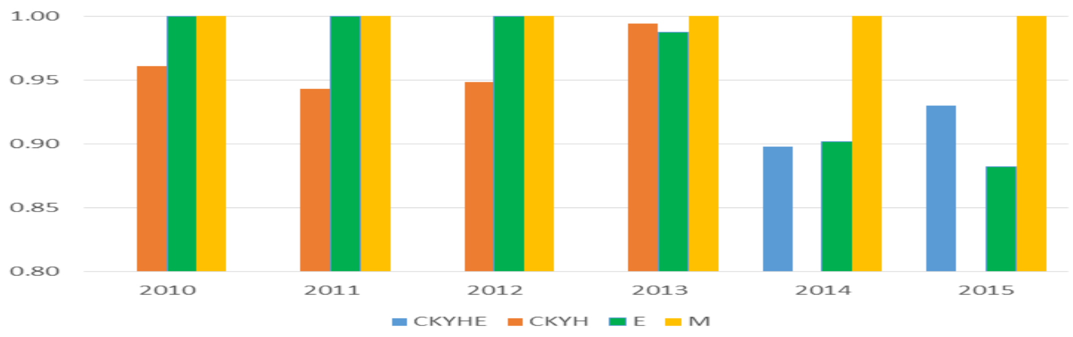


Figure 21Average financial efficiency, CCR-O model

Source: Author's own work based on results

6.2.2 Pure technical efficiency

Figure 22 presents the financial efficiency score in the BCC-O model, which assumes in variable returns-to-scale for DMUs. K Line, Yang Ming, Evergreen, and Maersk are efficient for almost the entire time period. The efficiency scores for COSCO and Hanjin experience fluctuation over the six years, even though the range of the fluctuation for Hanjin, from around 0.86 to 1, is lower than COSCO, which fluctuates from about 0.76 to 1.

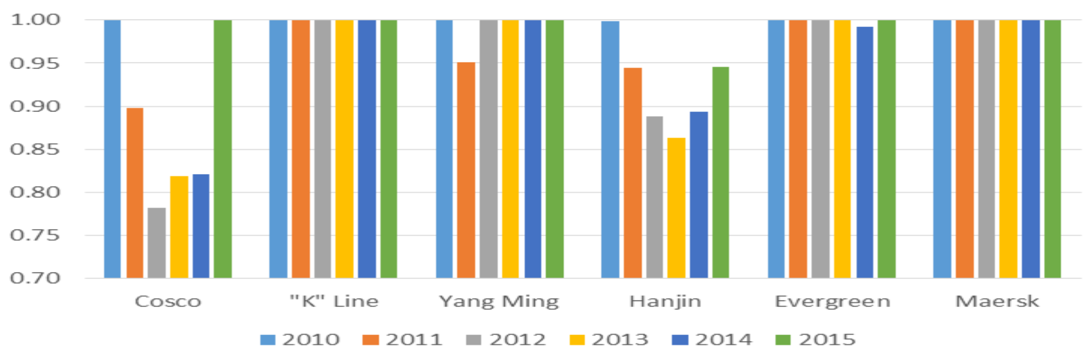


Figure 22Results of financial efficiency, BCC-O model

Source: Author's own work based on results

According to Figure 23, efficiency scores for Evergreen and Maersk are higher than average scores for members of the CKYH alliance and CKYHE alliance except in 2010, during which all were BCC-efficient.

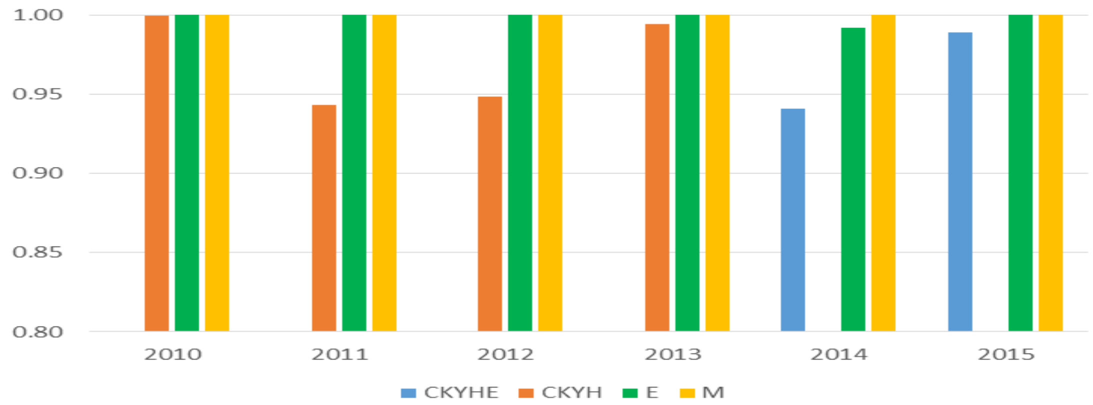


Figure 23Average financial efficiency, BCC-O model

Source: Author's own work based on results

6.2.3 Scale efficiency

Scale efficiency is measured through the calculation of technical efficiency, earned from the CCR model, divided by pure technical efficiency, gained from the BCC model. Generally, the CCR-efficiency does not exceed BCC-efficiency (Cooper at el., 2007).

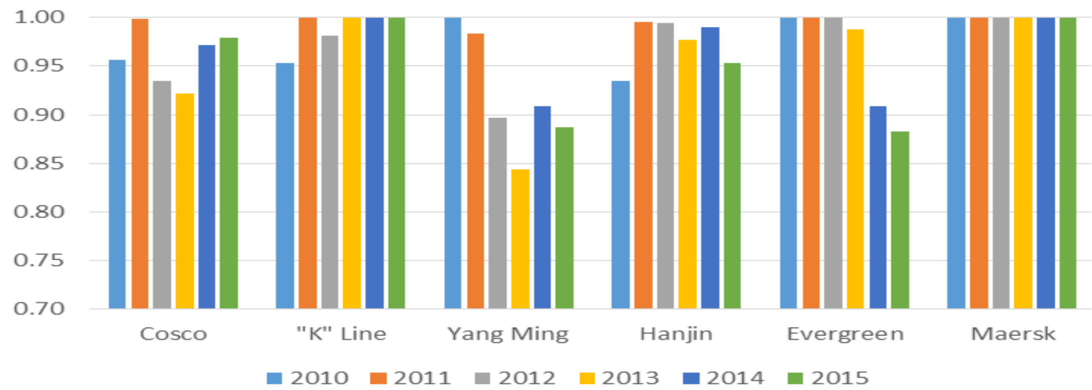


Figure 24Scale efficiency in financial efficiency analysis

Source: Author's own work based on results

Figure 24 shows the outcomes of scale efficiency for six lines from 2010 to 2015. Maersk is efficient in its scale during the whole period, and K Line is almost in scale-efficient except for two years in 2010 and 2012. COSCO and Hanjin are very similar in scores of scale efficiencies. Even though they are both volatile for six years in the efficiency scores in the CCR-O and BCC-O models, their scale efficiency scores are higher than 0.9. This means that their financial management is inefficiently operated, but their outputs are helped by the scales, which are dominant against other DMUs. For the case of Yang Ming, it is almost efficient for the entire time period in the BCC-O model except in the year of 2011 with a value of 0.95, but its scale efficiency scores are lower than other DMUs. This is because of lower technical efficiency scores from 2012 to 2015. If the company increases its inputs variables, the scales efficiency scores will be higher as it has the returns-to-scale characteristic of IRS (see Table 20), which stands for increasing returns-to-scale. The shape of Evergreen'sefficiency scores is exactly the same as thehistogram of the efficiency scores in the CCR-O model. The falling scores of technical efficiency motivate decreasing the scale efficiency scores as well as the average financial efficiency score for the CKYHE alliance in 2014 and 2015.

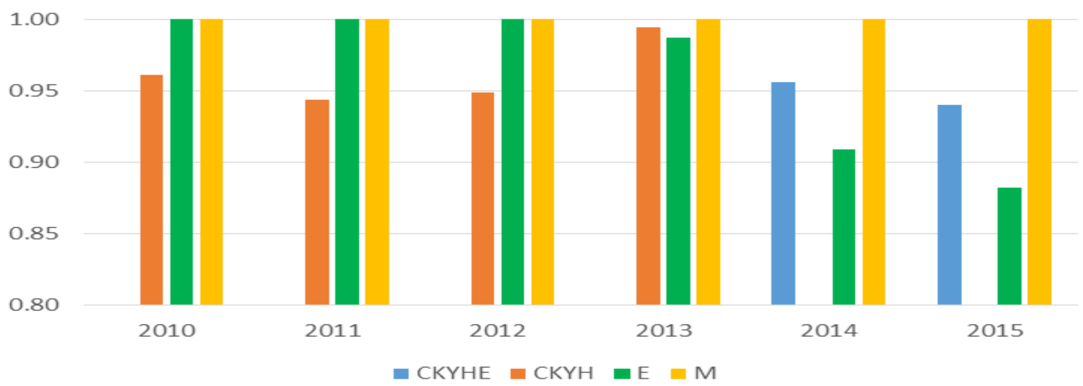


Figure 25 Average scale efficiency in financial efficiency analysis

Source: Author's own work based on results

Figure 25 presents average scores of scale efficiency for two strategic alliances and two shipping lines. The average scale efficiency score for four lines, the members of the CKYH alliance, fluctuates around 0.95 for the first three observed years, and increases to about 0.99 in 2014. The scores for the member of the CKYHE alliance drop for the last two years like the efficiency scores for Evergreen. Meanwhile, Maersk is scale-efficient for the entire time period. I summarize the analysis of financial efficiency in the Table 20.

Table 20 Summary of financial efficiency scores, 2010-2015

Lines		2010	2011	2012	2013	2014	2015
Cosco	CCR	0.96	0.90	0.73	0.76	0.80	0.98
	BCC	1.00	0.90	0.78	0.82	0.82	1.00
	RTS	DRS	CRS	IRS	IRS	IRS	IRS
	SE	0.96	0.999	0.93	0.92	0.97	0.98
"K" Line	CCR	0.95	1.00	0.98	1.00	1.00	1.00
	BCC	1.00	1.00	1.00	1.00	1.00	1.00
	RTS	DRS	CRS	DRS	CRS	CRS	CRS
	SE	0.95	1.00	0.98	1.00	1.00	1.00
Yang Ming	CCR	1.00	0.94	0.90	0.84	0.91	0.89
	BCC	1.00	0.95	1.00	1.00	1.00	1.00
	RTS	CRS	CRS	IRS	IRS	IRS	IRS
	SE	1.00	0.984	0.90	0.84	0.91	0.89
Hanjin	CCR	0.93	0.94	0.88	0.84	0.88	0.90
	BCC	1.00	0.95	0.89	0.86	0.89	0.95
	RTS	DRS	CRS	DRS	IRS	IRS	IRS
	SE	0.93	0.996	0.99	0.98	0.99	0.95
Evergreen	CCR	1.00	1.00	1.00	0.99	0.90	0.88
	BCC	1.00	1.00	1.00	1.00	0.99	1.00
	RTS	CRS	CRS	CRS	IRS	IRS	IRS
	SE	1.00	1.00	1.00	0.99	0.91	0.88
Maersk	CCR	1.00	1.00	1.00	1.00	1.00	1.00
	BCC	1.00	1.00	1.00	1.00	1.00	1.00
	RTS	CRS	CRS	CRS	CRS	CRS	CRS
	SE	1.00	1.00	1.00	1.00	1.00	1.00

Source: Author’s own work

6.3 Operational efficiency[4]

6.3.1 Technical efficiency

[4] See Appendix 4 for results of operational efficiency for each year between 2010 and 2015

Figure 26 presents the results of the operational efficiency scores for six lines using the CCR-O model. Two DMUs, COSCO and K Line, are CCR-efficient for six years, whereas four DMUs are CCR-inefficient for the same test years. Yang Ming shows an increasing trend during the first three years from about 0.92 to 1 and a decreasing trend for the last three years from around 0.88 to just above of 0.7. Three firms (Hanjin, Evergreen, and Maersk) out of four firms in an inefficient group experience fluctuation during the entire time period. The efficiency scores for Hanjin are above 0.8, while those for Evergreen and Maersk are below than 0.7. In particular, Evergreen witnessed the highest inefficiency scores between 2010 and 2015.

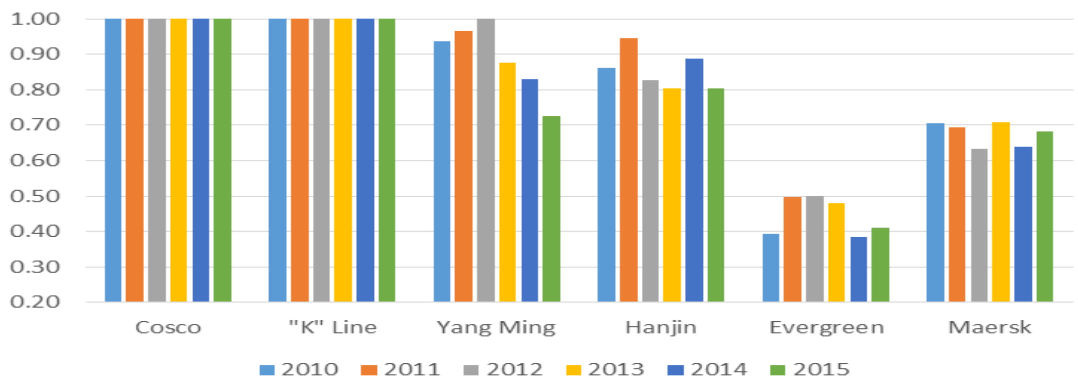


Figure 26Results of operational efficiency, CCR-O model

Source: Author’s own work based on results

To scrutinize the impact of joining a strategic alliance on operational performances, I analyzed the average operational efficiencies of members in the CKYH alliance from 2010 to 2013 and the CKYHE alliance from2014 to 2015 (Figure 27). The CCR-efficiency scores for Evergreen before joining a strategic alliance are lower than those for firms that were members of the CKYH alliance, and after forming the CKYHE alliance, that does not change. The relative efficiency scores are still low, they are lower than the values for the period when Evergreen was not a member of strategic alliance.

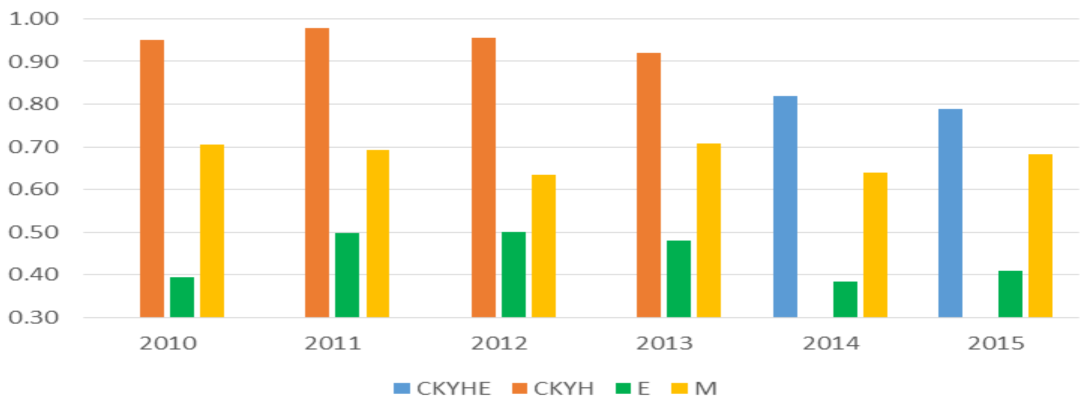


Figure 27Average operational efficiency, BCC-O model

Source: Author's own work based on results

6.3.2 Pure technical efficiency

A histogram, shown in Figure 28, indicates BCC-efficiency scores and a transition of numbers for six years. Three DMUs, which are COSCO, K Line, and Maersk, are BCC-efficient during the entire observed period. Yang Ming are BCC-efficient for the first five years, and it is about 24 percent inefficient in 2015. The efficiency scores for Hanjin in BCC-O model change; they are between about 0.81 and 0.95. Evergreen's scores are consistantly lower than other firms' scores. They are below 0.55.

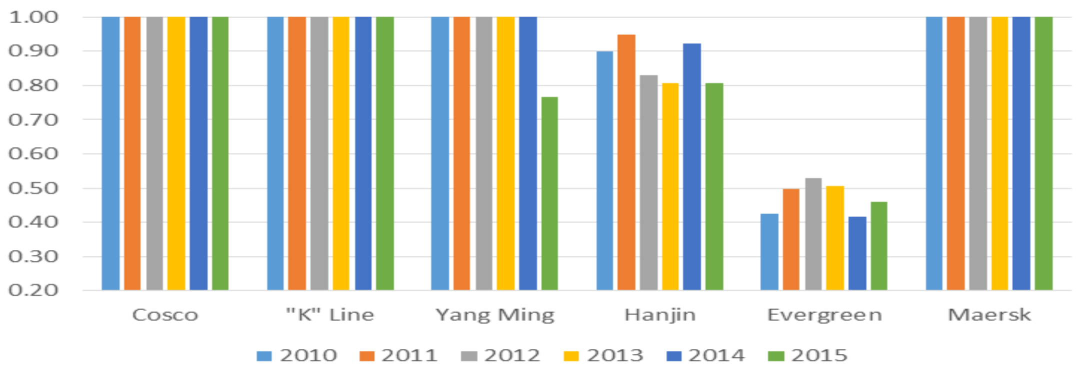


Figure 28Results of operational efficiency, BCC-O model

Source: Author's own work based on results

According to Figure 29, an average operational efficiency score of four firms in the

CKYH alliance is close to one (BCC-efficiency) from 2010 to 2013, and Evergreen's BCC scores are between 0.4 and 0.5 within the same period. Although Evergreen joined the strategic alliance in 2014, its relative BCC-efficiency values are not positively affected, its scores for the last two years are lower than the values between 2011 and 2013.

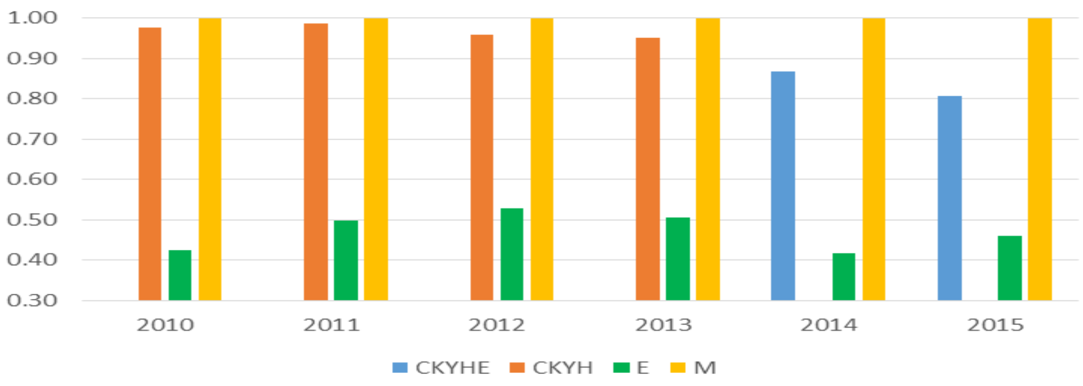


Figure 29Average operational efficiency, BCC-O model

Source: Author's own work based on results

6.3.3 Scale efficiency

I divided the results of scale efficiency scores for six DMUs (Figure 30) into three groups with similar features.

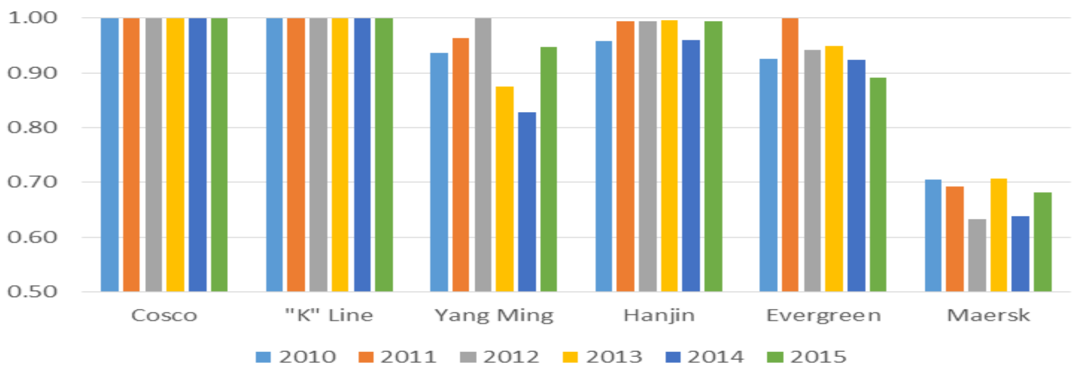


Figure 30Scale efficiency in operational efficiency analysis

Source: Author's own work based on results

COSCO and K Line are allocated into the first group because they are scale efficient during the entire period, while also being CCR and BCC efficient. Hanjin and Evergreen are placed into the second group with similar high scale efficiency scores, even though they are inefficient in both CCR and BCC models with lower efficiency scores than their scale efficiency scores. This means that, relatively, their scale efficiencies prevail over other companies' scores. As Table 21 demonstrates, Evergreen has high scale efficiency scores, in spite of the state of inefficiency with its average CCR-efficiency score of 0.44 and the average BCC-efficiency score of 0.47. The firms in the last group are Yang Ming and Maersk. Their scale efficiency values are relatively low compared to their BCC-efficiency values, due to low CCR scores. However, they have different returns-to-scale characteristics. Maersk has DRS, which stands for decreasing returns-to-scale, and Yang Ming has IRS, which means increasing returns-to-scale. By reducing input variables, Maersk can have more outputs, whereas by deploying more input variables, Yang Ming is able to gain better results.

Figure 31 displays average scale efficiency in evaluation of operational efficiency. The average efficiency scores for members of the CKYH alliance and CKYHE alliance changeover the six years with scores higher than approximately 0.93 each year. Two lines' scores are also altered during the years with the highest scores (about 0.94) for Evergreen and the lowest scores (about 0.68) for Maersk, both on average.

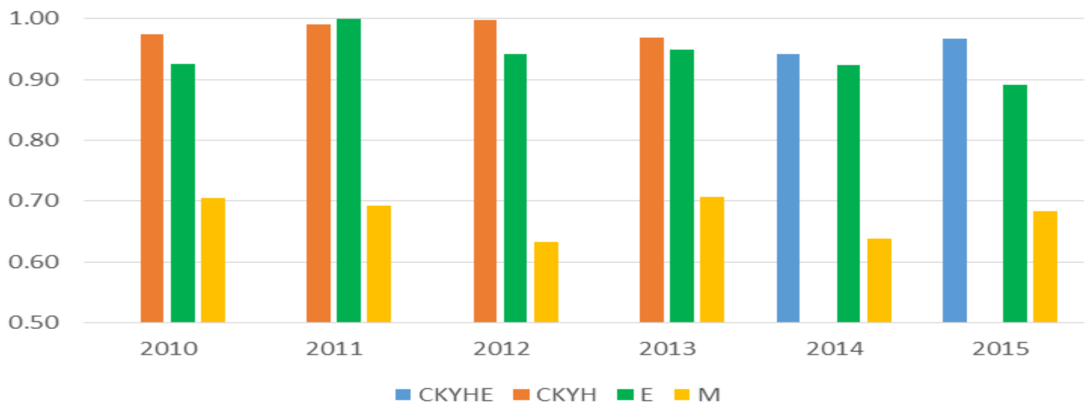


Figure 31Average scale efficiency in operational efficiency analysis

Source: Author's own work based on results

Table 21 Summary of operational efficiency scores, 2010-2015

Lines		2010	2011	2012	2013	2014	2015
Cosco	CCR	1.00	1.00	1.00	1.00	1.00	1.00
	BCC	1.00	1.00	1.00	1.00	1.00	1.00
	RTS	CRS	CRS	CRS	CRS	CRS	CRS
	SE	1.00	1.00	1.00	1.00	1.00	1.00
"K" Line	CCR	1.00	1.00	1.00	1.00	1.00	1.00
	BCC	1.00	1.00	1.00	1.00	1.00	1.00
	RTS	CRS	CRS	CRS	CRS	CRS	CRS
	SE	1.00	1.00	1.00	1.00	1.00	1.00
Yang Ming	CCR	0.94	0.96	1.00	0.88	0.83	0.72
	BCC	1.00	1.00	1.00	1.00	1.00	0.76
	RTS	IRS	IRS	CRS	IRS	IRS	CRS
	SE	0.94	0.96	1.00	0.88	0.83	0.95
Hanjin	CCR	0.86	0.94	0.83	0.80	0.89	0.80
	BCC	0.90	0.95	0.83	0.81	0.92	0.81
	RTS	DRS	IRS	CRS	DRS	CRS	CRS
	SE	0.96	0.99	0.99	1.00	0.96	0.99
Evergreen	CCR	0.39	0.50	0.50	0.48	0.38	0.41
	BCC	0.43	0.50	0.53	0.51	0.42	0.46
	RTS	DRS	IRS	DRS	DRS	DRS	DRS
	SE	0.93	1.00	0.94	0.95	0.92	0.89
Maersk	CCR	0.70	0.69	0.63	0.71	0.64	0.68
	BCC	1.00	1.00	1.00	1.00	1.00	1.00
	RTS	DRS	DRS	DRS	DRS	DRS	DRS
	SE	0.70	0.69	0.63	0.71	0.64	0.68

Source: Author's own work

6.4 Overview of analysis

6.4.1 Average financial efficiency scores

Figure 32 shows the results of analysis on financial performance indicated average values for six years. The graph contains the combined results of average scores of CCR efficiency and BCC efficiency for six years. A red dot is located in the upper right corner indicates a line is efficient financially.

According to the diagram, Maersk is the most financially efficient firm with an average efficiency score of 1 in both the CCR-O and BCC-O model. K Line is the second most financially efficient firm with a BCC-efficiency score of 1. The third most efficient company is Evergreen with BCC and CCR efficiency scoresjust a bit lower than K Line. COSCOoperates its financial resource the most ineffectively compared to the other five lines.

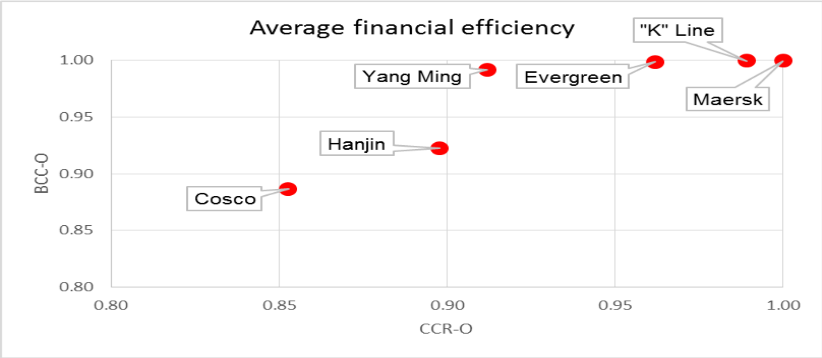


Figure 32Average financial efficiency

Source: Author's own work based on results

6.4.2 Average operational efficiency scores

On the other hand, as shown in Figure 33, COSCO is the one of two firms that possesses the highest average operational efficiency score. The other firm is K Line with an efficiency score of 1 in both the CCR-O and BCC-O models. Yang Ming is located more closely to the upper right side than Hanjin. Maersk is the fourth efficient line with a BCC-O score of 1 and a CCR-O score of about 0.68. Lastly, Evergreen received the highest inefficiency scores of the six firms.

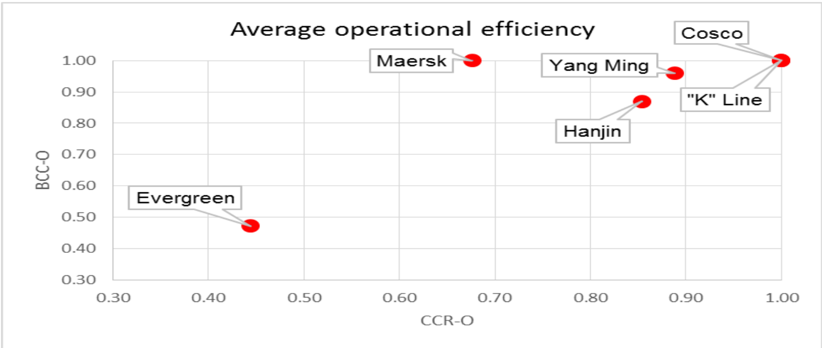
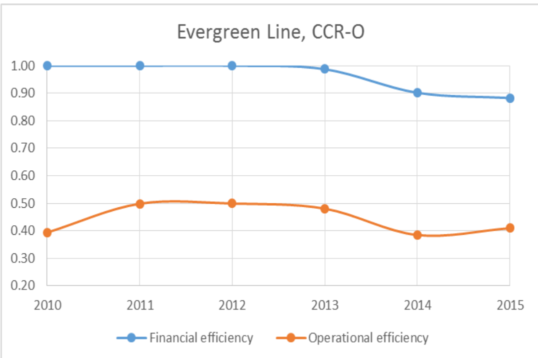


Figure 33Average operational efficiency

Source: Author's own work based on results

6.4.3 Transition of efficiencies for Evergreen Line

The purpose of this research is to explore the influence that forming a strategic alliance on a liner shipping company's efficiencies, in this case Evergreen. This, I examined the transition of efficiency scores by separating two types of efficiencies, financial and operational efficiency. The graphs (Figure 34 and 35) present two types of efficiency scores measured by the CCR-O and BCC-O models for Evergreen Line from 2010 to 2015. There are some common features between them. First of all, the CCR scores for the financial model and operational model drop in 2014, when Evergreen began cooperating with other lines as a member of the CKYHE alliance. In addition, the BCC score of operational performance declined in the same year. Secondly, financial efficiency scores are higher than operational efficiency scores during the observed period. Evergreen is always BCC-efficient financially except in 2014, and its financial management is almost always CCR-efficient except in 2014 and 2015. Lastly, its operational efficiency scores for both models are low with values fluctuating between 0.4 and 0.6.



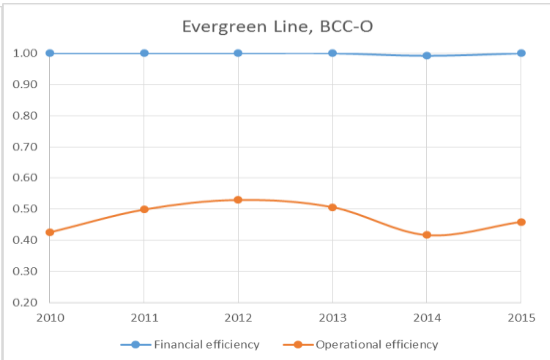


Figure 34 Evergreen's efficiencies in CCR-O model Figure 35Evergreen's efficiencies in BCC-O model

Source: Author's own work based on results Source: Author's own work based on results

The scale efficiency graph also presents a similar situation to the CCR-O and BCC-O models. Scale efficiency scores for both financial efficiency and operational efficiency analysis shows a downward trend after 2014, except in the operational efficiency analysis for 2014.

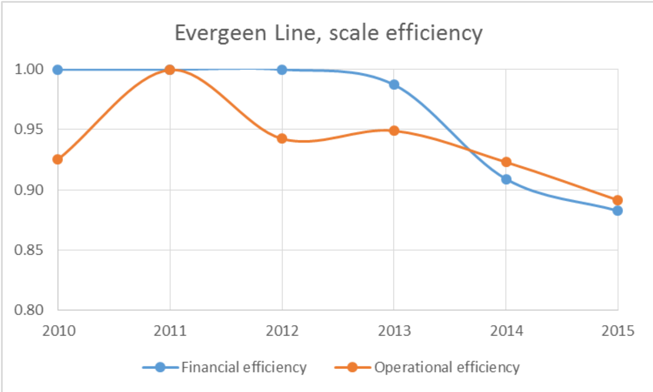


Figure 36Evergreen's scale efficiency

Source: Author's own work based on results

To scrutinize in detail, I calculated average efficiency scores by dividing the periodsbefore and after of formation of the CKYHE alliance, which are from 2010 to 2013 and from 2014 to 2015 (Table 22). There are three spaces, which blue, white, and red, in the table. The blue space indicates anefficiency score that is more than 0.3 higher than the score from the former period (2010-2013). The red area is the opposite of the blue area, representing an efficiency score that is more than 0.3 lower than that of the former period. The last white spacerepresents similar scores between the two periods, with a maximum differences of 0.3. According to the results, after forming the CKYHE alliance, only COSCO's financial efficiency scores is increased more than 0.3, and its operational scores arethe same between the two periods. The operational and financial efficiency scores of three lines', K Line, Hanjin, and Maersk, are almost unchanged before and after forming the shipping alliance. Financial efficiency for Yang Ming is nearly similar, however, the average operational efficiency scores for last two years are quite lower than those of the first four years. Evergreen's efficiency scores for 2014 and 2015 are lower than the average efficiency scores from 2010 to 2013 with a difference in scores of 0.3 in both financial and operational efficiencies, except for the BCC-financial efficiency scores.

Table 22 Average efficiency scores for Evergreen

Lines	COSCO			"K" Line			Yang Ming		
F.E	CCR	BCC	SE	CCR	BCC	SE	CCR	BCC	SE
2010-2013	0.83	0.87	0.95	0.98	1.00	0.98	0.92	0.99	0.93
2014-2015	0.89	0.91	0.98	1.00	1.00	1.00	0.90	1.00	0.90
O.E	CCR	BCC	SE	CCR	BCC	SE	CCR	BCC	SE
2010-2013	1.00	1.00	1.00	1.00	1.00	1.00	0.94	1.00	0.94
2014-2015	1.00	1.00	1.00	1.00	1.00	1.00	0.78	0.88	0.89
Lines	Hanjin			Evergreen			Maersk		
F.E	CCR	BCC	SE	CCR	BCC	SE	CCR	BCC	SE
2010-2013	0.90	0.92	0.98	1.00	1.00	1.00	1.00	1.00	1.00
2014-2015	0.89	0.92	0.97	0.89	1.00	0.90	1.00	1.00	1.00
O.E	CCR	BCC	SE	CCR	BCC	SE	CCR	BCC	SE
2010-2013	0.86	0.87	0.99	0.47	0.49	0.95	0.68	1.00	0.68
2014-2015	0.85	0.87	0.98	0.40	0.44	0.91	0.66	1.00	0.66

Source: Author's own work

*F.E: Financial Efficiency, O.E: Operational Efficiency

According to Table 23, it is required that Evergreen and Yang Ming need to change their amounts inputs to enhance their efficiencies. Evergreen's RTS characteristics for financial and operational analysis are opposite to IRS and DRS respectively for the last three years. This means that Evergreen should increase its scale of financial management and reduce the level of operational management by employing larger vessels and upgrading fleet utilization rates through more cooperation with members of the strategic alliance. Yang Ming should expand its fleet to make use of scale economies.

Table 23 Summary of returns-to-scale (RTS) characteristics by DEA

DMUs	Efficiency	2010	2011	2012	2013	2014	2015
COSCO	F.E	DRS	CRS	IRS	IRS	IRS	IRS
	O.E	CRS	CRS	CRS	CRS	CRS	CRS
"K" Line	F.E	DRS	CRS	DRS	CRS	CRS	CRS
	O.E	CRS	CRS	CRS	CRS	CRS	CRS
Yang Ming	F.E	CRS	CRS	IRS	IRS	IRS	IRS
	O.E	IRS	IRS	CRS	IRS	IRS	CRS
Hanjin	F.E	DRS	CRS	DRS	IRS	IRS	IRS
	O.E	DRS	IRS	CRS	DRS	CRS	CRS
Evergreen	F.E	CRS	CRS	CRS	IRS	IRS	IRS
	O.E	DRS	IRS	DRS	DRS	DRS	DRS
Maersk	F.E	CRS	CRS	CRS	CRS	CRS	CRS
	O.E	DRS	DRS	DRS	DRS	DRS	DRS

Source: Author's own work

*F.E: Financial Efficiency, O.E: Operational Efficiency

In summary, through the analysis of efficiency I found that the average relative efficiency scores of Evergreen for two years after joining a shipping allianceare lowerthan its average efficiency scores for four years just before joining shipping alliance. This means that I could expect that the joining strategic alliance has a negative effect on the Evergreen's financial and operational efficiencies, however, it cannot be said that the undesirable outcome is due to the forming ofan alliance.

Chapter 7 New generation of strategic alliance

7.1 Formation of new strategic alliances

Presently (2016), there are four groups of strategic alliances, which are 2M (Maersk and MSC), CKYHE (COSCO, K Line, Yang Ming, Hanjin, and Evergreen), G6 (APL, Hapag-Lloyd, HMM, MOL, NYK, and OOCL), and Ocean 3 (CMA CGM, CSCL, and UASC). However, the liner shipping industry will be changed enormously due to appearance of new strategic alliance groups, Ocean alliance and THE alliance, in 2017, resulting in three strategic alliance structures in the industry.

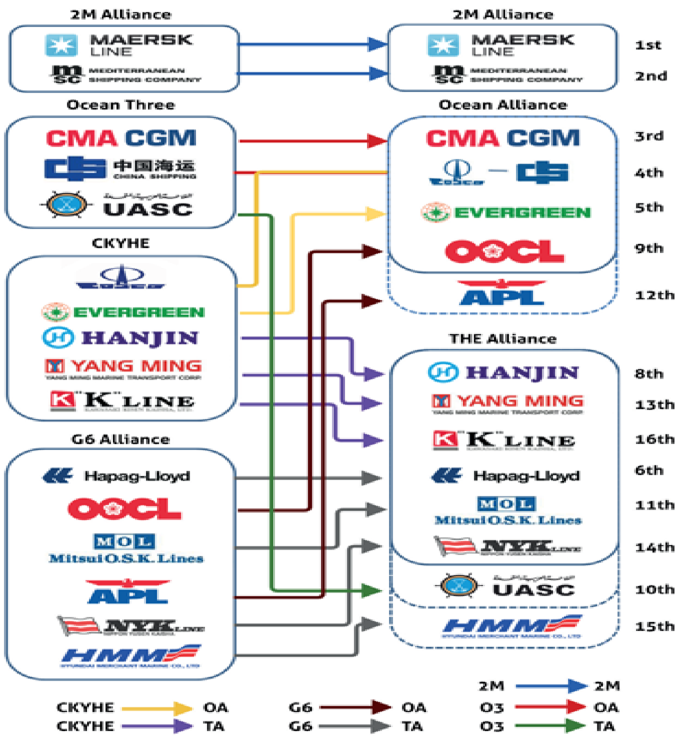


Figure 37Overview of alliance changes, 2016-2017

Source: Murphy, A. (2016). The three final alliances. Lloyd's List.

These new alliances will be formed by reshuffling thelines that are members of the existing three strategic alliances. Figure 37 shows the overview of alliance reformations. Only the 2M alliance will be continued, and the others will changetheirmembers. CMA CGM, China COSCO, Evergreen, and OOCL will cooperate firmly by forming a new alliance, named Ocean alliance. In addition to one of the new alliances, Hanjin, Yang Ming, K Line, Hapag-Lloyd, MOL and NYK will operate their fleets under the same roof as members of THE alliance. Two potential members of THE alliance are UASC and HMM. UASC is under the consideration of merger with Hapag-Lloyd, and HMM will join it after settling its debt-related problems.

7.2 Comparison among strategic alliances

These days, one of the hot issues in the liner shipping industry is the restructuring of the strategic alliances. The reason is that the groups of strategic alliances have a significant influence on liner business. According toK Line's factbook 2015 (Figure 38), four strategic alliances occupy more than 90 percent of the market share on both trade routes, which are Asia-Europe and Asia-North America. In addition to this, the lines were belonging to strategic alliances are able to make use of economies of scale so that they can be survived in the market if low freight rates occur, caused by over capacity of vessels. In addition, the global cooperation helps container shipping firms maximizing of their resources, such as fleets, networks, and services, andminimize their operating costs. With these crucial advantages, it can be said that nonmember lines are taught to make a profit to even survive in the international container delivery business.

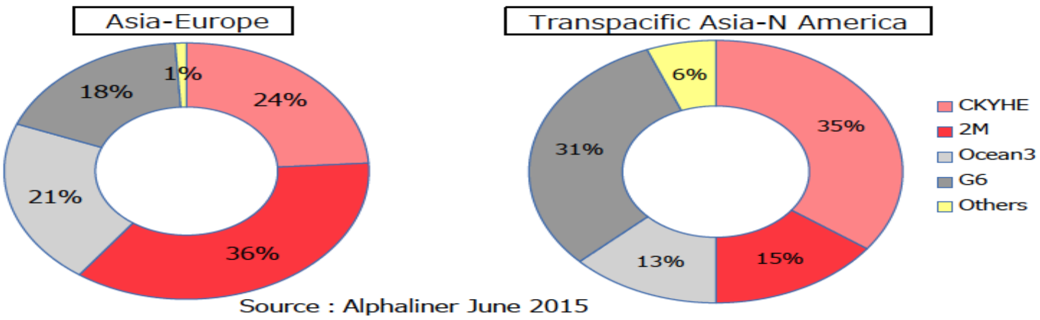


Figure 38Market shares by strategic alliances

Source: “K” Line’s FACTBOOK 2015, www.kline.co.jp

To compare the new strategic alliances and forecast the market powers, I investigated the total fleet capacity (current owned fleets + charted fleets + orderbook) in TEUs for the alliances (Figure 39). Currently, the 2M alliance operates more vessels than the other two alliances. However, if considering the volume of orderbook, 2M and Ocean alliance will be almost the same in line with volume of fleets. It is a fact that THE Alliance has a relatively smaller orderbook (587,492 TEUs) and a lower current operating capacity than the 2M Alliance (872,509 TEUs) and Ocean Alliance (1,290,174 TEUs).

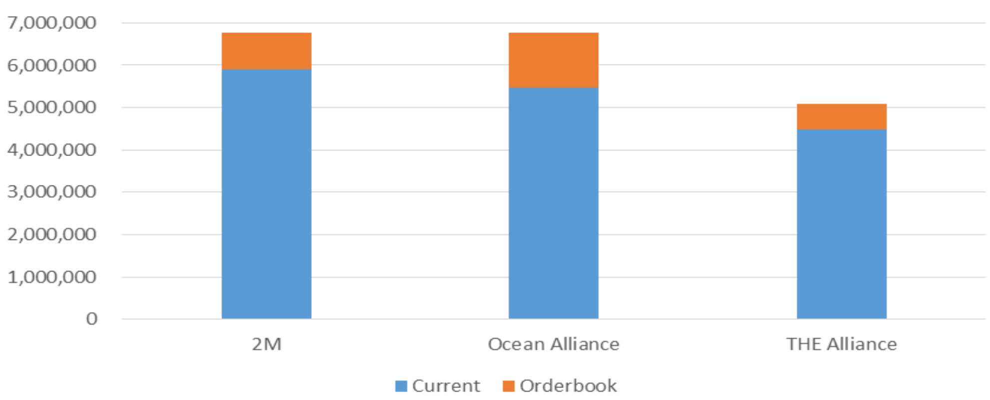


Figure 39Total operated fleets and orderbook, based on June 2016

Source: Own graph, data from Alphaliner

Ocean Alliance and THE Alliance are going to launch their new services in April 2017, severe competition is expected with 2M, the remaining alliance. The three strategic alliances are predicted to compete along two main routes, which are the Asia-North America route and Asia-North Europe route. According to Alphaliner (Table 24), on the one hand, Ocean Alliance and THE Alliance will be expected to have similar market share on the Asia-North America service route with 39% each, while 2M will possess 16% of market share on the same trade route. On the other hand, 2M, Ocean Alliance, and THE Alliance will be competing intensely with one another with similar market shares of 34%, 35% and 30% respectively. In addition to this, there are some more interesting features among the three alliances. In line with the contract period, 2M will be existed for 10 years, whereas OCEAN Alliance and THE Alliance will be maintained for 5 years. This difference in time period will give each alliance distinct advantages, which are stability for a longer period contract and flexibility for a shorter period of contract. In terms of number of members, 2M is only formed by only two firms, and THE Alliance is structured by eight firms, including two pending firms, HMM and UASC. This may cause a discrepancy in the speed of communications and decisions, which may affect the competitiveness of the firms.

Table 24 Summary on restricting of strategic alliances

Name of strategic alliance		2M	OCEAN Alliance	THE Alliance
Members (No.)		2	4	6(2)
Start date of service		Q1, 2015	Q2, 2017	Q2, 2017
Market shares	*Asia-North America*	16%	39%	39%
	Asia-Europe	34%	35%	30%
Contract period		10 years	5 years	5 years

Source: Author's own work, based on the data from Alphaliner

* The number 6(2) for THE Alliance implies 6 confirmed members and 2 unfixed members.

Chapter 8 Conclusion and recommendation

The liner shipping industry has witnessed a huge wave of structure change due to the restructuring of strategic alliances. This research measured the two types of efficiency, which are financial efficiency and operational efficiency, to observe a transition of efficiency for six lines, which are COSCO, K Line, Yang Ming, Hanjin, Evergreen, and Maersk, for the period between 2010 and 2015. DEA method is used to calculate efficiency scores, and in particular, output-oriented CCR model and BCC model are adapted to measure the technical efficiency and pure technical efficiency, respectively.

The main findings are as fallows.To begin, according to the results of financial performance analysis, I separatedthe six lines into four groups based on the similar characteristics. Maersk Line is categorized into the first group as the most efficient company, both CCR-efficient and BCC-efficient for six years. The members of the second group are K Line and Evergreen Line; both were BCC-efficient, even though the CCR-efficiency score of K Line is a little bit higher, 0.99, compared toEvergreen Line's 0.96. Yang Ming and Hanjin Shipping are included in the third group with similar efficiency scores. The company that operated financial resources most inefficiently among the six lines is COSCO, a member of the last group with lower CCR and BCC efficiencies than scale efficiency.Moreover, I dividedthe four groups pertaining to the similar aspects by the result of operational performance analysis. COSCO and K Line are the most efficient lines during the test period, and they are classified into the same group. Yang Ming is a member of the second group with 0.89 in the CCR-model and 0.96 in the BCC-model. Hanjin Shipping and Evergreen Line have similar resultsfor operational efficiency with the fact that their scale efficiency scores are higher than their CCR-efficiency and BCC-efficiency scores. Two companies are helped by their scales, even though they have relatively lower technical and pure technical efficiency scores. Evergreen Line is 56% inefficient in the CCR-O model and 53% inefficient in the BCC-O model. Maersk is categorized into a separated group, being both BCC-efficient and CCR-inefficient (32%). Lastly, through the analysis of average efficiency by dividing the years studied into two periods, the first four years (2010-2013) and the last two years (2014-2015), I found that Evergreen had not experienced a positive impact on both financial and operational efficiencies after joining a strategic alliance, with lower average efficiency scores than those during 2010 to 2013. In addition, Yang Ming's operational average efficiency scores were also dropped after forming the CKYHE alliance in 2014, while efficiency scores of the other three members of the CKYHE alliance were stable before and after the strategic alliance. Only COSCO's financial average efficiency scores were improved with more than 0.3 from former years.

There are some recommendationsto improve the efficiencies by making using of the results of returns-to-scale characteristics. First of all, Evergreen has the characteristics of increasing returns-to-scale from the financial efficiency analysis and decreasing returns-to-scale from the operational efficiency analysis. Therefore, Evergreen needs to increase financial related inputs (fixed asset and operating cost) and to decrease the operational related inputs (total operating capacity and number of ships) to increase its efficiency. This can be realized by employing larger vessels as well as by raising the utilization rates of ships by expanding the scale of strategic alliances among members. Lastly,Yang Ming needs to increaseits scale to enhance its efficiency scores with the same characteristics of increasing returns-to-scales from financial and operational efficiency analysis. To do that, Yang Ming should invest more inships to have a larger scale of operating fleets through purchasing new or second-hands ships or chartering ships.

There are some limitations existing in this research paper as well. First, the insufficient number of input and output variables for performance analysis is a weakness in this research. This research only adapted two input and output variables each to measure the financial and operational efficiency because it was difficult to collect valuable numerical data from the open sources, such as annual reports of firms and shipping news websites. It can be said that an efficiency analysis with a small number of variables only represents part of the lines' efficiencies. Therefore, in the future research, it will be necessary to adapt a greater number of inputs and outputs in order to explain performance on complex liner businesses.Second, another drawback in this paper is the scarce number of DMUs. According to Cooper at el. (2007), if the number of DMUs is less than the combined number of inputs and outputs, a large portion of the DMUs will be identified as efficient, and the efficiency discrimination among DMUs will be questionable due to an inadequate number of degrees of freedom. They also suggest that the number of DMUs needs to be equal to or greater than max{no. of output $\times$ no. of input, 3 $\times$ (no. of input + no. of output)}. Last, this study dealt with financial data coming from different accounting systems, which lead to bias among the data. Mainly, to measure financial efficiency, I collected data from the financial statements of six lines, which adapt three types of accounting rules, China GAAP, US GAAP, and IFRS (Table 25). Future studies should avoid this inconsistency.

Table 25 Accounting systems used by six lines, 2010 - 2015

	2010	2011	2012	2013	2014	2015
COSCO	*China GAAP*					
"K" Line	*U.S GAAP*					
Yang Ming	*China GAAP*		*IFRS*			
Hanjin	*IFRS*					
Evergreen	*China GAAP*		*IFRS*			
Maersk	*IFRS*					

Source: Author's own work, based on the data from financial statements for six lines

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Appendix 1 – Raw Data for DMUs used by efficiency analysis and exchange rates for currency conversion

1) DMU 1

COSCO	GAAP						
Segments	2015	2014	2013	2012	2011	2010	Unit
Property, plant and equipment	13,471	13,007	13,231	12,780	11,295	9,911	USD million
Operating cost	8,792	10,210	10,895	11,431	13,856	12,426	USD million
Total capacity	858	819	788	717	653	528	TEU Thousand
No. of vessels	164	163	171	159	148	135	Number
Revenue	9,135	10,864	10,750	10,818	13,091	14,252	USD million
Operating revenue (container shipping)	7,117	8,170	7,853	7,705	6,404	6,848	USD million
Operating income	515	169	-212	-1,286	-1,592	1,130	USD million
Handled volume	9,828	9,438	8,702	8,016	6,910	6,215	TEU Thousand

2) DMU 2

"K" Line	U.S. GAAP						
Segments	2015	2014	2013	2012	2011	2010	Unit
Property, plant and equipment / fixed assets	4,821	5,975	6,776	8,304	7,747	6,648	USD million
Operating costs	9,582	11,597	11,510	13,016	11,861	9,817	USD million
Total capacity	378	355	357	343	343	324	TEU Thousand
No. of vessels	68	68	69	70	80	77	Number
Revenue	10,276	12,776	12,544	14,213	12,180	11,219	USD million
Operating revenue (container shipping)	5,146	6,469	6,051	7,040	4,999	5,095	USD million
Operating income	78	453	296	186	-508	667	USD million
Handled volume	3,149	3,142	3,016	3,244	3,165	3,094	TEU Thousand

3) DMU 3

Yang Ming	IFRS				GAAP		
Segments	2015	2014	2013	2012	2011	2010	Unit
Property, plant and equipment / net properties	2,850	1,199	3,020	2,999	2,414	2,311	USD million
Operating cost	4,039	1,797	4,140	4,384	3,701	3,457	USD million
Total capacity	529	416	383	338	343	319	TEU Thousand
No. of vessels	99	91	90	81	83	77	Number
Revenue	4,014	1,877	4,001	4,444	3,553	4,145	USD million
Operating revenue (container shipping only)	3,772	1,764	3,698	4,178	3,347	3,951	USD million
Operating income	-203	39	-203	-66	-317	484	USD million
Handled volume	4,018	3,968	3,561	3,696	3,473	3,206	TEU Thousand

4) DMU 4

Hanjin Shipping	IFRS						
Segments	2015	2014	2013	2012	2011	2010	Unit
Property, plant and equipment, net	5,050	5,422	6,473	6,411	6,345	4,662	USD million
Operating cost	6,626	7,826	8,643	8,953	8,439	7,240	USD million
Total capacity	634	598	649	576	486	469	TEU Thousand
No. of vessels	105	95	121	110	102	102	Number
Revenue	6,773	8,009	8,406	9,033	8,279	8,104	USD million
Operating revenue (container shipping)	4,690	5,477	5,647	5,720	5,054	5,351	USD million
Operating income	19	-20	-436	-127	-465	593	USD million
Handled volume	4,624	4,553	4,748	4,477	4,167	3,706	TEU Thousand

5) DMU 5

Evergreen Line	IFRS				GAAP		
Segments	2015	2014	2013	2012	2011	2010	Unit
Property, plant and equipment / fixed assets	3,387	1,386	2,564	1,958	1,941	1,559	USD million
Operating cost	4,160	1,907	4,673	4,628	3,246	2,906	USD million
Total capacity	952	937	815	721	611	614	TEU Thousand
No. of vessels	200	195	200	183	167	162	Number
Revenue	4,211	2,009	4,686	4,769	3,241	3,472	USD million
Operating revenue (container shipping only)	3,850	1,845	4,322	4,441	3,082	3,324	USD million
Operating income	-121	52	-26	-38	-153	404	USD million
Handled volume	4,102	4,150	4,162	3,928	3,197	2,697	TEU Thousand

*Handled volume for Evergreen Line is calculated in proportion to the ratio of the operating handled volume to operating revenue for Yang Ming.

6) DMU 6

Maersk Line	IFRS						
Segments	2015	2014	2013	2012	2011	2010	Unit
Property, plant and equipment	43,999	44,671	41,293	42,824	47,577	43,343	USD million
Operating cost	31,265	35,633	36,261	38,160	45,848	40,255	USD million
Total capacity	2,962	2,946	2,631	2,625	2,521	2,166	TEU Thousand
No. of vessels (owned + chartered)	590	610	574	596	645	560	Number
Revenue	40,308	47,569	47,386	49,491	49,917	45,559	USD million
Operating revenue (container shipping)	23,729	27,351	26,196	27,117	25,108	24,022	USD million
Operating income	1,870	5,917	7,336	7,694	9,144	10,083	USD million
Handled volume	19,044	18,884	17,678	16,986	16,222	14,554	TEU Thousand

Table Average exchange rates versus USD

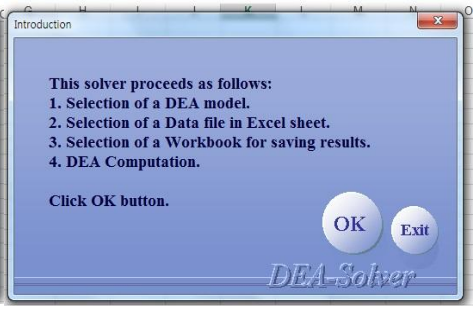
Currency	2015	2014	2013	2012	2011	2010
USD/TWD	31.78	71.82	29.71	29.57	33.37	31.49
USD/JPY	121.06	105.86	97.59	79.84	79.83	87.81
USD/KRW	1132.33	1053.58	1094.66	1126.44	1107.56	1156.53
USD/CNY	6.28	6.16	6.15	6.31	6.47	6.77
USD/DKK	6.73	5.62	5.62	5.79	5.36	5.62

Source: http://www.ukforex.co.uk/forex-tools/historical-rate-tools

Appendix 2 – Steps for using DEA-SOLVER

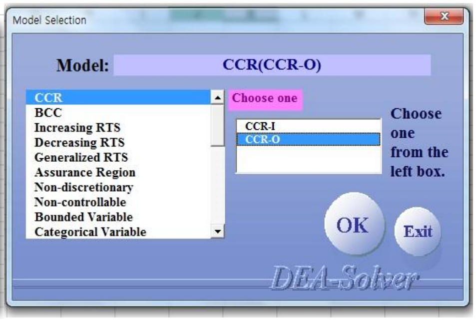
1) Step 1

2) Step 2

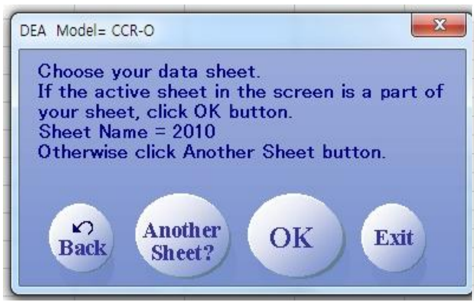


3) Step 3

4) Step 4

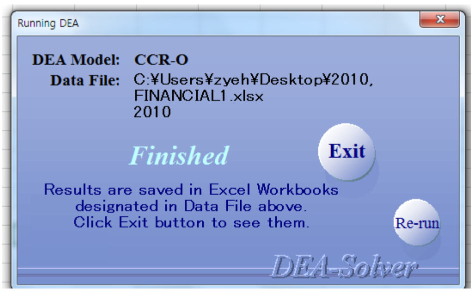


5) Step 5



6) Step 6

7) Step 7



Appendix 3 – Results of financial efficiency analysis, 2010 - 2015

2010	Efficiency			RTS	References			
DMU	CCR	BCC	SE		CCR	CCR, No.	BCC	BCC, No.
COSCO	0.96	1.00	0.96	DRS	Y	0	C	0
"K" Line	0.95	1.00	0.95	DRS	Y	0	K	1
Yang Ming	1.00	1.00	1.00	CRS	Y	3	Y	0
Hanjin	0.93	1.00	0.93	DRS	Y, E	0	K, E, M	0
Evergreen	1.00	1.00	1.00	CRS	E	1	E	1
Maersk	1.00	1.00	1.00	CRS	M	0	M	1
Average, CKYH	0.96	1.00	0.96					
Average, all	0.97	1.00	0.97					
No. of Efficient DMUs	3	5	3					

2011	Efficiency			RTS	References			
DMU	CCR	BCC	SE		CCR	CCR, No.	BCC	BCC, No.
COSCO	0.90	0.90	0.999	CRS	K, M	0	K, E, M	0
"K" Line	1.00	1.00	1.000	CRS	K	3	K	3
Yang Ming	0.94	0.95	0.984	CRS	K, E	0	K, E, M	0
Hanjin	0.94	0.95	0.996	CRS	K, M	0	K, E, M	0
Evergreen	1.00	1.00	1.000	CRS	E	1	E	3
Maersk	1.00	1.00	1.000	CRS	M	2	M	3
Average, CKYH	0.94	0.95	0.99					
Average, all	0.96	0.97	1.00					
No. of Efficient DMUs	3	3	3					

2012	Efficiency			RTS	References			
DMU	CCR	BCC	SE		CCR	CCR, No.	BCC	BCC, No.
COSCO	0.73	0.78	0.93	IRS	E, M	0	Y, M	0
"K" Line	0.98	1.00	0.98	DRS	E, M	0	K	1
Yang Ming	0.90	1.00	0.90	IRS	E, M	0	Y	1
Hanjin	0.88	0.89	0.99	DRS	E, M	0	K, E, M	0
Evergreen	1.00	1.00	1.00	CRS	E	4	E	1
Maersk	1.00	1.00	1.00	CRS	M	4	M	2
Average, CKYH	0.87	0.92	0.95					
Average, all	0.92	0.94	0.97					
No. of Efficient DMUs	2	4	2					

2013	Efficiency			RTS	References			
DMU	CCR	BCC	SE		CCR	CCR, No.	BCC	BCC, No.
COSCO	0.76	0.82	0.92	IRS	M	0	Y, M	0
"K" Line	1.00	1.00	1.00	CRS	K	3	K	1
Yang Ming	0.84	1.00	0.84	IRS	K, M	0	Y	1
Hanjin	0.84	0.86	0.98	IRS	K, M	0	K, E, M	0
Evergreen	0.99	1.00	0.99	IRS	K	0	E	1
Maersk	1.00	1.00	1.00	CRS	M	3	M	2
Average, CKYH	0.86	0.92	0.94					
Average, all	0.90	0.95	0.95					
No. of Efficient DMUs	2	4	2					

2014	Efficiency			RTS	References			
DMU	CCR	BCC	SE		CCR	CCR, No.	BCC	BCC, No.
COSCO	0.80	0.82	0.97	IRS	M	0	Y, M	0
"K" Line	1.00	1.00	1.00	CRS	K	3	K	1
Yang Ming	0.91	1.00	0.91	IRS	K, M	0	Y	3
Hanjin	0.88	0.89	0.99	IRS	K, M	0	K, Y, M	0
Evergreen	0.90	0.99	0.91	IRS	K, M	0	Y, M	0
Maersk	1.00	1.00	1.00	CRS	M	4	M	3
Average, CKYHE	0.90	0.94	0.96					
Average, all	0.92	0.95	0.96					
No. of Efficient DMUs	2	3	2					

2015	Efficiency			RTS	References			
DMU	CCR	BCC	SE		CCR	CCR, No.	BCC	BCC, No.
COSCO	0.98	1.00	0.98	IRS	M	0	C	0
"K" Line	1.00	1.00	1.00	CRS	K	3	K	1
Yang Ming	0.89	1.00	0.89	IRS	K, M	0	Y	1
Hanjin	0.90	0.95	0.95	IRS	K, M	0	K, Y, M	0
Evergreen	0.88	1.00	0.88	IRS	K, M	0	E	0
Maersk	1.00	1.00	1.00	CRS	M	4	M	1
Average, CKYHE	0.93	0.99	0.94					
Average, all	0.94	0.99	0.95					
No. of Efficient DMUs	2	5	2					

Appendix 4 – Results of operational efficiency analysis, 2010 - 2015

2010	Efficiency			RTS	References			
DMU	CCR	BCC	SE		CCR	CCR, No.	BCC	BCC, No.
COSCO	1.00	1.00	1.00	CRS	C	3	C	2
"K" Line	1.00	1.00	1.00	CRS	K	4	K	0
Yang Ming	0.94	1.00	0.94	IRS	C, K	0	Y	0
Hanjin	0.86	0.90	0.96	DRS	C, K	0	C, M	0
Evergreen	0.39	0.43	0.93	DRS	C, K	0	C, M	0
Maersk	0.70	1.00	0.70	DRS	K	0	M	2
Average, CKYH	0.95	0.97	0.97					
Average, all	0.82	0.89	0.92					
No. of Efficient DMUs	2	4	2					

2011	Efficiency			RTS	References			
DMU	CCR	BCC	SE		CCR	CCR, No.	BCC	BCC, No.
COSCO	1.00	1.00	1.00	CRS	C	4	C	2
"K" Line	1.00	1.00	1.00	CRS	K	4	K	2
Yang Ming	0.96	1.00	0.96	IRS	C, K	0	Y	2
Hanjin	0.94	0.95	0.99	IRS	C, K	0	C, K, Y	0
Evergreen	0.50	0.50	0.9996	IRS	C, K	0	C, K, Y	0
Maersk	0.69	1.00	0.69	DRS	C, K	0	M	0
Average, CKYH	0.98	0.99	0.99					
Average, all	0.85	0.91	0.94					
No. of Efficient DMUs	2	4	2					

2012	Efficiency			RTS	References			
DMU	CCR	BCC	SE		CCR	CCR, No.	BCC	BCC, No.
COSCO	1.00	1.00	1.00	CRS	C	1	C	2
"K" Line	1.00	1.00	1.00	CRS	K	2	K	2
Yang Ming	1.00	1.00	1.00	CRS	Y	2	Y	0
Hanjin	0.83	0.83	0.99	CRS	C, K	0	C, K	0
Evergreen	0.50	0.53	0.94	DRS	Y	0	C, K, M	0
Maersk	0.63	1.00	0.63	DRS	K, Y	0	M	1
Average, CKYH	0.96	0.96	1.00					
Average, all	0.83	0.89	0.93					
No. of Efficient DMUs	3	4	3					

2013	Efficiency			RTS	References			
DMU	CCR	BCC	SE		CCR	CCR, No.	BCC	BCC, No.
COSCO	1.00	1.00	1.00	CRS	C	4	C	2
"K" Line	1.00	1.00	1.00	CRS	K	4	K	2
Yang Ming	0.88	1.00	0.88	IRS	C, K	0	Y	0
Hanjin	0.80	0.81	1.00	DRS	C, K	0	C, K, M	0
Evergreen	0.48	0.51	0.95	DRS	C, K	0	C, K, M	0
Maersk	0.71	1.00	0.71	DRS	C, K	0	M	2
Average, CKYH	0.92	0.95	0.97					
Average, all	0.81	0.89	0.92					
No. of Efficient DMUs	2	4	2					

2014	Efficiency			RTS	References			
DMU	CCR	BCC	SE		CCR	CCR, No.	BCC	BCC, No.
COSCO	1.00	1.00	1.00	CRS	C	4	C	2
"K" Line	1.00	1.00	1.00	CRS	K	2	K	1
Yang Ming	0.83	1.00	0.83	IRS	C	0	Y	0
Hanjin	0.89	0.92	0.96	CRS	C, K	0	C, K	0
Evergreen	0.38	0.42	0.92	DRS	C	0	C, M	0
Maersk	0.64	1.00	0.64	DRS	C, K	0	M	1
Average, CKYHE	0.82	0.87	0.94					
Average, all	0.79	0.89	0.89					
No. of Efficient DMUs	2	4	2					

2015	Efficiency			RTS	References			
DMU	CCR	BCC	SE		CCR	CCR, No.	BCC	BCC, No.
COSCO	1.00	1.00	1.00	CRS	C	4	C	3
"K" Line	1.00	1.00	1.00	CRS	K	4	K	3
Yang Ming	0.72	0.76	0.95	CRS	C, K	0	C, K	0
Hanjin	0.80	0.81	0.99	CRS	C, K	0	C, K	0
Evergreen	0.41	0.46	0.89	DRS	C, K	0	C, K, M	0
Maersk	0.68	1.00	0.68	DRS	C, K	0	M	1
Average, CKYHE	0.79	0.81	0.97					
Average	0.77	0.84	0.92					
No. of Efficient DMUs	2	3	2					