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A Study on Economic Operation for Liner-Fleet by Fluctuation of Fuel Oil Price

- Focusing on the Case of 'H' Shipping Company -

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Abstract : *For container shipping company, fuel oil prise is a considerable expense. Since 2008, fuel oil prises have risen dramatically. An increasing fuel oil price in container shipping, in the short term, is only partially compensated through surcharges and may affect earnings negatively. This study discusses the impact of an increasing fuel oil price and capital costs for vessels on the Asia-Europe trade of 'H' Shipping Company. According to the result of 'H' carrier's operation in 2008, there were no cost differences between 8 and 9 vessels operations in case of fuel oil price with USD 169/tons while adopting USD 31,818 as a fixed cost. We can expect that the fuel oil price will not go lower than USD 200/Ton on the basis of current high oil price phenomenon. When the fuel oil price is over USD 200/ton, 9 vessel operation is more economic than 8 vessel operation even if the fixed cost is over USD 35,000.*

Key words : *Fuel Oil Price, Capital Cost for Vessels, Economic Analysis, Liner-Fleet, High Oil Price*

1. Introduction

Major shipping companies are facing great losses from the decreasing container shipping costs in the global financial crisis that started in 2008, the increases in vessel fuel oil price due to high oil prices, and increases in uncontrollable overland freight. Also, due to a sharp increase in international oil price, the price of vessel fuel oil increased more than two folds in a short time and the shipping industry is experiencing difficulties from worsening productivity. Although the shipping industry is struggling to find various measures, the worsening productivity is inevitable due to high oil prices.

Generally in the shipping industry, the portion of fuel oil price among the whole operation costs is as high as 10 to 20 percent and for every dollar increase in vessel fuel oil price, there is a pressure of a yearly increase of 1 billion dollars in cost. Accordingly, the percentage that fuel oil price constitutes in operation costs also rises drastically.

According to the announcements made by the Korea Ship Owners Association in 2007 , the price of fuel oil price went up to 372 dollars per ton (in Singapore standards), and although the portion of fuel oil price among the operation costs stopped at 12.3%, the total cost increased greatly by 19.5% in June 2008. In the future, if the oil price rises to 170 dollars in Dubai oil price standard, there are prospects that the portion of fuel oil price may rise to 24.1%. It was especially true that the burden of fuel oil price is even higher and the productivity is even worse for container shipping companies with faster ships than bulk carriers. In cases of 70000 DWT bulk carriers that operate on an average of 13 knots, they consumes 36 tons of fuel oil per day but 8000 TEU container ships of 22 knots in speed consume 230 tons of fuel oil. Accordingly, each shipping company is expanding the BAF (Bunker Adjustment Factor) while examining and executing all means to reduce fuel oil costs. In the case of Hyundai Marine Merchant Co., LTD, the vessel fuel is being supplied from Rotterdam of the Netherlands, Singapore, and the U.S. where the fuel oil price is the lowest and the company has set a recommended economic speed of the ships per sea route. In addition, through internet auctions, it is constructing and operating a Dutch internet auction system where it is possible to purchase vessel fuel oil at a cheaper price. Hanjin Shipping Co., LTD also receives its fuel supplies from Rotterdam, Netherlands as well as from Singapore in Asia and is maintaining its economic speed and expanding oil price hedge.

In such circumstances, Grand Alliance, in which NYK, OOCL, MISC, and HAPAG LLOYD are members, has decreased the sailing speed of the ship and as a way to save fuel oil, it will apply a measure to put in an additional ship in the existing service with 8 ships. If Grand Alliance takes

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such an action, the shipping turnover on the day of sailing (56 days) extends to 63 days and due to flexible operations of ships, they are able to decrease the shipping speed from 23.5 knots to 20 knots so that the shipping companies state that they can save 1 billion dollars in fuel costs. If such cost-saving measures succeed, Grand Alliance plans to expand it to other service channels.

Originally, the idea to decrease the fuel oil price burden by decreasing the shipping speed was proposed by the German shipping companies. In the case of container ships, the optimal economic speed is 20 knots and in the case of bulk carriers and oil tanker, the optimal economic speed is 15 knots each but because of the charter burden following the decrease in shipping speed and additional input of ships, there was a restriction for the shipping companies to apply this method without hesitation. However, in situations like this where the oil price continues to rise and the freight keeps falling due to excess supply of ships, it is evaluated to be a very useful strategy to gain competitiveness in the lower-priced market where the bottoms are decreased and the price decrease is prevented.

On the other hand, even the French shipping company CMA CGM, which is not a strategic alliance group, has added an extra ship in the northern China/Europe route in order to enhance the punctuality of the freight schedule and save fuel costs with a structure of nine 6,500 TEU container ships. Another representative strategic alliance, CKYH Alliance, is also positively considering a measure to reduce the number of services and the port of call in Asia/Europe and Asia/Mediterranean routes. CKYH is currently providing seven periodic sea route services in Asia/Europe but will reduce them to six in 2007 as well as reducing the port of call in Asia/Mediterranean sea route. This group is running a total of 27 service sea routes - 13 in Asia/Northern Europe, Mediterranean Sea routes, 20 in Asia/Northern American sea routes, and 4 in Northern America/Europe, Mediterranean Sea routes. As a result of focusing on the solution to reduce fuel oil costs by combining overlapping service routes and increasing the number of ships in the service, if two knots are reduced from the shipping speed of the ships in comparatively long distance Asia/European sea routes, it is estimated that 20 billion won can be saved yearly per service sea route. Maersk Line is planning to stop the ME2 service that connects South Asia, Middle East and Europe and restructure the existing ME1 and ME3 in order to supplement it. Also, APL and MOL, Maersk's strategic partners, are also planning to combine the service connecting South America and North America (NASA 1, NASA 2) and operate a reduced route. Likewise, as the recent worsened performance of periodic shipping companies is due to the drastic rise in oil price with excessive addition of ships and the competition for market share among shipping companies, whether such problems will be resolved seems to be the crucial point of reducing the range of loss.

Thus in this research, we analyze on the economic effects of additional input of ships for the economic speed and to reduce speed operation under the high oil price and excessive ship supply. To achieve this, we seek to analyze the economic feasibility of fuel oil consumption costs and additional costs based on real costs of 'H' shipping company.

2. Study on the operation cost of containerships

2.1 Types of operation costs of container ships

According to Song's research(2005), operation costs of container ships comprise of capital costs, direct costs, running costs, and loading and unloading charges. Capital cost refers to the cost needed in order to possess a ship and has a similar characteristic to fixed cost because it is a cost needed even when the ship is not operating, much like the charter, shipping investment interest, shipping depreciation cost, and shipping insurance fee for the introduction of new and used ships. Direct cost refers to the costs needed in order to maintain the ship in a condition for sailing, such as costs for crewmen, lubrication costs, costs for articles for ship, general maintenance costs, and other expenses which are not changed easily depending on the operation of ships; thus, are much like semi-fixed costs. Costs for sailing refer to the costs needed to operate the ships and are costs such as fuel oil costs, freight costs, and port charge and are also called operation costs. Operation costs are costs that occur during the operation, clearance, and anchoring and are fees such as fee paid to the government office, tax, utility bill, ferry charge, towage, snatching fee, dockage, harbor due, light due, launch hire, anchorage, custom fee, and agency fee. Loading and unloading charge is a cost that occurs when freight is loaded and discharged in the port and has a characteristic much like variable costs, which change according to the amount of freight treated.

2.2 Changes in fuel costs among operation costs of container ships

1) Current state of increase in vessel fuel oil price

As vessel fuel oil, usually HFO (Heavy Fuel Oil) and MDO (Marine Diesel Oil) are used. HFO is mainly used during sail as the main fuel oil of the propulsion unit and generator of the ship and is classified into 380cst, 180cst and such according to the viscosity. MDO (Marine Diesel Oil) is usually used for generation within the ship when it is anchored.

The price of fuel oil(bunker) endlessly fluctuates due to market principle and the cost. The fuel oil market is very sensitive to the ships that selectively decide the supply and demand of fuel oil as there are differences in the price of fuel oil for each port. The task of deciding the supply and demand of fuel oil is greatly affected by the relative price premium which results from fuel tax resulting from the various accounting policy of various countries and areas. Table 1 shows the HFO 380cst price changes of main competition ports.

Table 1 HFO 380cst Price Changes in Main Competition Ports

(Unit : US$/Ton)

Country / Date	SINGAPORE	JAPAN	KOREA	HONGKONG
2002. 01. 04	115.0	140.0	124.5	125.5
2003. 01. 03	175.0	195.0	185.0	185.0
2004. 01. 02	162.5	201.0	179.0	179.0
2005. 01. 07	163.5	235.0	179.5	175.0
2006. 01. 06	303.5	347.5	3375	329.5
2007. 01. 05	278.0	347.5	317.5	288.5
2008. 01. 04	503.0	522.5	555.0	527.5
2008. 03. 21	504.0	612.5	580.0	512.5
2009. 01. 02	246.3	265	280	254.5
2010. 01. 04	532	493	532	499.5
2010. 12. 31	508	547	540	525.5
2011. 01. 04	521	568	551.5	533.5
2011. 04. 01	663	709.5	681	672.5
2011. 10. 01	640	692	653.5	634.5

Source : Clarkson Research Services Limited 2011.

As can be seen in Table 1, the price of HFO 380cst has drastically increased since 2008 when the global financial crisis started. Once in 2009 the price fell to 1/2 of the original price but started to rise again to go over 600 USD in February 2011 and is going over 640 USD as of October 1st, 2011. The price increase in vessel fuel oil leads to an increase in cost and whether the increased fuel oil cost can be offset by the high freight charge depends on the market situation while such fuel oil price burdens are generally huge for ships and even bigger for long distance operation routes.

2) Reasons for vessel fuel oil price increase

First of all, the most important factor of vessel fuel oil price increase results from the price increase of crude oil, which is the raw material for vessel fuel oil production. Between 2000 and 2004, the price of Dubai crude oil increased by 5.43 dollar per barrel and the price of heavy oil also increased by 5.22 dollar/bbl. However, between 2007 and 2009, the price of crude oil drastically increased to 38.41 dollars per each barrel and the price of heavy oil also increased sharply, each barrel increasing to 31.29 dollars. The price of heavy oil of 2010 recorded 79.4 dollars per barrel and was increased to 94.4 dollars in 2011, increased by 15 dollars compared to 2010.

Second, we can point out the decrease of vessel fuel oil supply resulting from building additional advanced refinement facilities of oil companies as a factor for price increase due to the characteristics of the supply in vessel fuel oil market. Advanced refinement facilities accord to the added value expansion strategy of oil companies that produce gasoline and diesel by putting in heavy oil (bunker C oil), which is a low value product, again in the refinement facility primarily to produce gasoline and diesel which are relatively high value products. Due to such strategies, consequently, this acts as a reason for the decrease in the amount of heavy oil produced.

Third, a considerable amount of vessel fuel oil produced domestically is exported to China. Heavy oil exported to China is mainly supplied to petroleum refineries with power plants or secondary refinement facilities; therefore, the price increased as the amount of vessel fuel oil supplied that can be sold within the country decreased due to the increase in heavy oil demand in China.

In the view of oil companies, not only are the exports to China done in massive amounts, but also the relatively stable markets, coastal cost of transport, carrying charge, and usage charge of tank vessels following the supply of vessel fuel oil do not occur additionally; therefore, the oil companies prefer China exports.

The most important variable in deciding the price for vessel fuel oil is the movement of crude oil price. With the recent jump in oil price, there is a dominating view that the prices are considerably high when evaluated apart from the situation of the physical market due to the concentrated inflow of speculative funds in respect of the instability of the financial market. If OPEC maintains the amount of production at the current level, there may be a possibility of stabilizing the oil price through enhancement in supply and demand. Despite such facts, considering the possibility of production decrease of OPEC and the trend of the financial market (the U.S. economic recession, interest rate reduction, decrease in dollar value), there is a possibility that the oil price will show a downward trend but if the global economy recovers in the early stages and China's economy continues to grow, the oil price may increase again due to the accompanying increase in demand.

2.3 Effects of vessel fuel oil price increase on container shipping companies

1) Effects of vessel fuel oil price increase on cost of transportation of shipping companies

In the case of container shipping, fuel oil is a not an ignorable cost factor. There are multiple corporate examples where the increase in fuel oil price in the recent years brought on financial difficulties on the company's part. In order to make up for parts of the loss due to the increase in fuel oil price, shipping companies are using fuel surcharge as a part of the efforts to transfer the fuel costs. Continually increasing fuel oil cost(especially with increases in a short term) is partially offset through a surcharge on the fare called BAF (Bunker Adjustment Factor) and as a result, it affects the profit negatively. All fares in the container shipping market are a value which excludes BAF. BAF can be adjusted by changing the price and exchange rates (US$). Policy regarding BAF can differ depending on how the shipping companies and Liner Conference decide to apply BAF. While the carrier bears the basic fuel cost, BAF is only applied in changes exceeding a certain level for a certain sea route. Table 2 shows ratio of fuel surcharge by price.

The amount of fuel cost increase for outward shipping companies in Korea is estimated to increase to 483.03 million dollars (about 448.8 billion won, apply 929.2 won/dollar exchange rate) in 2007 in comparison to 2006 and is estimated to be 1.14351 billion dollars (about 1.1102 zillion won, apply 962.2 won/dollar exchange rate) in 2008 (Hyungjin Jeon, 2005). Considering the fact that the ordinary income of the all the outward shipping companies in Korea in 2006 was about 2.9 zillion won, it is estimated that the fuel cost that occurred additionally in 2007 was 21.4% of the ordinary income and 52.6% in 2008, which created a serious damage to the managerial performance of shipping companies. In the case of periodic container ships, as opposed to non-periodic bulk vessels, the shipping speed is regarded to be important because of a high energy consumption rate. So the increase in fuel oil price creates a more serious effect on the periodic container ships than the non-periodic bulk vessel.

Table 2 Ratio of Fuel Surcharge by Price

(Unit : Euro/Ton)

IFO 380 price level	BAF IFO surcharge (%)	IFO 380 price level	BAF surcharge(%)
140(base level)	2.00	216-220	6.50
141-155	2.50	221-230	7.50
156-165	3.00	231-240	8.00
166-180	3.50	241-250	8.50
181-190	4.50	251-255	9.00
191-200	5.00	256-265	9.50
201-205	5.50	266-270	10.50
206-215	6.00	271-280	11.00

Source : Notteboom, T. E. and Vernimmen, B.(2009), "The Effect of High Fuel Cost on Liner Service Configuration in Container Shipping," Journal of Transport Geography, p. 2.

2) Effect of vessel fuel oil price increase on ocean freight charge

Unlike the past, the oil price increase greatly affects the stevedore index. In the case of Shanghai/European route, it dropped to 40% of last year's peak from 2,100($/TEU) in February 2010 to 800($/TEU) in September 2011. Freight decreased about 60% in the case of Shanghai/West U.S. route from 2,802 ($/TEU) in July 2010 to 1,650 ($/TEU) in September 2011 and in the case of Shanghai/East U.S. route, it dropped from 4,134 ($/TEU) in August 2010 to 3,324 ($/TEU) in September 2011. In the coastal route of Shanghai/ West Japan route, it increased from 325($/TEU) in April 2010 to 333($/TEU) in March 2011 and in the case of Shanghai/Southeastern Asia route, it decreased by 46% from 439($/TEU) in April 2010 to 235($/TEU) in March 2011, as well as the Shanghai/Pusan route, which decreased by 7% from 230($/TEU) in May 2010 to 213($/TEU) in March 2011.

3. Preceding Research and Type of Container Ship Fuel Cost Reduction

3.1 Measures to reduce fuel consumption through management in areas other than shipping

First of all, the amount of fuel consumption can be reduced through the selection of fuel oil type. High fuel cost prompts the shipping companies to establish a plan to save costs. Fuels such as IFO(Intermediate Fuel Oil)420, 500, 600, and 700 Grades that have high viscosity have great potential texture and thus are becoming more popular. IFO is 7 to 11 US dollars per metric ton cheaper than IFO380. IFO700 can save up to 16 US$. However, considering the downsides of fuel oils with high viscosity, Singapore uses about 70% of the vessel fuel with the traditional IFO380 grade. In the US, fuel with high viscosity is becoming more popular and IFO500 is used in less than 20%.

Second, fuel oil cost can be reduced through the improvement of ship structure. These days, on a global dimension, the focus is on equipment for fuel reduction in order to maintain an economic profit for ships. Ships lose energy because of axial power. The propeller generates momentum because of the acceleration of water flowing in and in the rear of the ship; the discharged wavelength is mixed with natural liquids. Energy loss occurs from resistance. Also there are losses due to the friction between water and the blade. Lastly, ships experience rotational losses as the propeller blades rotate again within the wake.

Third, fuel oil cost reduction is possible depending on the purchase method of the vessel fuel oil by the shipping companies. In the case of outward shipping companies, in places where there are frequent calls and the fuel oil price is cheaper than other ports, a long-term contract is made for the vessel fuel oil supply. With long-term contracts, the supplying companies that are larger corporations (oil companies, globally supplying companies) can purchase vessel fuel oil at a relatively cheap price by receiving more discounts than others.

Fourth, fuel oil cost can be reduced by transferring the increased fuel oil cost through systems like fuel surcharge. When the cost of transportation rises due to the increase in fuel oil price, the shipping companies can reflect this in their freight, which is called the fuel surcharge system. Fuel surcharge (BAF), which is a specific way of the fuel surcharge system is a representative accessorial cost that comprises of the freight along with CAF(Currency Adjustment Factor) and THC (Terminal Handling Charge). If there is an unpredicted increase in the price of fuel oil at the time of the contract, the additionally imposed surcharge on the freight of container shipping can be made without changing the existing contract.

3.2 Measures of reducing fuel consumption through shipping management

First of all, the amount of fuel consumption can be reduced through planning and adjustment of the service route. Planning of service route and shipping schedule is a very important strategic problem for the shipping company (Fagerholt, 2004). Before practically designing the periodic container service, shipping companies have to execute an evaluation on the targeted markets and the distribution of the service demand which includes the number and distribution of port of call, the density of distribution between ports and the analysis on the trade imbalance. First of all, if the market-to-be-entered is determined, the planner of the shipping service needs to make a decision on three important factors that are closely related to each other. In other words, fuel oil consumptio can be reduced through decision-making on the number of shipment, size and composition of ships, the number of port of call and others.

Second, fuel consumption can be reduced through the adjustment of the input ship size and shipping speed. As a cost-saving measure countering the increasing fuel cost is to maintain a low shipping speed and additionally dispatching new ships for a more effective scheduling (Notteboom and Vernimmen, 2008). Several shipping companies are additionally dispatching ships to the Asia-European route in order to overcome the delay do to crowded port and also at the same time dealing with the high fuel cost. This is to noticeably decrease the amount of fuel consumption by sailing the ship in economical speed and removing ships that sail at maximum speed. Generally ships can only reduce a few knots unless they overwork the ship's engine and thus, the number of additional ships put in is limited.

3.3 Preceding research

McLellan (1997) insisted on the impracticality of a mega ship in terms of operation by pointing out the realistic limiting factors of maximizing ships, such as the limitation on cranes, Suez Canal limitation, and limitation on the length of a 15,000 TEU ship. For a more practical discussion, instead of the nine 6,000 TEU ships that are put in the North-West Europe/Far East service route, which are existing standard ships, a 15,000 TEU ship was assumed to be used to compare the weekly shipping schedule. As a result, within the given condition, the hours needed for a round trip for a standard ship takes 64 days while the 15000 TEU ship takes 84 days and whereas the standard requires nine ships, the required number for a big ship is 12 ships. With such a background, the 15,000 TEU ship needs additional ships in order to set the weekly shipping schedule and as the size of the ship increases, it was insisted that the decreasing capital cost per TEU will begin to rise again. Also the realistic view, such as the limit on loading and unloading system, problem of shortage of yard space due to the heightened possibility of container relocation in the shed, and the capacity of inland transportation system were emphasized.

Jeffery (1998) discussed mega ships in a negative sense in the view of port management. As he discussed the trend and background of mega ships, he gave an example of mega tank vessels that fell behind due to insufficient freight. He stated that periodic shipping companies are still maintaining shipping patterns calling at 4~5 European ports with the same shape as ten years ago and that such service schedules will not be easily adjusted to mega ships.

To evaluate the optimal size of container ships, Cullinane et al. (1999) developed three cost models, which are daily fixed cost per TEU, cost per TEU-mile, and total sailing expense per TEU. Cost was restricted to costs relating to shipping and loading and unloading and terminal-related costs while feeder and inland transportation costs were excluded. By adding docking cost per TEU (docked date x daily fixed cost per TEU + oil cost in the port) and shipping cost per TEU (cost per TEU-mile x shipping distance), the total cost per TEU can be drawn, on which a comparative analysis was performed on the economy of scale according to the change in size of ship. With such backgrounds and the result of executing a sensitivity analysis according to the length of the route of the three main East-West routes (Europe-Fareast, Trans-Pacific, and Trans-Atlantic each 4000, 8000, and 11500 miles) in the 'Europe-Fareast' and 'Trans-Pacific' route, it was found that there is economy of scale on ships of more than 8,000 TEU and that the optimal size of the ships are 5,000~6,000 TEU in the short-distance 'Trans-Atlantic' route.

Gilman (1999) asserted that the economy of scale effect of the container ships, considering the port load and unload and the total shipping network, will weaken gradually for ships over 10,000 TEU and that the existing 'End to End' service (including the Pendulum shape) will be the basic shipping pattern of sea transport, as well as that the operation of 'Hub and Spoke' will only be a part of the whole operating shape and refuted the plausibility of a 15,000 TEU ship. For a comparative evaluation on the cost of the existing 'End to End' service and 'Hub and Spoke' service, he conducted a simple analysis comparing various port call strategies and one port call strategy centered in Rotterdam. Also, on feeder ships, which are essential to mega shipping, a considerable amount of time is needed for the transshipment and he emphasized that it is difficult to stably secure a feeder transportation system. Consequently, in the case of 10,000 TEU ships (width 42m, full length 320~350m, maximum draft about 14.5m), they can maintain existing shipping patterns and although there is no need for facility investment in access canals of main ports and container terminals because 15,000TEU ships need a new port loading and unloading system, although there are many limitations in realizing it.

In each of their research, Baird (2001) and Cullinane (2000) organized the costs that occur during shipping and calculated the total cost and found that there is operation cost, which include capital cost due to the ship construction, maintenance cost, insurance fee, management cost, and cost for crewmen as well as fuel cost used in main and auxiliary engines, lubrication cost, and port cost, which occur in the port.

In the research conducted by Tozer (2002), the targets were the ships between 4,000TEUs and 12,500TEUs and the cost items that occur at seas were mentioned. Like Cullinane (2000) and Baird (2001), capital cost that occurs in the ship construction was suggested first and then operation cost, which includes cost of crewmen, insurance fee, maintenance fee, and other fee, was suggested. However, cost that occurs at seas was not included in these researches.

Notteboom and Vernimmen (2008) first researched the kind of effects that the increase in fuel oil cost has on the periodic service plan of Europe and Fareast routes. Second, he evaluated how shipping companies adjusted their periodic service schedules in order to deal with the increased fuel oil cost problem.

Lastly, he adjusted cost models to experiment the effect of changes in fuel oil cost on the operation cost of periodic service. The cost model insisted that even when a big size post panama ship is used in the typical North Europe- East Asian route, the current fuel oil cost has a considerable effect on the operation cost per ton. Song's research (2005) targeted routes in which 4,000 TEU ~ 5,500 TEU ships are operated and executed analysis on the origin and destination and economic feasibility with operational scenarios of when mega ships substitute the existing ships on the same route. On the other hand, if the mega ships are substituted in route 'B' (Europe-Asian route) and route 'C'(Europe-Asia-American route), it will have the same economic feasibility with the existing transportation ships only when they handle more than 150% and 140% each compared to the current status because of the high feeder cost.

Kim's research (2005) first selected the total cost model and economic feasibility evaluation model to draw the type of ships that generate minimum cost for each service route that big periodic shipping companies operate on and then chose the targeted variables that are to be put in the selected model to perform an evaluation on the economic feasibility and total cost analysis. Using the cost per TEU calculated through the economic feasibility evaluation, the type of ship which generates minimum cost among the ships put in each service route was drawn out. Looking at the research results, first, in the Europe-Far east route, in the case of ships that are operating currently by domestic shipping companies, 6,500TEU ships were found to be the most competitive, and in the case of ships that are to be utilized in the future, 8,200 TEU ships were found to generate the least amount of cost following 6,500 TEU ships. Second, in the case of Far East-North American routes, 4,00TEU and 6,500 TEU ships generated the lowest cost and when mega ships are put in, the 8,200 TEU ships are the most competitive types of ship. Also, the 8,200 TEU ships that CGM-CMA and China Shipping started to operate since 2004 are also sailing in the routes that connect the Far East and the North American area.

Third, also in the case of the ships operating currently in the Pendulum service, which is a Europe-Far East-North American route, the 6,500 TEU ship was the optimal type of ship and when the mega ships are put in, the 8,200 TEU ships will follow the 6,500 TEU ships as the next competitive ship. The research conducted by Nam (2006) not only included the operation cost and cost of transportation that other researches also included, which occur during shipment, but also conducted an economic feasibility analysis in respect of the total cost including the feeder cost in the hub port and feeder port network when using mega ships as well as port cost and loading and unloading costs that occur in the port. After examining and analyzing each running cost between each port, loading and unloading costs in each port, facility usage fee in each port, and feeder costs when Pusan port is selected as the Hub port, it will be the most economic of all. However, in the case of Shanghai port, there is not much of a difference in the cost with Pusan port and seeing that the quantity of goods transported are recently on the rise, it will become a competitor port in respect of total costs. Because this research did not include inland transportation costs, there is a need for a research which includes information on the cost and freight of inland transportation in the future.

4. Economic feasibility analysis on fuel cost reduction through additional input of ships using the Case of 'H' Shipping Company

4.1 Summary of sea route that are targets of the economic feasibility analysis

The analysis was performed based on the operation data of H shipping company from 2007 to 2008 centering on the Far East-European route, which is one of the three main container routes to where most of the over 7,000 TEU ships are assigned. The reason the period of the analysis was on the operation data from 2007 to 2008 is because 2008 is when the world economy faced difficulties due to the financial crisis and this phenomenon was transferred to the shipping market and the price of HFO 380cst increased on 503.0(US$/ton) in 2008 by 1.8 folds compared to the 278.0(US$/ton) in 2007. Thus, it was thought that using the data from 2007 to 2008 in which the increase in fuel price was noticeable would be the most appropriate period to search for an economic operational plan of the container ships according to the changes in fuel oil price. The European route selected in this research has long sailing hours and has many hub ports in which mega ships can dock and is also suitable for enjoying economy of scale in putting in ships for each shipping company as well as being a route in which the operation cost per TEU due to mega ship input can be easily calculated. Also due to the fact that it has to pass the Suez canal, like the American route, it is not easy to change the ships according to the change in port of call and distribution; therefore, it was easy to analyze the change in fuel consumption amount due to the change in the number of ships put in a certain route. According to the website of ASX-Alphaliner, in the European route in mid-December of 2007, there are about 70 periodic container ship services and also AEX(Asia-Europe eXpress) of H shipping company, which is the target of this research, belongs to the roundtrip service type between the Far East and Northern Europe.

1) Characteristic of AEX

AEX service is a typical periodic service of the European route run by H shipping company which stops at 15 ports in the Far East, Southeast Asia, and Northern Europe with the expected time needed for a roundtrip of the service of 54.24 days when the Port time is 10 days. In 2007 when the assigned number of ships was 8 ships with once weekly trips, the maximum time needed for a roundtrip of the periodic service is 56 days.

When the route is planned and operated, round time, the number of input ships and the shipping speed is closely related to one another. When there are 8 ships assigned and the total Port time is 9.92 days, the periodic service operated in an average shipping speed of 24 knots and the total sailing time was 44.32 days (total Round time 54.24 days) with 1.76 days of surplus time; however, when operating at 23 knots, the total sailing time is 46.07 days (total Round time 55.99 time) with no surplus time so that if there is a delay due to accidental situations or weather, the on-time service becomes impossible. Thus, when the assigned number of ships is 8 ships for the route, the right shipping speed for on-time service is at least more than 24 knots. On the other hand, if 9 ships are used instead of the 8 ships on the same route, the maximum allowed time for a roundtrip increases to 63 days from 56 days. Here, under the same conditions, if the total Port time is 9.92 days and the number of assigned ships is nine, then the periodic service takes a total sailing time of 51.20 days (total Round time 61.12 days) and has about 1.9 days of surplus time when operating under a shipping speed of 20.5 knots. When operating at 20 knots, the total shipping time is 52.38 days (total Round time 62.30 days) and 0.7 days of surplus time is generated. Thus, when nine ships are being used, in order to have the same surplus time as an eight ship operation, it is suitable to operate at a sailing speed of 20.5 knots and while operating under 20.5 knots, a surplus time of 1.88 days is enough to handle various delays and obstacles so as to have no problems in timely operation.

There are many things to consider when considering additional utilization of a ship in a route. Among the many things, the effect of cost is to be considered most seriously. However, since 2007, due to the rapid increase in fuel oil price, each shipping company started to study for a solution to reduce fuel oil costs even if they have to increase the number of ships and decrease the speed which is a new method than the traditional way of decreasing the number of operating ships and operating period. Thus, in this research, we seek to analyze the economic feasibility of fuel oil consumption costs and additional costs on the effect of change in periodic service plans when another ship is added based on real costs.

4.2 Economic feasibility analysis on the AEX route of 'H'shipping company

1) Analysis on the operational ability to pay of 8 and 9 vessel operation on the AEX route

As seen previously, when operating at the normal service speed, 1 round trip operation is possible with only 8 ships for the AEX route and we can consider operating with 9 ships in order to reduce the fuel cost burden due from the increase in fuel oil price. Here, there is a need to compare the amount of increased fixed cost per ship including capital costs, such as charter and the fuel oil cost that is reduced due to the decrease in speed. However, the speed-reduced operation through additional ship input increases the sailing time between call ports and decreases the service level, and also since shippers can leave, in order to minimize the operational effects due to the decrease in service level in this research, when 9 ships are operating, the cost structure was examined with classifications into <Far East-Europe> segment and <Europe-Far East>segment. Table 3 is a result of comparative analysis on operational ability to pay on the operational retention quantity during 8 and 9 vessels operation.

Table 3 Analysis on the Operational Ability to Pay of 8 and 9 Vessels Operation

Far East-Europe		8 vessels operation	9 vessels operation (Far Ease-Europe segment speed-reduced operation)		
		Performance	Performance	Difference	%
Far East-Europe	TEU	1,993	2,012	19	0.95%
	Charge/TEU	1,286	1,432	146	11.35%
	Total Charge ($)	2,562,998	2,881,184	318,186	12.41%
Europe-Far East	TEU	1,277	1,121	-156	-12.22%
	Charge/TEU	615	660	45	7.32%
	Total Charge($)	785,355	739,860	-45,495	-5.79%
charge income in each shipment		3,348,353	3,621,044	272,691	8.14%
Annual charge income		174,114,356	188,294,288	14,179,932	8.14%

The Far East-Europe bound segment maintains its current shipping speed. Because most of the freight exported to Europe from the Far East are finished goods, as the shipping period gets longer, it is expected that the satisfaction of shippers will decrease and retention rate of freight will decrease as well. Also, in terms of cargo freight, compares to the 660$/TEU of the Europe-Far East segment (E-bound) of 2008, the Far East-Europe (W-bound) segment reaches 1,432$/TEU, which is 2.16 times in 2008 and has a relative importance. It is certain that if the shipping speed is decreased through additional ship input in such Far East-Europe segment (W-bound), in the long term it will be isolated in the periodic Europe route market and this will, of course, negatively affect future operational activities. 'H' shipping company decided to re-examine the application of speed-reduced operation of the Far East-European route based on the future market situations, the trends of jointly operating shipping companies, and the maintenance of the current shipping periods without further delays as resistance among joint operation shipping companies is expected to be strong.

Changing from the existing 8-ship service to 9-ship service in the Far East-Europe route (W-bound) and putting in 7 days of surplus time in the Europe-Far East segment, the decrease in quantity due to shippers' leave is shown to be an average of 156 TEU per ship and the freight profit resulting from this was $739,860, which was $45,495 less. However, this is the effect of limiting the collection of low profit freights for the realization of freight in the Europe-Far East segment, in which the freight is relatively low, and it has been analyzed that part where the results decreased had partial effects as well. The cargo freight in the Europe-Far East segment was $660/TEU, which was 50% lower than the $1,432/TEU in the Far East-Europe segment that is notably lower than the Far East-Europe segment and the decrease in cargo retention rate (-12.22%) had insignificant effects in the operational ability to pay of the same route and consequently, the average freight profit per shipment in 2008 was $360,000 with a 8.14% increase. Thus, the decrease in operation due to additional ship input, for which this research had much concerns, was judged to be negligible during speed-reduced operation as long as it is for the Europe-Far East segment.

2) Cost items for the economic feasibility analysis

First of all, a concept of ship maintenance cost that occurs when owning a ship was composed after separating it into shipping depreciation cost, cost for crewmen, maintenance cost, insurance fee, general management cost, and ship inspection cost in this study. If the ship is not owned, the ship maintenance cost can be applied as charter. Shipping depreciation cost item is calculated through the construction price for each ship that operates in the AEX route and this was calculated with the 0% salvage value and 6.4% interest rate with its standards on a 15 year straight-line method on the ship building cost that H shipping company normally pays to the ship builder. The cost for crewmen was calculated using total costs that include personnel expenses, education costs, and other welfare expenses. The repair cost item was calculated using the total cost including general repair costs, preventative maintenance cost and various inspection fees. The costs for articles for ship item are calculated using the average purchased articles for the ship, which includes auxiliary purchase costs for each shipment of the AEX route. The insurance fee item is calculated using the total cost which includes the ship insurance and P&I club insurance fee. Items of costs other than shipping were calculated with other costs related to ship maintenance excluding items above as its standard.

Second, port costs which occur in ports that ships call on can be classified in the usage fee of port facilities which comprises of dockage, ferry charge and landing charge, and loading and unloading fee. However, because the quantity transported used in this research is not in units for each port but are quantity transported according to average load, the landing charge was excluded and only the net port facility usage fee was calculated as the port cost. Since the port cost is generated as a slightly different item according to the characteristic of the country of each port, the Suez Canal passage fee was applied as the standard.

Third, for the fuel oil cost item, the fuel supply of the AEX route of H shipping company is supplied 25% from Singapore and 75% from Rotterdam where the fuel price is cheaper. Thus, according to the standard of actual fuel supply and the standard price with weighted average price are 25% of the yearly Singapore average purchase price and 75% of the yearly Rotterdam average purchase price, respectively.

4.3 Result of economic feasibility analysis for the fuel cost reduction of 'H' shipping company

1) Comparison of fuel costs for 8 vessels vs. 9 vessels operation models

If the average purchase price of fuel oil is converted into purchase patterns in the AEX routes of 'H' shipping company, the average yearly fuel oil purchase price in 2008 was $471.56. Table4 shows a comparison of fuel costs when operating 8 and 9 vessels by the shipping company and shows the average fuel oil consumption amount per shipment of the company.

Table 4 Average Amount of Bunker Consumption Per Vessel for Each Voyage in 2008

Voyage Average Per Quarter	Average Amount of Bunker Consumption Per Vessel (Ton)			Average Fuel Oil Price Per Vessel (US$)			
	2007 8 vessels	2008 9 vessels	Difference	2008 base price	2007 8 vessels	2008 9 vessels	Difference
1/4	8,998	7,472	1,527	439.94	3,958,674	3,286,980	671,694
2/4	8,619	7,382	1,237	548.89	4,730,845	4,052,108	678,736
3/4	8,603	7,220	1,384	632.43	5,440,794	4,565,827	874,967
4/4	8,201	7,022	1,114	281.05	2,304,917	1,991,924	312,993
Annual Average	8,605	7,290	1,315	471.56	4,057,945	3,437,780	620,165

Footnote : Apply standard supply price SINGAPORE 25%, ROTTERDAM 75%

With $471.56 per ton as the average price in fuel oil in 2008, when applying average consumption amount per shipment, it was found that there is about $620,000 in cost reduction effect per shipment on a 9-ship operation model. This figure refers to the 9.3% of the total operation cost which is $6,706,023, excluding the landing charge, which is 18.1% of the fuel oil $3,437,780.

2) Economic feasibility model per each varying step of the fuel oil price and shipping maintenance cost for 8 vessels vs. 9 vessels operation

When separating other cost items defined previously into 8-ship and 9-ship operation of AEX route by H shipping company and comparing result is shown on Table 5. Thus, we can see that the daily fixed cost per shipment is $31,818. However, when analyzing the economic feasibility, the landing charge lacks relativity with the problem dealt in this research, assuming that the quantity transported is the same for 8-ship operation and 9-ship operation and the weekly service operation pattern is maintained, there are no changes in the costs so it has been excluded from the target to be considered.

Table 5 Comparison of Operation Cost of Container Ships

Classification		Day	9 vessels/63day	8 vessels/63day
Ship maintenance cost (fixed cost)	Cost for crewmen	3,154	198,700	176,622
	Capital cost	23,139	1,457,734	1,295,763
	Repair cost	307	19,332	17,184
	Cost for articles for ship	3,351	211,128	187,669
	Insurance fee	942	59,375	52,728
	Other cost	925	58,271	51,796
	Subtotal	31,818	2,004,539	1,781,813
Running Cost	Port cost	-	1,263,704	1,263,704
	Fuel cost	-	3,437,780	4,067,945
	Subtotal	-	4,701,484	5,321,649
Total			6,706,023	7,103,462

Footnote 1) Apply an average fuel oil price of $471.56/Ton in 2008(Apply standard supply price SINGAPORE 25%, RORRERDAM 75%)
2) No change in harbor due/port usage cost among running cost
3) Apply actual operation costs for 9 ships in 2008

We can find results similar to Table 6 when analyzing the operational economic feasibility by considering the varying situation of ship possession costs following future price changes and market situations based on the comparison data of operation costs during 8-ship and 9-ship operation through the operation data of 2008 in Table 5. When applying the daily average fixed cost of $31,818 per ship in 2008 for H shipping company, the operation cost for 8-ship and 9-ship operation was equivalent. Considering the current high oil price situation, it is expected that it will be difficult for the fuel oil price to decrease to less than $300/ton. Even if the fixed cost(charter) exceeds $35,000 when over $200/ton, a 9 vessels operation is analyzed to be more economic compared to the 8 vessels operation.

Table 6 Analysis of economical efficiency by stage of fuel oil price and capital cost for vessels in operation of 9 vessels

(Unit : USD)

Fixed cost or Hire age	Bunker price per ton									
	100	150	169.35	200	250	300	350	400	450	500
20,000	-8,500	57,250	822,722	123,000	188,750	254,500	320,250	386,000	451,750	517,500
25,000	-43,500	22,250	47,722	88,000	153,750	219,500	285,250	351,000	416,750	482,500
30,000	-78,500	-12,750	12,722	53,000	118,750	184,500	250,250	316,000	381,750	447,500
31,818	-91,226	-25,476	0	40,272	106,024	171,774	237,524	303,274	369,024	434,774
35,000	-113,500	-47,750	-22,278	18,000	83,750	149,500	215,250	281,000	346,750	412,500
40,000	-148,500	-82,750	-57,278	-17,000	48,750	114,500	180,250	246,000	311,750	377,500

According to the cost items for the economic feasibility analysis examined previously, during speed-reduced operation for fuel reduction, the service type for each call port of weekly service is maintained and there are no particular differences in the case of other costs and landing charge for each call port among the operation cost of container ships of the service. It is just that the increase in the direct fixed cost including the capital cost for the possession and maintenance following additional ship input is the most representative cost increasing factor and reversely, the reduction of fuel cost following speed-reduced operation was found to be a cost-reducing factor.

Recently, due to the rapid increase in oil price and the global economy recession brought along by the American bound financial crisis, there are instances where container shipping companies reduced the shipment of some of the uneconomical routes and are improving the surplus ships due to such routes for the long term. Even when such improvements are made, most of the shipping companies cannot stop the service on routes that are related to big size shippers like the European routes. In such cases, if the ships are owned by the shipping company, even if the ship is not operating, yearly improvement costs of about $1.6 million (daily $4,384) per ship is generated. In case of chartered ships, even if the ship is not operating, daily charter of about $35,000 (by 6,800 TEU standards) must be paid in charter. Thus when improving the surplus ship due to the evacuation and reorganization, if additional ships are put in for fuel cost reduction, we can exclude the additional burden factor of capital cost for ship possession and basic fixed cost. In other words, when there is an improvement in other operation routes, there is a need for an analysis on the cost for economic feasibility when adding additional ships for cost reduction in main routes and decision-making needs to be done with a consideration for the customers' sensitivity following the change in service level.

5. Conclusion

We have countered the rapid increase in fuel oil after 2005 with a more active fuel cost reduction plan that reduces the amount of fuel consumption by decreasing the shipping speed with additional ships even if shipping possession and maintenance cost is generated. This is to increase the number of ships used and operating at an economic speed rather than the maximum speed in order to reduce the amount of fuel consumption and decrease the portion of fuel cost.

In reality, most of the shipping companies cannot make a decision despite the fact that it has been made possible to secure additional economic feasibility by putting in additional ships between 2004, when oil prices began to rise, and 2007. This shows that measures to deal with the high fuel oil cost are considerably late. Of course, the reason such periodic service adjustments are lagging behind may be due to the rigidity, which is characteristic of the shipping industry, problem of shipping periods, problems in credibility of schedule, and increasing cost problems related to the additional ship security. Until now, the relationship between the amount of fuel consumption and periodic service plan was the main concern of ship management, service planners, and periodic service operators but did not lure academic interests. In this research, an economic feasibility analysis was conducted to reduce the shipping fuel oil burden of shipping companies on whether the fuel oil cost can be reduced due to the additional input of vessels.

The academic and practical implications of this research are as follows: First of all, in terms of the AEX route service of 'H' shipping company, difference in cost was sought with the actual cost structure of an 8-vessel operation during the year 2007 and actual 9-vessels costs for reduced-speed operation in 2008 as its standards. Base on this, a profit and loss analysis model according to the changing steps of the oil price, ship possession, and varying steps of maintenance and were suggested. Second, fuel oil price in July 2008 started to decrease at $766 as its peak in Pusan standards and reached its bottom price of $246 in only 4 months, but due to global expectations of economic recovery, it increased again and rose over $400 in June 2009 and is currently $640 in October 2011. Planning shipment in such rapidly changing economic situations and periods of rapid fuel oil price changes, the exemplary economic feasibility analysis of additional ship input of 'H' shipping companies will become the foundation for faster decision-making process.

Although this research has economic and practical implications, it leaves the following limitations and problems. This research was not conducted vastly according to various service areas like the Far East-Southern American route, Far East-European route, and the Atlantic route and has a limit of only conducting a comparative analysis on costs of one specific route, 'AEX route of H shipping company', among the Far East-European routes and thus, the result may vary depending on which specific route of application. Thus there is a need to analyze the effects of fuel costs on a more expanded periodic service network with an analysis on various service types in various routes and also a need to research more on the connection with the problem on schedule credibility. Also, along with the operational view which was dealt heavily in this research, a research considering the operational effects like the preference of shippers on the change of shipping periods due to the reduction in shipping speed must be conducted in depth in order to be of help to the shipping companies.

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