An empirical model of the bulk shipping market

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Abstract: There are four markets in shipping, namely the freight market that trades sea transport, the second-hand market that trades used ships, the new building vessel market that trades new ships and the demolition market that deals with scrap ships. These four shipping markets are closely associated. This study aims to provide insights into the four shipping markets and to explain how these markets affect one another by empirically testing the relationships among the key variables of bulk shipping – prices of ships (in new building market, second-hand market and demolition market), fleet size, freight rate, and seaborne trade. The study results show that seaborne trade significantly affects fleet size, while fleet size is also affected by freight rate. On the other hand, freight rate has a significant impact on ship prices, i.e., new building, second-hand and scrap vessel prices. Based on the findings, a regression equation is developed to predict fleet size. Theoretical and practical implications of the bulk shipping market model are also discussed in this study.

Keywords: shipping market; fleet size; freight rate; freight market; bulk shipping.

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1 Introduction

Shipping and international trade are closely related (Lun et al., 2006). Bulk shipping transport is the most practicable and cost-effective means of transporting large volumes of cargoes for international trade. The purpose of bulk shipping is to provide an economical means of transporting goods across oceans. Bulkers mainly carry dry cargoes in bulk from one port to another and often do not have a fixed itinerary. In the freight market, cargoes are carried at freight rates, whereby the terms and conditions are usually negotiated between shippers and carriers. As a result, the performance of the bulk shipping market depends on the demand for and supplies of bulk shipping services, as well as the market structure in terms of the number of shipping firms, their size of operations, degree of homogeneity of their services, and so on and so forth (Brooks, 2000). The market structure of an industry affects the competition characteristics of the industry and bulk shipping researchers have suggested that the bulk shipping industry operates under a market structure close to that of perfect competition (Harlaftis and Theotokas, 2002; Clarkson Research Studies, 2004).

The market structure of bulk shipping is characterised by several conditions. First, large numbers of firms that own bulk ships are able to provide similar bulk shipping services (Clarkson Research Studies, 2004). In addition, entrants to the bulk shipping market can easily gain access to information and customers such as freight rates from the Baltic Index and customers from ship brokers. Although the large capital investment required to purchase ships may be a barrier to new entrants to the bulk shipping market, assistance and support from shipping commercial banks are available for investors. Apart from such large capital investment requirements, there are limited entry barriers to the bulk shipping market. On the other hand, there are no regulatory or economic obstacles for bulk shipping firms to withdraw from the market. Their exit is unlikely to result in a corresponding decrease in the supply of tonnage as the exiting bulk shipping firms may have sold their tonnage to other shipping firms in the second-hand sale and purchase market. Product development and promotion activities are not necessary for bulk shipping firms to operate, and information about freight rates and other business matters can be easily obtained through various sources such as the Baltic Index. To a large extent, prices (i.e., freight rates) and fleet size in the bulk shipping market are determined by the market.

From the industrial organisation perspective, the demand and supply conditions in the bulk shipping market can influence the market structure, which in turn affects the decisions of firms in the marketplace (Tirole, 2003). The bulk shipping market brings buyers and sellers together to set the freight rate (i.e., price) and determine the fleet size (i.e., quantity). In other words, seaborne trade affects the freight rate as the former is the key to the demand for bulk shipping services. Furthermore, freight rate can influence carriers' decisions on adjusting fleet size affecting the supply of bulk shipping services.

The bulk shipping market comprises four separate but interrelated markets (Stopford, 2004) namely:

1 the freight market where sea transport services are traded

2 the new building market where new ships are ordered and built

3 the sale and purchase market where second-hand ships are sold and brought

4 the demolition market where old ships are scrapped.

These shipping markets can also be divided into real market and auxiliary market (Adland et al., 2006). Real market represents the new vessel building and demolition markets, where an increase in new building leads to an increase in total capacity while an increase in ship scrapping means a decrease in total capacity in the bulk shipping market. On the other hand, the auxiliary market corresponds to the freight market which trades sea transport as well as the sale and purchase market for second-hand ships. These are auxiliary markets because the transaction in sea transport between shippers and shipping firms as well as buying and selling of second-hand ships between ship owners have no influence on the total capacity in the bulk shipping market.

Topics of the shipping market have received considerable attention in the shipping literature (Marlow and Gardner 1980; Talley et al., 1986; and Evans, 1988). Nevertheless, prior studies are confined to investigating the characteristics of the shipping market and how firms behave in the shipping industry. Limited research attention has been devoted to developing an empirical shipping market model to predict fleet size which is crucial for managers to make strategic decisions such as determining their operational capacity or investment in ships. This study aims to fill this important but under-explored research gap by developing an empirical model to examine the causal relationships among the variables (i.e., the prices of ships, freight rate, seaborne trade and fleet size) in the bulk shipping market. We also examine the relationships among the freight market, the new building market, the sale and purchase market and the demolition market. In this study, we empirically test the relationships among these study variables using data collected from the Clarkson Research Studies. This study also helps us gain an understanding of the factors influencing the bulk shipping market and we used a regression equation in this study to predict fleet size.

2 Theoretical framework and hypotheses development

The four aforementioned shipping markets can be linked by cash flows between these markets (Stopford, 2004). The main cash inflow is the revenue generated from the freight market, where the ups and downs of freight rates are the primary mechanism driving investors to adjust their fleet size. In the demolition market, old ships sold to scrap dealers provide another source of cash inflow. In general, more old ships deliver to scrap yards during a recession period. Demand for shipping service decreases during economic downturn, scrapping of old ships in the demolition market reduces the total capacity in the bulk shipping market. On the other hand, both cash inflow and outflow can be generated from the second-hand market where ship owners transact for used ships. However, the transactions in second-hand ships would not change the shipping capacity available in the shipping industry. Lastly, the new building market is an outflow of cash as ship owners pay cash to ship yards for new ships.

2.1 New building vessel

Demand for new vessels reflects the need for sea transport capacity (Wright, 1991). It usually takes a few years from ordering a new ship to its service in the freight market. A decision to order a ship should reflect a shipping investor's expectation on future freight rates. The price for building a new vessel can serve as a stabilisation mechanism for the shipping industry. When sea transport demand goes up, freight rate would increase and accelerate investment in new vessels. As a result, new building vessel price will rise, stabilising the shipping market with a 'barrier' to excessive profits (Dikos, 2004). To increase the supply of sea transport at the period of high freight rate, ship owners increase their fleet size by purchasing new ships (Leach, 2004). Following the rise of freight rate, ship builders would respond to the increased demand for new vessels by setting a higher price on new building vessels. Thus, freight rate can be considered as a determinant for the price of new building vessels.

Building new ships is the primary method of increasing the supply of tonnage in the bulk shipping market. The demand for new ships by shipping firms derives from the need for new tonnage to meet their increased sea transport requirements. While it requires a large capital investment for purchase of a new ship, the cost of building a new ship therefore becomes crucial in terms of return on investment. Ship owners tend to favour a low new building price (Tsolakis et al., 2003). Investors opt for new ships when they perceive the price is low, with the expectation of selling the vessel later at a higher price (McConville, 1999). Therefore, investors may order new ships when the price of building new ships is low. The price mechanism of the new building industry has implications for the demand for new vessels.

2.2 Second-hand vessel

The main cash inflow of the bulk shipping business is the revenue generated from the freight market. For example, the large volume of raw materials imported by China in 2004 consumed most of the capacity of bulk ships and generated a large amount of cash inflow. Such inflow of cash from the freight market provides capital to ship owners to acquire new vessels as well as second-hand ships to meet the market demand for sea transport (Clarkson Research Studies, 2004). While it takes a few years to build a new vessel, the second-hand ship market becomes an alternative source of ships during freight boom (Tsolakis et al., 2003). Indeed, Beenstock (1985) has suggested that second-hand and new ships can be substitutes as they are the same assets only differing in age.

The second-hand ship market can be considered as an auxiliary market because the buying and selling of second-hand ships is less likely to change the number of vessels or carrying capacity in the shipping market. On the other hand, the second-hand market is closely integrated with the freight market (Adland et al., 2006). Second-hand vessel price rises at the time of freight boom and drops at the time of freight depression. A key function of the second-hand ship market is to reallocate vessels among ship operators. Besides, the second-hand ship market contributes to increasing the efficiency of the shipping market by reducing market exit costs where ship owners can sell their used ships when they leave the industry. It also facilitates market entry by allowing potential investors to buy used ships and enter the shipping market. A ship could have been bought for about US$32 million in late 2001. In 2004, a few years later, a similar size used ship could be sold at US$62 million (Xinhua Financial Network News, 2004). To maximise their profit, investors acquire ships when ships are cheap and sell ships when the peak is reached. Due to the cyclicality of the second-hand ships, considerable profit opportunities may arise through ‘buy low and sell high’. However, low freight rates usually coincide with low vessel prices, which are not desirable for ship owners with excessive tonnage, but they do provide a good opportunity for investors to buy ships at low prices (Tsolakis et al., 2003).

2.3 Scrapping vessel

The second-hand vessel sale and purchase market is highly competitive and cyclical, while the price movement is usually limited by the price of a new ship and the price of a scrap vessel (McConville, 1999). The price of a new ship poses a constraint on the upper limits of second-hand ship prices. However, there are exceptions during periods of freight boom when ship owners pay in excess of new building vessel prices in order to timely secure tonnage to provide shipping service in the freight market (Ocean Shipping Consultants Ltd., 2004). On the other hand, the vessel scrapping price denotes the minimum price of a second-hand vessel. Similar to the second-hand vessel price, the scrap vessel price tends to follow the movement of the freight market (McConville, 1999). During the period of freight boom, when expectation of future revenue is high, second-hand vessel price is high and ship owners are reluctant to sell their tonnage for scrap. As such, there will be reduced scrap supply during the period of freight boom, exerting pressure on the scrap dealers to increase vessel scrapping price. Old vessels sold to scrap dealers provide a useful source of cash from the perspective of ship owners (Stopford, 2004). The decision to scrap a ship is based on a carrier’s expectation of their future operating profitability of ships and its own financial position. Usually, the supply of old ships to the scrap market depends on the scrapping value. The decision to scrap is related to ship owners’ expectations about the future trading prospects. Ships will be scrapped when profitability for ships is negative. A high scrap price leads carriers to offer more ships to the demolition market, which in turn reduces fleet size. Scrapping can also be a tool for ship operators to adjust capacity (Farthing and Brownrigg, 1997).

In sum, vessels in the bulk shipping market include new building, second-hand and scrap vessels. Fleet size can be influenced by the price of these vessels. We therefore hypothesise that:

Hypothesis 1 Fleet size is positively affected by vessel price, namely new building, second-hand and scrap vessel prices.

2.4 Freight rate

The freight market trades shipping services for the transport of goods. The demand of freight transport is a function of freight rates and the demand of shipping services per time period (Truett and Truett, 1998). The freight market creates a situation where freight rate moves to a level at which demand from shippers equates to the supply of shipping services from shipping firms (McConville, 1999). Seaborne trade growth would lead to an increase in freight rate. When seaborne trade grows leading to a shortage of ships, the shipping industry adjusts by increasing fleet size (Leach, 2004). On the contrary, the fleet size in the bulk shipping market would fall if the freight rate reduces as carriers will be less optimistic they can generate profit from their existing fleet size. We therefore conjecture that:

Hypothesis 2 Fleet size is positively affected by freight rate.

2.5 Seaborne trade

Bulk shipping tends to maintain flexibility in sea transport to meet the needs of seaborne trade by providing transport services worldwide (Kendall and Buckley, 2001). Carriage of cargo generally does not take place unless there is a need for cargoes to be shipped. Demand for shipping services depends on the demand from shippers to transport their goods. Hence, seaborne trade is a major determinant for shipping services. An increase or a decrease in seaborne trade volume would change the demand for sea transport which in turn influences the freight rate. In other words, freight rate is determined by the demand for and supply of shipping services. The freight rate can serve as a signal for carriers and shippers to transact for shipping services. If the seaborne trade volume increases, shippers demand more shipping services. When the shipping demand exceeds the shipping supply, the freight rate will go up. The freight rate coordinates the decision of carriers and shippers to transact for shipping services in the bulk shipping market. A high freight rate tends to encourage growth in the world's fleet. Such an association between freight rate and fleet size can be regarded as the existence of an invisible hand that regulates the bulk shipping market (Smith, 1776). We therefore speculate that:

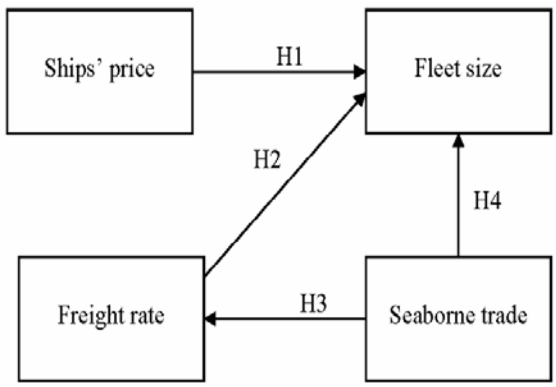
Hypothesis 3 The volume of seaborne trade positively affects the freight rate.

While acquiring ships requires a high level of capital investment, the return on investment in ships depends on the volume of trade (Stopford, 2004). If ships are invested in, but seaborne trade does not grow as expected, expensive ships could be laid up (Metaxas, 1971). Demand for ships is derived from seaborne trade (Jansson and Shneerson, 1987), where a change in seaborne trade can lead to a change in demand for ships. Demand for ships reflects the need for shipping capacity, while the demand for sea transport is determined by the demand of consumers for goods. Such customer demands will subsequently lead to demand for bulk shipping. This suggests that shipping service providers have little control of the shipping demand (McConville, 1999). To cope with an increase of seaborne trade volume, carriers increase the supply of sea transport. In other words, shipping managers adjust their fleet size based on the seaborne trade. Accordingly, the following hypothesis is developed:

Hypothesis 4 The volume of seaborne trade positively affects fleet size.

The conceptual model guiding this research is shown in Figure 1. We begin our discussion of the research model by proposing that the prices of vessels affects investors' decisions in adjusting their fleet size in the bulk shipping market, while investors make decisions relating to their shipping capacity based on freight rates. Freight rate plays an important role in affecting fleet size in the bulk shipping market. We also speculate that there is a positive association between seaborne trade and freight rate. A change in seaborne trade also affects ship owners' decisions to adjust their fleet size.

Figure 1 The bulk shipping market model for fleet size



3 Research design

In this study, we used 16 years of data from Panamax Bulkers, from 1990 to 2005, collected from the Clarkson Research Studies to test our propositions. These secondary data included seaborne trade, freight rate, fleet size, new building vessel price, second-hand vessel price and scrapping vessel price. Sources of data for bulk cargo trade included the International Iron and Steel Institute, Tax Report, Australian Bureau of Statistics, National Coal Association (USA), Coal & Coke Statistics (Canada), Joint Coal Board (Australia), South African Coal Report, International Wheat Council, and the US Department of Agriculture publications. Data sources of freight index were generated from a database maintained by the daily Baltic Freight Indices, the rates of its component routes, and indications as reported by Clarkson Securities Limited. Data on fleet size was complied by the Clarkson Research Statistics Department. Information of fleet data was continuously updated through consultation with the H. Clarkson broking network and through questionnaires and direct contacts with ship owners and shipyards. Checking and validation was carried out with reference to a range of published sources. The data of new building vessel price was sourced from market information provided by H. Clarkson brokers and from published materials. Prices for second-hand vessels were collated in conjunction with H. Clarkson & Co., sale and purchase brokers who filled in proformas prepared by Clarkson Research. Information on vessel scrapping price was based on market information provided by H. Clarkson brokers, and was checked and validated by reference to a range of published sources (Clarkson Research Studies, 2005). Details of the data to test our propositions are summarised in Table 1.

Our research model provides an overview of a number of key factors affecting the bulk shipping market and how these factors are related to each other. We use statistical tools to test the relationship between fleet size and vessel prices. To know how the four shipping markets are related, we use the statistical technique of correlation to examine these four segments of the bulk shipping market. In addition, several regression models were used to test Hypotheses 2, 3 and 4. To understand the determinants for fleet size, we developed a regression equation to predict the fleet size.

Table 1 Data for testing the hypotheses

Year	*Seaborne trade* [a]	*Freight rate* [b]	*Fleet size* [c]	*New building vessel price* [d]	*Second hand vessel price* [e]	*Scrapping vessel price* [f]
1990	1598.00	1446.00	12.52	30.00	19.00	2.45
1991	1625.00	1494.00	44.13	34.00	24.00	2.06
1992	1596.00	1373.00	45.17	28.00	18.75	1.94
1993	1616.00	1215.00	44.82	28.50	19.50	2.06
1994	1696.00	1965.00	46.73	28.00	21.000	2.39
1995	1805.00	1604.00	50.31	28.50	21.50	2.06
1996	1819.00	1516.00	54.77	26.50	19.50	2.00
1997	1916.00	1231.00	57.01	27.00	22.00	2.00
1998	1900.00	794.00	61.22	20.00	14.00	1.37
1999	1896.00	1211.00	62.72	22.00	16.75	1.81
2000	2042.00	1562.00	65.46	22.50	16.00	2.18
2001	2095.00	884.00	69.86	20.50	14.00	1.74
2002	2172.00	1731.00	75.95	21.50	17.00	2.30
2003	2291.00	4467.00	78.86	27.00	28.00	3.35
2004	2426.00	4438.00	80.09	36.00	40.00	4.80
2005	2536.00	2321.00	86.38	36.00	29.50	4.19

Notes: a seaborne bulk trade in million tonnes
b Baltic freight index is a weighted average of spot prices from different routes
c fleet size in million deadweight tonnes
d new ship building price in million USD
e second-hand five-year vessel price in million USD
f scrapping price in million USD.

4 Test results

To check the reliability of the data, Cronhach's Alpha reliability coefficients for the vessel prices were obtained. In this study, Cronhach's Alpha reliability coefficient of vessel prices is 0.763. The closer the coefficient gets to 1.00, the higher the reliability of the measures. In general, reliability coefficients of less than 0.600 are considered as poor and those in the 0.700 range are considered as acceptable (Hair et al., 2006). As Cronhach's Alpha value of the vessel prices is 0.763, the reliability of the measures for vessel prices can be accepted.

To test our hypotheses, we used the variables relating to fleet size, freight rate and seaborne trade. Inter-item correlation is used to test the reliability of these variables. According to Table 2, the inter-item correlations of the three variables range between

0.556 and 0.984, which exceeded the threshold of 0.30, suggesting the reliability of these variables are acceptable (Hair et al., 2006).

Table 2 Inter-item correlation of fleet size, freight rate and seaborne trade

	Fleet size	*Freight size*	*Seaborne trade*
Fleet size	1		
Freight rate	0.556(*)	1	
Seaborne trade	0.984(**)	0.615(*)	1

Notes: ** significant at the 0.01 level (2-tailed)
* significant at the 0.05 level (2-tailed).

4.1 Vessel prices and fleet size

Our first hypothesis suggests that fleet size is affected by vessel prices. To test our hypothesis, a series of regression analyses were carried out. A summary of the relationships between fleet size and vessel prices is shown in Table 3. Our results show that both new building vessel price and second-hand vessel price do not have significant impact on fleet size as their *p* values are greater than 0.100. On the other hand, our findings show that fleet size is significantly affected by scrapping vessel price with a $\beta = 0.622$ at the *p* value which is significant at the 0.01 level.

Table 3 Results of regression analyses for Hypothesis 1

Model	*Dependent variables*	*Independent variables*	R^2	*(β) Beta coefficient*	*Sig.*	*Results*
1.1	Fleet size	New building vessel price	0.000	–0.07	0.979	Reject
1.2	Fleet size	Second-hand vessel price	0.172	0.415	0.110	Reject
1.3	Fleet size	Scrapping vessel price	0.387	0.622	0.010	Reject

Note: * significant at the 0.05 level.

Our findings suggest that the price for new building vessel is not significantly related to the fleet size, indicating that low new building vessel price has no significant impact influencing the decision of shipping firms to increase their fleet size with new ships. Similarly, our results show that the price for second-hand vessels does not have significant impact on fleet size. On the other hand, our results suggest that scrapping vessel price positively affects fleet size. The finding indicates ship owners do not scrap their old ships to reduce the fleet size because of high scrapping value. High scrapping prices do not lead shipping firms to offer more ships to the demolition market. Therefore, our Hypothesis 1 is not supported as fleet size is not found to be affected by vessel prices.

4.2 Four shipping market segments

To understand how the new building market, second-hand market, demolition market, and freight market are associated, we conducted a correlation analysis to examine the direction, strength, and significance of the relationships of these variables. Our results suggest that there is a positive correlation between new building vessel price and second-hand vessel price with a correlation coefficient (*r*) of 0.821. Our findings also suggest a positive correlation between new building vessel price and scrapping vessel price with a correlation coefficient (*r*) of 0.711. On the other hand, the results indicate that the relationship between new building vessel price and freight rate is weakly significant with the *p* value between 0.050 and 0.100 level and a correlation coefficient (*r*) of 0.493 (Corbett et al., 2005). In addition, second-hand vessel price is positively correlated with scrapping vessel price with the correlation coefficient (*r*) of 0.915. Second-hand vessel price is also positively correlated with freight rate with a correlation coefficient (*r*) of 0.847. Furthermore, our findings show that scrapping vessel price and freight rate is positively correlated with correlation coefficient *(r)* of 0.848.

Table 4 Pearson correlations of new building vessel price, second-hand vessel price, scrap vessel price, and freight rate

	New building vessel price	*Second-hand vessel price*	*Scrapping vessel price*	*Freight rate*
New building vessel price	1			
Second-hand vessel price	0.821(**)	1		
Scrapping vessel price	0.711(**)	0.915(**)	1	
Freight rate	0.493(*†*)	0.847(**)	0.848(**)	1

Notes: ** significant at the 0.01 level (2-tailed)
† significant at the 0.10 level (2-tailed).

4.3 Freight rate, seaborne trade and fleet size

A series of regression analyses were carried out to test our Hypotheses 2, 3 and 4. The results are shown in Table 5. Our findings show that fleet size is affected by freight rate with β = 0.556 and the relationship is significant at the *p* = 0.025 level. Hypothesis 2 is therefore supported. The results also demonstrate that freight rate is influenced by seaborne trade with β = 0.615 and the relationship is significant at the *p* = 0.011 level. Hence, Hypothesis 3 is supported. In testing Hypothesis 4, we found that fleet size is affected by seaborne trade with β = 0.984 and the relationship is significant at the *p* = 0.000 level. As a result, Hypothesis 4 is supported.

Table 5 Results of regression analysis for testing Hypotheses 2, 3, and 4

Hypotheses	*Dependent variables*	*Independent variables*	R^2	*(β) Beta coefficient*	*Sig.*	*Results*
2	Fleet size	Freight rate	0.309	0.556	0.025*	Accept
3	Freight rate	Seaborne trade	0.378	0.615	0.011*	Accept
4	Fleet size	Seaborne trade	0.968	0.984	0.000**	Accept

Notes: ** significant at the 0.01 level
* significant at the 0.05 level.

4.4 Determinants of fleet size

In bulk shipping, the fleet size has experienced continued growth in recent years. According to our findings, three determinants affecting fleet size have been identified. The findings show that seaborne trade, freight rate, and scrapping vessel price are determinants of fleet size. To understand how the determinants affect fleet size, we developed a regression equation to predict the fleet size.

The first step to develop the regression equation involves the selection of a complete set of potential predictor variables. Any variable that might add to the accuracy of the prediction should be included. According to our findings, seaborne trade, freight rate, and scrapping vessel price should be used to predict fleet size. When researchers choose predictor variables to include in the regression equation, they may want the equation to include as many predictor variables as possible. However, the simplest equation is usually the best (Hanke et al., 2001). In a simple regression equation, only the predicator with the highest predictive power can be included in the equation.

The second step is to screen out the independent variables that are not appropriate to be included in the analysis. Multicollinearity, which refers to the correlation among the independent variables, can reduce independent variable's predictive power by the extent to which it is associated with other independent variables (Tabachnick and Fidell, 2007). Therefore, we selected the variables that have low multicollinearity with the independent variables but have high correlations with the dependent variables. Table 6 shows the correlation relationship among the three independent variables (i.e., scrapping vessel price, seaborne trade, and freight rate) of our study. The results suggested that the three independent variables are highly correlated. Hence, an independent variable associates with other independent variables as multicollinearity exists.

Table 6 Correlations of the scrapping vessel price, seaborne trade, and freight rate

	Scrapping vessel price	*Seaborne trade*	*Freight rate*
Scrapping vessel price	*1*		
Seaborne trade	*0.717(**)*	*1*	
Freight trade	*0.848(**)*	*0.615(*)*	*1*

Notes: ** significant at the 0.01 level (2-tailed)
* significant at the 0.05 level (2-tailed).

The next step is to refine the list of predictor(s) to determine the 'best' regression equation. To select the best independent variable among the predictors, we compare the value of beta coefficient (β) of the independent variables. The beta coefficient (β) indicates how much the value of the dependent variable changes when the value of that independent variable increases by 1.0 and the values of the other independent variables do not change. A positive β means that predicted fleet size increases when the value of independent variables increase. Beta coefficient allows for a direct comparison between coefficients as to their relative explanatory power for the dependent variable. According to Table 7, the β of the independent variable of seaborne trade is the highest (i.e., 0.984) when compared with others. The findings indicate that the independent variable of seaborne trade is the best predictor among the three independent variables to predict fleet size.

Table 7 Comparison of beta coefficient

Dependent variables	*Independent variables*	R^2	*(β) Beta coefficient*
Fleet size	Freight rate	0.309	0.556
Fleet size	Scrapping vessel price	0.387	0.662
Fleet size	Seaborne trade	0.968	0.984

4.5 The regression analysis

When firms operate in an atmosphere of uncertainty, forecasting is necessary for them to make decisions that affect the future of the firms. In the bulk shipping industry, quantitative forecasting in fleet size can be the starting point for effective decision making. To predict fleet size in the bulk shipping market, we use a regression analysis technique to develop a regression equation.

Table 8 Results of regression analysis

R	R^2	*df*	*Sig.*	*Constant*	*B*
0.984	0.968	14	0.000	–32.291	0.048

Notes: Predictor: seaborne trade
Independent variable: fleet size.

In a regression model, the fitted regression equation is of the form

$$Y = b_0 + b_1X_1$$

where

b_0 = intercept

b_1X_1 = linear effect of X_1

The coefficients for the independent variable to affect fleet size are listed in column B of Table 8. Using these coefficients, the following regression equation to predict fleet size can be obtained:

$$FS = -32.291 + 0.048ST$$

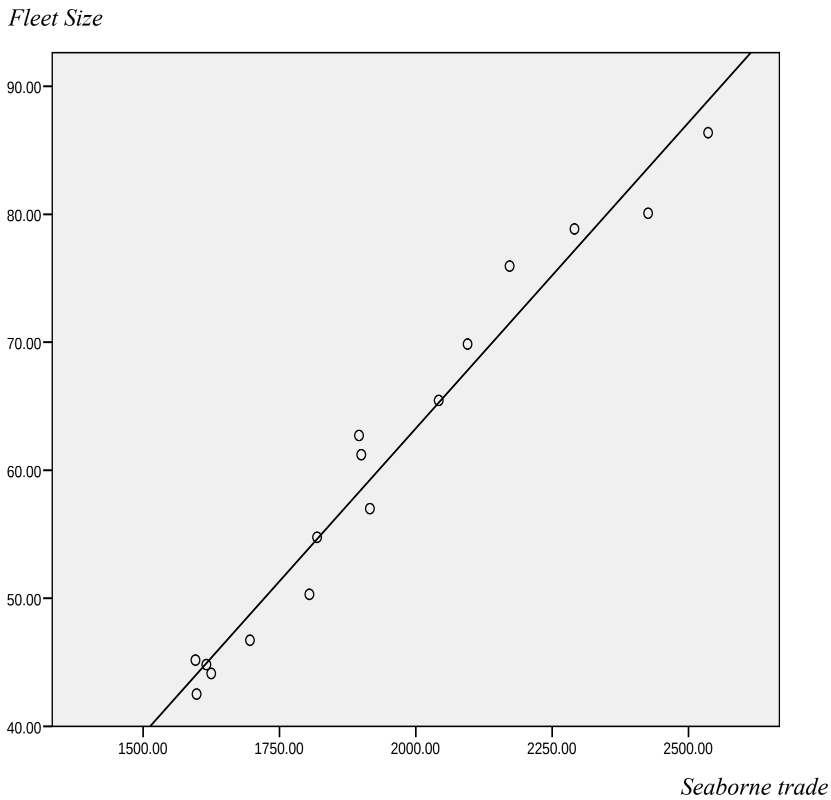
where

FS = Fleet size

ST = Seaborne trade

In the regression equation, seaborne trade is the indicator of fleet size in the bulk shipping market. The coefficient of the variable (i.e., 0.048) in the equation has a positive value meaning that the predicted value of fleet size increases when the value of seaborne trade increases. Figure 2 is a scatter plot of predicted and observed values of fleet size expectancy. The points (n=16) are evenly distributed above and below the line. The result is an indication that the regression model is a good choice and the regression equation predicts the fleet size in the bulk shipping market reasonably.

Figure 2 The curve fit for fleet size and seaborne trade



4.6 Generalisability of the study

Coefficient of determination (R^2) is useful in checking how well the regression model fits. R^2 measures the percentage of variability in the dependent variable that can be explained through the knowledge of the variability in the independent variable. R^2 can vary between 0 and 1. The higher the value of R^2, the greater the explanatory power of the regression equation, and the better the prediction of the dependent variable. The R^2 of 0.968 suggests that 96.8% of the observed variability in fleet size can be explained by the independent variable of seaborne trade. The prediction accuracy of 96.8% indicates that the regression equation (i.e., FS = –32.291 + 0.048ST) predicts fleet size very well.

In understanding the fitting of a statistical model, the issue on degree of freedom should not be neglected. The best regression model is the one with the highest predictive accuracy for the most generalisable sample. According to Hair et al. (2006), the degree of generalisability is represented by the degrees of freedom. Degree of freedom can be calculated as (*df*) = *n* – number of estimated parameters. Hence, the *df* is:

(*df*) = *n* – number of estimated parameters

In this study, the degrees of freedom of the regression can be calculated as:

$$(df) = n - 2 = 14$$

Degrees of freedom provide a measure of how data are to reach a certain level of prediction. Prediction accuracy of the regression equation could be very high if the degree of freedom is limited. A value of large degrees of freedom indicates the prediction is fairly robust. The larger the degrees of freedom, the more generalisable are the results. The concept of degree of freedom can be indicative of the generalisability of the result and gives an idea of the over fitting of the regression model.

To determine the statistical power, sample size affects the generalisability of the result by the ratio of observations to independent variable. As a general rule, the minimum ratio is 5:1 (Hair et al., 2006) meaning that five observations are made for each independent variable. In this study, 16 years of data (i.e., $n = 16$) and one independent variable (i.e., ST = seaborne trade) were used to develop the regression equation. The ratio of observations to variable for our study is 16:1 indicating that the result of this study can be generalisable.

5 Discussions and conclusions

This study examines the relationships among seaborne trade volume, fleet size, freight rate, and prices of ships in the bulk shipping market. In the bulk shipping market, there are numerous shipping firms providing homogenous ships and services to compete for the revenue generated from freight rates. In the freight market, the shipping demand is composed of many shippers who need ships to transport their goods by sea. Our findings generally support the view that seaborne trade cargo volume positively affects the freight rate. More demand for shipping services lead to higher freight rates. The capacity of the bulk shipping market is influenced by shipping firms' responses to changes in the freight rate. Our findings suggest that there is a positive relationship between freight rate and fleet size. A trade boom that leads to increased freight rate would motivate shipping firms to increase their fleet size. These findings indicate the dynamics of the bulk shipping market in determining freight rates and fleet size. A market can be defined as 'an arrangement whereby buyers and sellers interact to determine the prices and quantities of a commodity' (Samuelson and Nordhaus, 1992). In the context of the bulk shipping market, higher seaborne trade volume leads to more demand for shipping services resulting in higher freight rate. The positive relationship between freight rate and fleet size indicates that suppliers of shipping services tend to increase their capacity when they experience a high market price for shipping service.

In this study, both freight rates and seaborne trade are found to have a significant effect on fleet size. The coefficient of seaborne trade ($\beta = 0.984$) is higher than that of freight rate ($\beta = 0.556$). It indicates that ship owners tend to increase the fleet size when cargoes are available to fill their ships. Return on investment in ships depends on the volume of trade. If fleet size has not been increased while trade grows, sea transport will be overburdened due to a shortage of ships. On the other hand, if fleet size has been increased but trade does not grow, the expensive ships will lay up. Shipping firms adjust fleet size when they are optimistic about the cargo volume for shipping services.

There are different but inter-related markets in bulk shipping. Specifically, the new building and second-hand vessel markets where ships are bought and sold can be considered as the factor market. On the other hand, the product market is the freight market where sea transport services are traded. In general, shipping firms engage in two exchange functions: they buy factors of production in the factor market and they sell sea transport services in the product market. In the context of bulk shipping, the factor market is the new building and second-hand vessel markets where ships are bought and sold, while the product market is the freight market where sea transport services are traded. In this study, the results indicate that both new building vessel price and second-hand vessel price do not have a direct impact on fleet size. This means that shipping firms do not buy ships in the factor market because of low vessel prices. Instead, freight rate is found to influence the decision of shipping firms to adjust their fleet size. The results of this study indicate the product market (i.e., the freight market) is crucial in determining fleet size.

Our findings suggest that the price for new building vessels is positively correlated with the freight rate with an $r = 0.493$ and the relationship is weakly significant as the p value is between the level of 0.050 and 0.100. As its p value is higher than 0.050, the price for new vessels seems to be sub-optimal (i.e., a satisfactory but not optimal price). The sub-optimal price may be due to the subsidisation patterns by governments in the ship building industry (Dikos, 2004), which leads to a lack of response of ship yards with respect to the market conditions for additional shipping capacity.

On the other hand, the correlation results of our study shows that the new building vessel price affects the second-hand vessel price with an $r = 0.821$ and the relationship is significant at the $p = 0.000$ level, and the freight rate also affects the second-hand vessel price with an $r = 0.847$ and the relationship is significant at the $p = 0.000$ level. The results indicate that both the new building market and the freight market are related to the second-hand market in bulk shipping. In the second-hand ship market, timing of investment is critical because of the cyclicality of the shipping market (Tsolakis et al., 2003). The ship value varies directly with the expected return on ships. Higher freight rate can lead to higher profitability and higher second-hand vessel price. This study found that the new building ship price affects the second-hand ship price, with the relationship being significant at the $p = 0.000$ level with an $r = 0.821$. Our finding is in line with the view of Beenstock (1985), that new and second-hand ship prices are correlated. Second-hand and new building ships are substitutes as they are the same asset; the only difference is their age. On the other hand, the findings suggest that the scrapping vessel price has a significant impact on the second-hand vessel price, where the relationship is significant at the $p = 0.000$ level with an $r = 0.915$. These findings are consistent with McConville's (1999) argument: 'second-hand vessel price movement is usually between maximum and minimum limits with the price of new ships acting as a constraint on the upper limits and the scrapping price acting as a floor of the second-hand ship price'.

Our results showed that there are several determinants for shipping firms to adjust their fleet size. A regression equation is formulated to predict fleet size in this study. Our equation indicates that fleet size is positively related to seaborne trade. Seaborne trade positively affects fleet size indicating that change in demand for sea transport is an important determinant for shipping firms to adjust their fleet size. Additionally, freight rate is an important factor that motivates shipping firms to adjust their fleet size as our results indicate that higher freight rate will lead to larger fleet size. In this study, the regression equation contributes to predicting fleet size, and explains seaborne trade volume as a key determinant that affects fleet size in the bulk shipping market.

Implications of this study are twofold. From an academic perspective, we have identified the factors that affect fleet size, freight rate and ship prices in the bulk shipping market and examined exchange functions in the factor and product markets as well. Our finding suggests that seaborne trade volume positively affects fleet size and freight rate. We found that determinants of fleet size include seaborne trade, freight rate and vessel scrapping price, but the impact from seaborne trade is the highest among these factors. This indicates that shipping firms will increase their supply of shipping service if their ships are able to fill up with the cargoes pending for sea transport. Compared with revenue derived from freight rate, cargo volume is more important in affecting the decision to adjust the fleet size in bulk shipping. In affecting the decision to adjust their fleet size, cargo demand is more influential than revenue generated from the freight market. Ship owners tend to increase their capacity when extra space can be filled while the revenue is not as important as cargo volume. It implies that the primary objective in managing shipping operations is business growth while monetary return is important but the priority is not as high as an increase in shipping service capacity.

This study provides an insight into the relationship between seaborne trade and freight rate, and examines how the freight market, new building market, second-hand market and demolition are related to each other. Additionally, this study also provides an equation to predict fleet size and explains the factor (i.e., seaborne trade) that determines fleet size. It advances knowledge for shipping managers to understand the relationship between seaborne trade and fleet size. Furthermore, our findings indicate that both new building ship price and scrapping price are determinants of second-hand ship price. This implies that new ship building is important in the bulk shipping market even if the new ship building price is regarded as sub-optimal because of the possibility of government subsidisation. Our empirical model can be used as a tool for shipping mangers to predict fleet size in the shipping industry. It also provides a reference guiding shipping mangers to make appropriate decisions in adjusting fleet size as well as buying and selling ships in different shipping markets.

The limitations of this paper can be viewed in terms of both methodology and scope. Methodologically, the data we used to test the hypotheses were based on secondary sources. Although data from 1990 to 2005 were collected, there is a lack of information to triangulate the data accuracy. With a focus on developing an empirical model in the bulk shipping market, the scope of this study could be extended to include development of theoretical concepts in shipping management. For instance, two of the key findings of this study are: 'compared with revenue derived from freight rate, cargo volume is more important in affecting the decision to adjust fleet size in bulk shipping' and 'the impact on the product market is more important than that on the factor market in determining fleet size'. It is desirable for further studies to investigate the causes and consequences of such scenarios in the shipping market and develop strategic theories in shipping management to fill this research gap in the shipping literature.

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