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The impact of freight rates on ship values: An investigation of major dry bulk carriers

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Abstract

Many factors affect ship values, but the most important is freight rates. This effect is more dynamic, especially in the dry bulk market, which has characteristics close to a perfectly competitive market. The literature does not provide a complete answer about whether the effects of freight on ship values differ by ship type and age in the market; therefore, this study examined the effect of changes in the freight rates of the main ship types used in the dry bulk market on their values in different age groups. The ship types included in the study are Capesize, Panamax, and Handymax vessels, while the age groups are newbuilds, 5-year-old, and 10-year-old ships. Individual regression models were established and analyses were applied for each category. According to the obtained results, smaller vessels were more affected by changes in freight rates, and the effect of changes in freight rate increased with the age of the ship. Also, the price volatility of smaller ships was lower, while it was higher for older ships. It is hoped that these results may provide comparative results by ship type and guide industry stakeholders in reducing risks.

Introduction

When freight rates increase, shipowners may decide to expand their fleet by purchasing new or secondhand ships (Dai et al., 2015); however, ship purchases are very risky investments in the maritime industry because these assets are expensive. Additionally, the cycles experienced in the maritime market can cause the values of the ships to sometimes exceed their purchasing costs and sometimes fall far below expected selling prices (Stopford, 2009, p. 265). Secondhand ship values not only reflect past construction costs but also the possibility of making a profit under current and future market conditions (Lun & Quaddus, 2009). That is to say, secondhand prices are the weighted average of freight earnings in the short term and long term (Strandenes, 1984); therefore, market expectations significantly shape secondhand ship prices.

The derived demand structure of the maritime markets and the shipbuilding process are effective in excessive fluctuation of secondhand prices, and this can also cause maritime transport to be immediately affected by developments in the world economy (Vermeulen, 2010, p. 856). Besides, as the construction process of the ship can vary between 1 and 4 years on average (Stopford, 2009, p. 157), the sea transportation supply in the short-term is inelastic (Chen et al., 2014, p. 64). Due to this structure, since increases in demand cannot be responded to immediately with new ships (Alizadeh & Nomikos, 2010, p. 325), there may be excessive increases in freight rates. These fluctuations in freight can also affect asset prices, especially secondhand prices;

however, although cargo types are similar, ship types also have sub-markets with different characteristics, and this effect may differ. In fact, this may differ according to the age and type of ship. As far as the authors know, this important research question has not received attention in the literature. In this regard, the purpose of this study is to determine whether the effects of freight on ship values differ by the age group for different ship types. To examine possible differences, due to data availability, we considered three ship types used for dry bulk shipping: Capesize, Panamax, and Handymax. By econometrically analyzing the relationships between the freight levels in each market and in new-build, 5-year-old, and 10-year-old ships, we have demonstrated differences between the coefficients of the age groups of the related ships. As a result of the research, we revealed that freight rates had different effects on the values of ships in different age groups.

To outline our study, we reviewed studies of secondhand and newly-built ships in the second section. Information about the dry bulk market and the types of ships used in this market is explained in the third section. The dataset that we collected for our analyses is introduced in the fourth section. After describing the method we used in the fifth section, the analysis results are presented in the sixth section. Finally, an evaluation and discussion of the results are included in the last section.

Theoretical background and literature review

While drawing the theoretical framework, it may be useful to consider the subject from two angles: (i) the effect of age on the costs of ships; (ii) the effect of freight rates on the value of a ship. By examining the effect of age, we will attempt to explain the effect of age on the choice of ships, and by examining the effect of freight, we will try to explain the effect of freight on ship values.

As with all other assets, when the age of a ship increases, maintenance costs increase, and the asset value decreases since its economic life decreases (Gültekin et al., 2021). Additionally, as the age increases, the physical condition of the ship also decreases, so the insurance costs increase. Moreover, the fuel consumption of new ships is lower since the engine technologies of new ships are more advanced (Harwood, 2008, p. 70). Since the biggest operational cost is the fuel cost, this difference provides a significant cost advantage to new ships. Older ships may also require more spare parts and more crew members (Alizadeh & Nomikos, 2009, p. 43). The ratio of operating costs to all costs is 18% for a 5-year-old ship and 33% for 20-year-old ships, and the ratio of voyage costs to all costs is 33% for 5-year-old ships and 40% for 20-year-old ships. For these reasons, transportation costs per unit are higher in older ships. Alternatively, since old ships are cheaper, their capital costs are also lower (Stopford, 2009, p. 222).

It will be useful to show changes in the value of a ship over time using an example in terms of book value and market value. This example was developed by Stopford (Stopford, 2009, p. 265) and illustrated using the value of a new dry bulk carrier purchased in 1996. In this example, we used the assumptions that there is a depreciation of 5% in the value of the ship each year and that there is an inflation of 3% each year. In this framework, the value of the ship after 10 years (corresponding to 11 in the graph) has been examined in Figure 1. The book value variable in the figure was obtained by deducting the 5% depreciation from the purchase price of the ship, which is $28 million. After 10 years, the book value dropped to $14 million. The inflation value, on the other hand, showed that the book value decreased according to the value of a new ship after 10 years, under the assumption of 3% annual inflation. Since the value of a new ship increased to $37.63 million this year, the book value of the ship was determined to be $18.8 million dollars calculated based on this value. In other words, the book value of the ship on that date can be expressed as this value since the prices of newly-built ships increased; however, since the maritime market is cyclical, trading at book value does not always work. As has been witnessed many times in the past, these values can climb to very extreme highs or decrease to minima. In past periods, there were also periods when the market value was 70% below or 70% above the book value. In this context, when the ship is 10 years old, its value may be $32 million if the market is at the top of the cycle, or $5.6 million if the market is at the bottom of the cycle. If the market is at its highest, the value of the ship may even exceed the cost of acquiring it. In this respect, it is vital for ship investors to closely follow the cycles and do the right business decisions at the right time. A representation showing the cyclic fluctuation between the lowest and highest ship prices is shown in Figure 1.

When examining the studies in the literature, the factors affecting ship values include freight rates, age, ship size, fuel prices, newbuilding prices, orderbook size (Pruyn, Van De Voorde & Meersman, 2011),

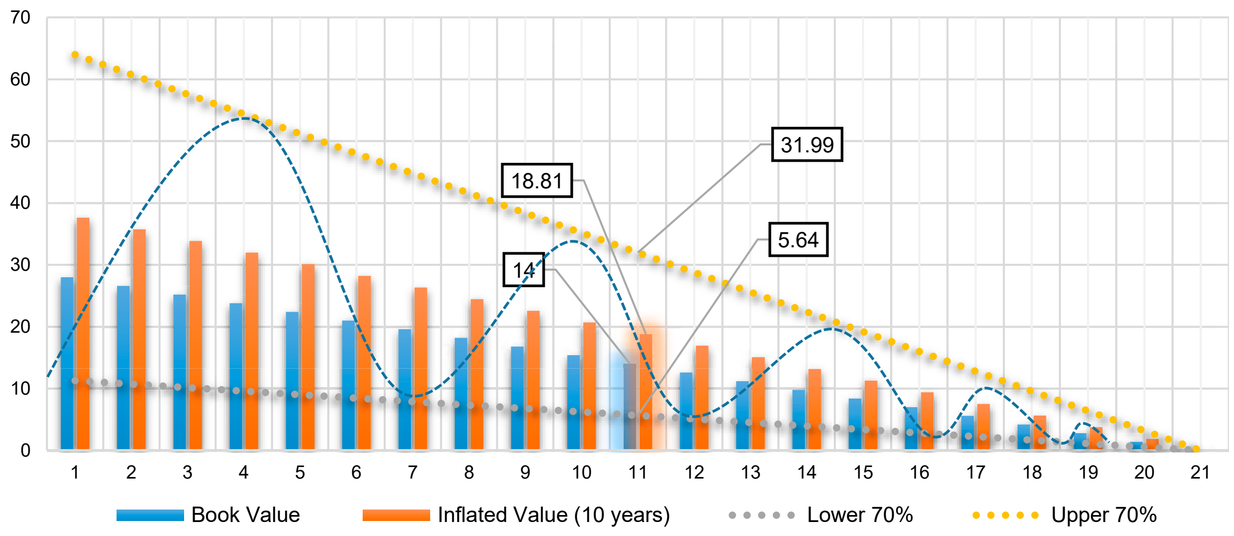

Figure 1. Difference between Book and Market Values

commodity prices (Başer & Açık, 2019), interest rates (Beenstock, 1985; Youngjae & Hyunsok, 2016), and trading volumes (Alizadeh & Nomikos, 2003; Syriopoulos & Roumpis, 2006). Among these factors, the variable that affects ship values the most is freight levels. Because freight rates are the main source of income for shipowners, when shipowners see high-income opportunities, they want to increase their carrying capacity. To do this, they purchase ships. In this respect, there is a strong interaction between freight rates and the demand for ships, and therefore ship prices. There are periods when ship prices increase more than expected. Especially in these periods, sales transactions conducted by shipowners can provide them with great profit opportunities. In this respect, in a study by Açık and Başer (Açık & Başer, 2018), price bubbles were first determined for 5-year-old Panamax-type dry bulk cargo ships. These bubbles represent positive deviations from the expected price. Then, they analyzed the probability of an increase in freight rates to form a bubble in secondhand ship values. According to the results, a 1000-point increase in BPI (Baltic Panamax Index) increased the probability of a price bubble by 11%. This result reveals that strong increases in freight rates can cause significant price bubbles in secondhand ship prices. In addition to the relationship between freight and secondhand ships, increasing secondhand ship prices may positively affect freight rates. As the capital costs of acquiring ships increase, the freight rates demanded by shipowners may also increase. Or the secondhand values may be priced before freight rates, as secondhand prices are shaped according to future market expectations. Shipowners demand ships by considering current and future income opportunities. Examining this relationship, Açık and İnce (Açık & İnce, 2019) examined the relationship between freight and ship values for the Capesize market. The bidirectional causality relationships between the freight index and the 5 and 10-year-old ship values were determined in the analysis results using the variables of Capesize index, newbuild, 5-year-old, and 10-year-old ship values. However, there was a one-way relationship between freight and newbuild price. In other words, there was no impact from newbuild prices on the freight rates. The same finding was confirmed by Xu et al. (Xu, Yip & Liu, 2011), who determined a positive relationship between freight and newbuild prices. They also found that freight rates are more sensitive to market developments than newbuild prices. Based on the research question – which factors affect the volatility of newbuild prices – Dai et al. (Dai et al., 2015) showed that the factors affecting the volatility in newbuild prices were volatilities in freight rates, secondhand prices, exchange rates, and shipbuilding costs. Nevertheless, newbuild prices are still more stable than secondhand prices because the newbuild process takes an average of 2 years (Adland & Jia, 2015).

One of the main differences between the ships subjected to our research is their size. In this respect, the ship size may also affect their value. Kavussanos (Kavussanos, 1997) examined whether the size of dry bulk carriers affected their price volatility. In their analysis, they used ARCH modeling to show that the price volatility of small ships was higher than that of large ships. The reason for variations in volatility by size may be due to differences in the sale & purchase volume of ship types traded in the markets. In this respect, it may be useful to examine transaction volumes according to ship types.

In the literature, studies have examined the effect of general sale & purchase transaction volume on the secondhand price volatility. Alizadeh and Nomikos (Alizadeh & Nomikos, 2003) examined this relationship in the dry bulk market, while Syriopoulos and Roumpis (Syriopoulos & Roumpis, 2006) examined both the dry bulk and tanker market. In parallel, the researchers found that the trading volume in the markets had a negative effect on price volatility. In other words, increasing transaction volumes in the market supported price stability.

As in Stopford's (Stopford, 2009, p. 265) example, newbuild values may affect secondhand ship values, as they are subject to inflationary effects from construction material costs. Rises in newbuild costs can reduce demand and increase the demand for secondhand ships. Kou et al. (Kou, Liu & Luo, 2014) examined this question empirically by examining the lead-lag relationship between both dry bulk and tanker markets. The results showed that the relationships between the two markets were different, possibly due to competition and business structuring. In the dry bulk market, the value of secondhand ships led the newbuild values, while in the tanker market, the value of newbuild ships led the secondhand ship values. Market cycles in the tanker market are somewhat weaker, as the demand for tanker vessels is mainly related to oil, and ships are sometimes used as storage (Başer & Açık, 2018). In this respect, the effect of cycles in secondhand ship prices may be weaker than in the dry bulk market because the dry bulk market meets the conditions for perfect competition, and its dynamics are faster.

The first factor affecting the value of ships is their demand, which is mainly affected by the demand for the cargo they carry and the interest rates in the market. In terms of cargo, as the need for transportation increases with demand, the demand for ships that specialize in the relevant cargo also increases. Here, as the freight level in the market also increases, secondhand ship values may also increase. Although the relationship between cargo carried and ship value is indirect in this way, the direct relationship between them was empirically investigated by Başer and Açık (Başer & Açık, 2019). Since Capesize ship types specialize in iron ore transportation and 70–80% of this fleet is used to transport iron ore around the world, researchers have studied the relationship between ore price and 5-year-old Capesize value. The results showed that positive shocks in ore prices caused positive shocks in ship values, while negative shocks caused negative shocks in ship values. Accordingly, commodity prices, which change in line with increasing/decreasing demand, were reflected in the value of secondhand ships. Alternatively, as interest rates affect capital costs, they can affect the demand for secondhand ships. When interest rates rise, both ship acquisition costs may increase, and investors who intend to purchase ships can place their capital in investment instruments with higher returns. In this respect, it can be expected that the effect of interest rates may be negative. In this subject, in the empirical study by Youngja and Hyunsok (Youngja & Hyunsok, 2016), the effect of freight and interest rates on ship prices was examined. While the researchers determined the effect of freight as positive, they determined the effect of interest as negative.

When examining the literature within the framework of our study, there is a literature study examining the interaction between ship size and price volatility (Kavussanos, 1997), but no study has examined the relationship between a ship's age and the freight rate and ship value. It has been examined and confirmed in many theoretical and empirical studies that the contribution of freight rates to the values of the ships is positive. Additionally, in ship valuation studies, the current freight level in the market has been considered to be an important variable for ship valuation. However, at this point, the question arises whether the effect of the freight rate on different age groups of the same ship type differs or not. As the capital costs of ships of different age groups differ greatly, the demand for these ships may differ in different market conditions, which may have different relationships with freight levels in the market. Also, for players dealing with ship trading, older, less-expensive ships may offer greater opportunities in terms of capital efficiency. Within the framework of this research question, we chose three vessel types from the dry bulk market: Capesize, Panamax, and Handymax. Although their technical and commercial properties differ, their size makes a significant difference among them. Using the variables of newbuild, 5-year-old, and 10-year-old values of these ship types, we analyzed their relationship with freight rates using econometric methods. We increased the validity of our results by analyzing three different ship types for the same research question. Additionally, we analyzed whether there is any variation due to their size.

Main vessels in dry bulk transportation

Nearly 90% of world trade in terms of tonnage is carried out by ships (Rodrigue, 2013, p. 28). These transported cargoes are divided into various categories such as containerized, general, bulk, hazardous, and petroleum (Rowbotham, 2014, p. 9).

Dry bulk cargo transportation has a critical function in the global economy. It provides information about the current and future economic situation (Lawson, 2008, p. 2; Langdana, 2009, p. 94; Şahin et al., 2018), as this is how the raw materials for the production of future final products are transported (Geman, 2009, p. 191; United Nations, 2009, p. 35). The seaborne cargo carried around the world and the share of major dry bulk cargoes are presented in Figure 2. Tanker-type cargoes include crude oil, refined petroleum products, gas, and chemicals; major bulk cargoes include iron ore, grain, and coal; other dry bulk cargoes include minor bulks, containerized trade, and residual general cargo. Dry bulk cargo increased in the period considered. Although the highest rate was realized in 2014 (30%), there has been a constant increase of 29% for a long time, which is almost an indicator of the stagnant economy in recent times.

The choice of the type, size, and speed of the ship used to transport cargo is determined by various factors: the type and amount of cargo, voyage time and route characteristics, port facilities and cargo-handling equipment, infrastructure status of the country, and service frequency and competition status (Buxton, Daggit & King, 1978, p. 283). By considering these factors, the dry bulk cargo fleet has been formed because of cumulative investments made by the owners of ships to be used in commodity transportation. The dry bulk cargo fleet accounts for 42.6% of the transport capacity of the global fleet in 2019, giving the dry bulk market an important position in the world maritime trade (UNCTAD, 2019b). Vessel types in the dry bulk shipping market are classified based on their sizes as Handysize (20,000–35,000 DWT), Handymax (35,000–45,000 DWT), Supramax (45,000–55,000), Panamax (60,000–75,000 DWT), and Capesize (80,000–300,000 DWT) (Alizadeh & Nomikos, 2009, p. 30). These ship types are specialized for some types of cargo, considering the factors expressed by Buxton et al. (Buxton, Daggit & King, 1978, p. 283). For example, Capesize ships are specialized for transporting iron ore over the ocean, Panamax ships in transporting coal, and Handymax ships in transporting wheat and coal. In this respect, these ship types differ both in size and in the markets they serve. In our study, we examined whether these differences caused a difference in the rates of freight effects on the values of different age groups.

Methodology

Since our aim in this study was to examine the impact of changes in freight rates according to different ship types and different age groups, we used linear regression analysis. In our research, we modeled the market of three major ship types in dry bulk transportation: Capesize, Panamax, and Handymax. We used the newbuild, 5-year-old, and 10-year-old values of these ship types as the dependent variable, and the freight rates of these ship types as the independent variable.

Regression analysis is a popular method that is widely used in many areas such as sociology, geology, medicine, engineering, economics, marketing, management, agriculture, etc. (Yan & Su, 2009, p. 4). This analysis method estimates the value of a variable by using the values of one or more variables (Allen, 2004, p. 3). It is a useful tool for identifying functional and theoretical relationships

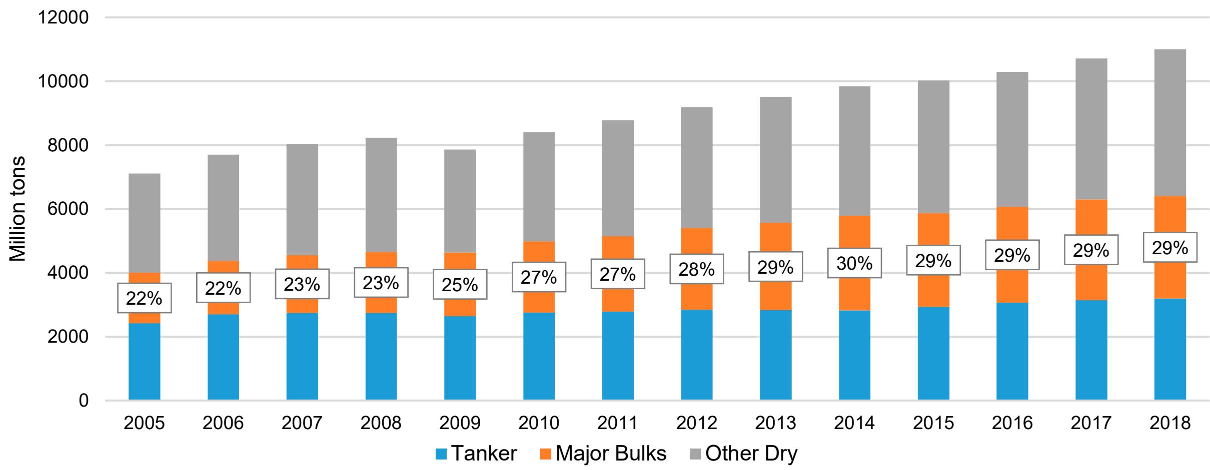

Figure 2. World maritime trade (UNCTAD, 2019a)

between variables (Chatterjee & Hadi, 2015, p. 1). Although there are many different types of this method, we chose to use simple linear regression analysis that is suitable for our study, which can be expressed as:

$$Y = \beta_0 + \beta_1 X_1 + \varepsilon \quad (1)$$

In this equation, Y represents the dependent variable, X the independent variable, and ε represents the unexplained parts of the model, which is the difference between actual Y and estimated Y (Darlington & Hayes, 2017, p. 17). Since Eq. (1) contains only one independent variable, it is defined as a simple linear regression analysis (Gaurav, 2011, p. 3). Of course, more than one independent variable should be used in some models according to their usage areas and purposes. If more than one independent variable is used, such models are called multiple regression analysis (Allen, 2004, p. 4). According to the results obtained after the model was estimated, we can obtain information such as whether the model and independent variables are significant, the model's explanatory power, and the interaction degree between variables. We can interpret the interaction between variables through the variable β, which reveals how much one unit of change in the independent variable changes the dependent variable and whether the effect is positive or negative (Esquerdo & Welc, 2018, p. 2). Since there is more than one independent variable in multiple regression models, the obtained β values also provide information about the differences between the effects of each independent variable (Archdeacon, 1994, p. 148).

Following the estimation of the model, the validity of the model should be verified by applying other tests to its residuals related to several assumptions. These are: the conditional mean of ε is zero, coefficient constancy, serial independence in disturbances of ε, and a normality assumption in the distribution of ε (Pagan & Hall, 1983). These assumptions are important for the validity of the model (Menard, 2002, p. 5), but if any of them are not met, the model coefficients can be interpreted by applying correction methods to the standard errors.

The model we estimate using ordinary least squares method in our analysis is presented in Eq. (2). The value of ships in different age groups was used as the dependent variable, and the freight index of that ship type is used as the independent variable. Thus, nine estimates were made, including three regression equations for each ship type. In our study, analysis was performed by taking the logarithms of the data. Thus, the percentage-based response of ship values to a 1% change in freight price can be obtained and comparisons between coefficients can be made more easily.

$$\ln SV_t = \ln\beta_0 + \beta_1 \ln(\text{FREIGHT}_t) + \varepsilon_t \quad (2)$$

where SV is the ship value and FREIGHT is the freight index related to the ship type.

We used the log-log regression model to easily make comparisons between the coefficients obtained from the estimates; thus, it can be determined which age group is more or less affected by changes in freight rates. Based on the literature and our knowledge, we hypothesized that ships whose value is lower than others may be more affected by changes in freight rates. Since the value of a ship is directly proportional to its size and inversely proportional to its age, smaller ships and older ships are expected to be more affected. Because the capital costs are lower than the others (Stopford, 2009, p. 222), the demand for these ships may be higher in possible market revivals. Of course, many variables affect a ship's value. While variables such as steel cost, labor cost, exchange rate, capital cost greatly affect newbuild ships, variables such as the physical condition of the ship, equipment features, and engine technology have a greater effect (in addition to similar variables) on secondhand ships. While looking for an answer to our research question, we assumed that all these variables were constant, and we only investigated the effect of freight on ship values in different age groups.

In the next section, the variables of the three ship types we used in our analysis, freight, newbuild, 5-year-old, and 10-year-old value variables are examined and introduced.

Data

The data used in this study were obtained from the Bloomberg (Bloomberg, 2018) data platform. As freight rate variables, the Baltic Capesize Index (BCI) for the Capesize market, Baltic Panamax Index (BPI) for the Panamax market, and Baltic Supramax Index (BSI) for the Handymax market were used. The Handymax ship category also includes Supramax vessels. The ship values were also obtained from the Bloomberg (Bloomberg, 2018) data platform, and its unit is a million dollars. Newbuild values are based on Japanese-ordered ship prices. If the 15, 20, and 25-year-old ship values could have been obtained, the analysis would have been more comprehensive, but we could not find these data due to limitations.

Table 1. Descriptive statistics of the Capesize market (Bloomberg, 2018)

	Index	NB	5Y	10Y	R IND	R NB	R 5Y	R 10
Mean	3381.0	55.4	48.0	35.5	0.005	0.001	0.001	0.002
Median	2245.0	51.0	36.1	26.4	0.0213	0.000	0.000	0.000
Maximum	18749.0	105.0	153.5	127.0	1.419	0.116	0.273	0.334
Minimum	174.0	36.0	21.0	12.0	–1.512	–0.095	–0.720	–0.732
Std. Dev.	3076.0	16.8	29.8	25.5	0.35	0.02	0.07	0.08
Skewness	2.20	1.29	2.05	2.15	–0.30	0.49	–3.69	–2.59
Kurtosis	8.42	4.39	7.01	7.42	5.83	7.32	40.7	26.6
Jarque-Bera	466.5	82.6	314.5	363.0	79.7	187.4	14090	5548
Probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	229	229	229	229	228	228	228	228

Descriptive statistics of the variables of Capesize-type ships are presented in Table 1 as both raw and return forms. The dataset covers the period between July 1999 and July 2018 and consists of 229 monthly observations. When the skewness of the return series was analyzed, it can be said that the effects of negative shocks, especially the 5 and 10-year-old ship values, are high in the period under consideration. Additionally, the effect of negative shocks was partially higher in the freight index and positive shocks have a higher impact on newbuild prices. When the volatilities of the variables are investigated by the ratio of standard deviation to the mean, the volatility of freight was 91%, the volatility of newbuild was 30%, the volatility of a 5-year-old ship was 62%, and the volatility of a 10-year-old ship was 72%. Here, the volatility increases as the age of the ship increases.

The values of descriptive statistics of Panamax-type ships are presented in Table 2. The dataset covers the period between July 1999 and July 2018 and consists of 229 monthly observations. When the skewness of the return series was examined, the effects of negative shocks were much greater for 5 and 10-year-old ships, similar to Capesize ships. When the volatilities of the variables were investigated, the volatility of freight was 89%, the volatility of newbuilds was 27%, the volatility of a 5-year-old ship was 60%, and the volatility of a 10-year-old ship was 69%. Here, as in the Capesize dataset, the volatility increased as the age of the ship increased.

Descriptive statistics for Handymax-type vessels are presented in Table 3. The dataset covers the period between August 2005 and July 2018 and consists of 156 monthly observations. When the skewness of the return series was analyzed, it is seen that the effects of negative shocks for 5 and 10-year-old ships were high in the period under consideration. The effect of positive shocks was higher in newbuild values, but despite negative shocks in freight rates, their effects were small. By the ratio of the standard deviation to the mean, the volatility of freight was 81%, the volatility of newbuild ships was 21%, the volatility of a 5-year-old ship was 55%, and the volatility of a 10-year-old ship was 62%. Here, as in the Capesize and Panamax dataset, the volatility increased as the age of the ship increased.

Table 2. Descriptive statistics of the Panamax market (Bloomberg, 2018)

	Index	NB	5Y	10Y	R IND	R NB	R 5Y	R 10Y
Mean	2299.3	31.5	28.9	22.4	0.001	0.001	0.001	0.001
Median	1542.0	31.0	22.5	16.0	0.005	0.000	0.000	0.000
Maximum	11515	56.0	90.5	77.9	0.682	0.114	0.273	0.229
Minimum	287.0	20.0	11.0	6.03	–1.258	–0.101	–0.713	–0.543
Std. Dev.	2039.4	8.46	17.4	15.4	0.24	0.02	0.07	0.07
Skewness	2.04	0.92	1.95	1.93	–0.91	0.47	–3.84	–2.08
Kurtosis	7.32	3.72	6.68	6.71	7.02	7.27	40.3	15.9
Jarque-Bera	337.8	37.42	274.6	274.9	185.4	182.0	13815	1770
Probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	229	229	229	229	228	228	228	228

Table 3. Descriptive statistics of the Handymax market (Bloomberg, 2018)

	Index	NB	5Y	10Y	R IN	R NB	R 5Y	R 10Y
Mean	1706.4	31.1	28.2	22.0	–0.004	–0.000	–0.003	–0.003
Median	1102.0	30.0	24.9	19.0	0.020	0.000	0.001	0.002
Maximum	6949.0	48.0	75.50	64.7	1.094	0.100	0.149	0.176
Minimum	304.0	22.5	9.50	6.00	–1.543	–0.108	–0.552	–0.540
Std. Dev.	1387.1	6.55	15.64	13.72	0.22	0.02	0.06	0.07
Skewness	1.83	1.21	1.68	1.73	–1.63	0.25	–3.90	–2.86
Kurtosis	5.86	3.96	5.21	5.51	19.9	9.06	29.7	19.6
Jarque-Bera	140.8	44.42	105.4	119.4	1917	239	4999	1994
Probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	156	156	156	156	155	155	155	155

Results

The logarithms of all variables were taken before analysis because better distributions were obtained (Shahbaz et al., 2017). Additionally, this provided an easier comparison between ship types by estimating log-log regression models. The regression model used in the estimations of each ship type age group by the least-squares method is shown in Eq. (2).

Since the variables used in the regression analysis are time series, unit root tests should be applied. For this, the augmented Dickey-Fuller (Dickey & Fuller, 1979) unit root and Kwiatkowski-Phillips-Schmidt-Shin (Kwiatkowski et al., 1992) stationarity tests were applied to the series, and the results are presented in Table 4. According to the ADF test, the unit root null hypothesis could be rejected at the level only for the Capesize Index and Handymax 5-year-old ship variables. When the first differences in the variables were taken, the unit root null hypothesis was rejected for all variables. When the variables were examined with the KPSS test, the stationarity null hypothesis could not be rejected for all variables at the level. Here, analysis was performed by considering the results of this test and assuming that all variables were I (0).

After performing unit root tests for the variables, regression equations for each ship type's age categories were estimated separately. The results of the regression estimates for Capesize vessels are presented in Table 5. All estimated models and independent variables were statistically significant. The coefficient of the freight index was 0.20 for the newbuild model, 0.47 for the 5-year-old ship model, and 0.54 for the 10-year-old ship model. In general, it can be said that the effect increases as the age of the ship increases. Additionally, the R^2 values increased as the age of the ship increased. Due to the robustness tests performed on the residuals of the models, heteroscedasticity, autocorrelation, and non-normal distribution conditions were determined in all models. For this reason, the standard errors of the models were recalculated by applying HAC correction. As a result of this correction, both models and independent variables retained their significance.

The results of the regression models estimated for each age category for Panamax vessels are presented in Table 6. Both models and independent variables were statistically significant. The coefficient of the

Table 4. Unit root and stationarity test results

		Level		First difference	
		Constant	Intercept and trend	Constant	Intercept and trend
ADF	Cap Index	-3.50^{***}	-3.71^{**}	-14.95^{***}	-14.92^{***}
	Cap NB	–2.03	–1.97	-4.63^{***}	-4.64^{***}
	Cap 5Y	–2.20	–2.23	-8.61^{***}	-8.62^{***}
	Cap 10Y	–2.08	–2.14	-9.03^{***}	-9.03^{***}
	Pan Index	–2.56	–2.86	-13.76^{***}	-13.74^{***}
	Pan NB	–1.75	–1.74	-5.97^{***}	-8.33^{***}
	Pan 5Y	–2.10	–2.12	-8.61^{***}	-8.61^{***}
	Pan 10Y	–2.04	–2.10	-8.03^{***}	-8.03^{***}
	Han Index	0.25	–3.02	-11.17^{***}	-11.13^{***}
	Han NB	–1.20	–1.37	-7.42^{***}	-7.40^{***}
	Han 5Y	–1.47	-3.27^{*}	-6.71^{***}	-6.69^{***}
	Han 10Y	–1.66	–2.80	-6.34^{***}	-6.32^{***}
KPSS	Cap Index	0.52^{***}	0.30	0.11^{*}	0.09^{*}
	Cap NB	0.42^{**}	0.38	0.19^{*}	0.08^{*}
	Cap 5Y	0.38^{**}	0.37	0.14^{*}	0.06^{*}
	Cap 10Y	0.40^{**}	0.38	0.15^{*}	0.06^{*}
	Pan Index	0.63^{***}	0.29	0.04^{*}	0.03^{*}
	Pan NB	0.46^{***}	0.39	0.17^{*}	0.09^{*}
	Pan 5Y	0.39^{**}	0.38	0.13^{*}	0.06^{*}
	Pan 10Y	0.41^{**}	0.39	0.13^{*}	0.07^{*}
	Han Index	1.07	0.10^{*}	0.05^{*}	0.05^{*}
	Han NB	0.99	0.09^{*}	0.12^{*}	0.11^{*}
	Han 5Y	1.06	0.07^{*}	0.07^{*}	0.07^{*}
	Han 10Y	1.05	0.07^{*}	0.07^{*}	0.07^{*}

Null of unit root is rejected at ***1%, **5%, *10% for ADF test. Null of stationarity cannot be rejected at ***1%, **5%, and *10% for the KPSS test.

Table 5. Capesize regression model

Model	Cap NB	Cap NB R.	Cap 5y	Cap 5y R.	Cap 10y	Cap 10y R.
Freight Index	0.20 [0.000]	0.20 [0.000]	0.47 [0.000]	0.47 [0.000]	0.54 [0.000]	0.54 [0.000]
Constant	2.38 [0.000]	2.38 [0.000]	0.055 [0.790]	0.055 [0.904]	–0.84 [0.000]	–0.84 [0.080]
F Stat.	117 [0.000]	117 [0.000]	309 [0.000]	309 [0.000]	325 [0.000]	325 [0.000]
R^2	0.34	0.34	0.57	0.57	0.58	0.58
Adj. R^2	0.33	0.33	0.57	0.57	0.58	0.58
Durbin-Watson	0.11	0.11	0.31	0.31	0.32	0.32
Autocorrelation	Yes	–	Yes	–	Yes	–
Heterosc.	Yes	–	Yes	–	Yes	–
Normality (JB)	11.1 [0.003]		32.2 [0.000]	–	39.6 [0.000]	–
Wald *F* Stat.	–	24 [0.000]	–	62 [0.000]	–	78.5 [0.000]

Probabilities are shown in [ ].

Table 6. Panamax regression model

Model	Pan NB	Pan NB R.	Pan 5y	Pan 5y R.	Pan 10y	Pan 10y R.
Freight Index	0.18 [0.000]	0.18 [0.000]	0.50 [0.000]	0.50 [0.000]	0.60 [0.000]	0.60 [0.000]
Constant	2.06 [0.000]	2.06 [0.000]	–0.54 [0.009]	–0.54 [0.183]	–1.53 [0.000]	–1.53 [0.001]
F Stat.	88.5 [0.000]	88.5 [0.000]	333 [0.000]	333 [0.000]	360 [0.000]	360 [0.000]
R^2	0.28	0.28	0.59	0.59	0.61	0.61
Adj. R^2	0.27	0.27	0.59	0.59	0.61	0.61
Durbin-Watson	0.06	0.06	0.20	0.20	0.21	0.21
Autocorrelation	Yes	–	Yes	–	Yes	–
Heterosc.	Yes	–	Yes	–	Yes	–
Normality (JB)	4.28 [0.117]	–	77.4 [0.000]	–	101 [0.000]	–
Wald *F* Stat.		22.6 [0.000]	–	85.8 [0.00]	–	98 [0.000]

Probabilities are shown in [ ].

freight index used as an independent variable was 0.18 for the newbuild model, 0.50 for the 5-year-old ship model, and 0.60 for the 10-year-old ship model. For these ship types, the coefficient increased as the age of the ship increased. Additionally, the R^2 values increased with the age of the ship. HAC correction was applied because heteroscedasticity, autocorrelation, and non-normal distributions were detected in the residuals of the models. There was no change in the significance of either the model or the independent variable in Robust models after correction.

The regression models estimated for the Handymax ship type are presented in Table 7. Both models and independent variables were statistically significant. According to the coefficients of the freight index, there is an effect of 0.21 in the newbuild model, 0.60 in the 5-year-old ship model, and 0.68 in the 10-year-old ship model. As with other ship types, an increased effect was observed with increasing age.

Table 7. Handymax regression model

Model	Han NB	Han NB R.	Han 5y	Han 5y R.	Han 10y	Han 10y R.
Freight Index	0.21 [0.000]	0.21 [0.000]	0.60 [0.000]	0.60 [0.000]	0.68 [0.000]	0.68 [0.000]
Constant	1.89 [0.000]	1.89 [0.000]	–1.13 [0.000]	–1.13 [0.004]	–2.01 [0.000]	–2.01 [0.000]
F Stat.	181 [0.000]	181 [0.000]	462 [0.000]	462 [0.000]	453 [0.000]	453 [0.000]
R^2	0.54	0.54	0.75	0.75	0.74	0.74
Adj. R^2	0.53	0.53	0.74	0.74	0.74	0.74
Durbin-Watson	0.17	0.17	0.34	0.34	0.33	0.33
Autocorrelation	Yes	–	Yes	–	Yes	–
Heterosc.	Yes	–	Yes	–	Yes	–
Normality (JB)	651 [0.000]	–	458 [0.000]	–	380 [0.000]	–
Wald *F* Stat.		40.5 [0.000]	–	134 [0.000]	–	118 [0.000]

Probabilities are shown in [ ].

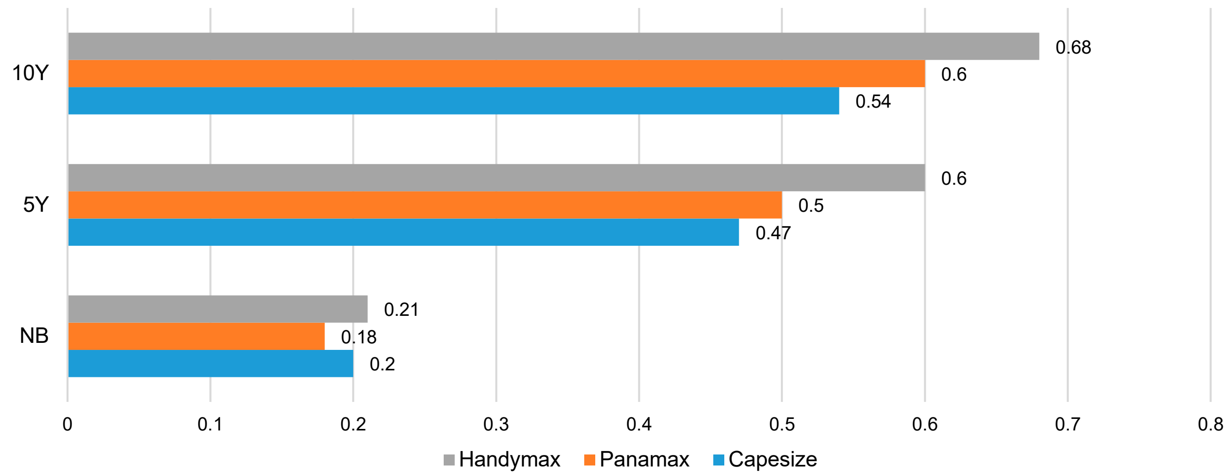

Figure 3. Comparison of the coefficients

Additionally, the R^2 value increased with the ship age. Since heteroscedasticity, autocorrelation, and non-normal distributions were detected in the models due to the tests performed on residuals, HAC correction was applied, and Robust models were obtained.

The coefficients obtained from the models are presented in Figure 3 to provide a better evaluation. Since the variables are in logarithmic form, they can be interpreted as percentage values of responses corresponding to a 1% change in freight rates. For the newbuild values, a 1% change in freight rates resulted in Capesize ships reacting by 0.20%, Panamax ships by 0.18%, and Handymax ships by 0.21%. For the 5-year-old ship, a 1% change in freight rates caused a reaction in Capesize ships by 0.47%, Panamax ships 0.50%, and Handymax ships 0.60%. Lastly, for 10-year-old ships, a 1% change in freight rates caused Capesize ships to react by 0.54%, Panamax ships 0.60%, and Handymax ships 0.68%.

Discussion

In this study, we evaluated the relationship between freight rates and ship values by using freight, newbuild ship, and secondhand ship values. We made general inferences by examining this effect in different-sized ship types and different age groups and comparing them with each other. We chose Capesize, Panamax, and Handymax ship types, which are widely used in the dry bulk market, and we used the freight indices representing the freight rates in the market for each ship type. When we examined the variables in the dataset in terms of volatility, the volatilities in freight rates were 91% for Capesize, 89% for Panamax, and 81% for Handymax; the volatilities in newbuild values were 30% for Capesize, 27% for Panamax, and 21% for Handymax; the volatilities in 5-year-old values were 62% for Capesize, 60% for Panamax, and 55% for Handymax; the volatilities in 10-year-old values were 72% for Capesize, 69% for Panamax, and 62% for Handymax. These results also coincide with the results of the analysis made by Kavussanos (Kavussanos, 1997), which indicates that smaller ships experience less price volatility. Additionally, newbuild prices are less volatile than secondhand prices, as determined by Adland and Jia (Adland & Jia, 2015). Another finding from these results is that as the age group increases, the volatility increases. From another viewpoint, in our research, we modeled the values of ships in different age classes with the freight index in the relevant market using simple linear regression analysis.

We can evaluate the results we obtained from two angles; in terms of size and in terms of age. When we evaluate in terms of size, it can be said that changes in freight rates affect the small-sized vessels much more. For example, the coefficients of Handymax ships were the highest among all age groups. Panamax ships, on the other hand, have a higher coefficient of secondhand values than Capesize ships, except for the newbuild value. Capsize newbuild value may be higher than that of Panamax due to the statistical method, data quality, or market structure; however, it would not be wrong to state that small-sized ships are generally affected more, possibly due to fleet size or targeted cargo type. Volatility may be higher because larger fleets of smaller ships have more ship sales and purchase transactions. Capesize ships are the most inelastic type of ship in terms of cargo selection. Approximately 70–80% of the fleet is used for iron ore transportation (Chen et al., 2014). Since this market depends on a constant cargo type, it may have less flexibility. Other smaller ships have much more cargo selection options such as grain, coal, bauxite, etc.

When we examine the results in terms of ship age, it is seen that the response of older ships to freight is higher for all ship types. The response of newbuild values has the lowest coefficients. Also, the R^2 values of newbuild models are low. This shows that factors other than freight are also effective in determining shipbuilding values. An example of this factor is steel costs. The reason why older ships are more affected by changes in freight may be their lower prices, which may cause greater demand for them. When the volatility rates were analyzed, we found that older ships had more volatile prices. An answer can be found by looking at the ratio of the average prices of 5 and 10-year-old ships to the average newbuild price. In the Capesize market, 5Y/NB is 86.6% and 10Y/NB is 64.1%; in Panamax market, 5Y/NB is 91.7% and 10Y/NB is 71.1%; in Handymax market, 5Y/NB is 90.7% and 10Y/NB is 70.7%. As can be seen from the rates, there is a difference of about 20% between 5Y and 10Y values, which may cause greater demand for 10-year-old ships due to their cost advantages.

These results can be useful for investors who are engaged in ship sales and purchases. According to our results, the volatility of 10-year-old ships and their degree of exposure to freight rates are higher than other age groups. This situation also shows that capital efficiency is higher in older ships. For players who want to make a profit with ship sales and purchases, this generates great income opportunities. Although this situation brings high risks, it also opens the door to large profit opportunities. For investors who want to avoid risk, 5-year-old ship investments can be seen as more advantageous; however, considering the 20% difference in value between them, focusing on resource sharing for older ships may provide more profit opportunities. Additionally, considering the depreciation with respect to the newbuild price, it is seen that Capesize ships experienced the greatest depreciation, while Panamax ships experienced the least. By taking these factors into consideration, the loss of value resulting from monitoring cycles in the market and waiting for the appropriate time to sell can be analyzed better.

Conclusions

In the literature, freight rates are considered as one of the most effective factors for ship values, and empirical analysis has been applied in this direction. Additionally, it has been investigated whether there is a difference in the effect of freight rates on the values of ship types in different markets; however, no studies have investigated whether the effect of freight rates on different age groups of the same ship type differs. As the values and capital costs of the ships are largely affected by their age, there can be large variations in demand for ships according to the freight level in the market. In this context, we established our hypotheses, considering that changes in freight rates will have a greater effect on the demand for older ships and, therefore, their response to freight will be higher due to the lower values of older ships. Additionally, tested whether the relationship differs according to the size of the ship by applying our analysis to three different ship types operating in the same market. In the results we obtained by applying econometric analysis, we found that the effect of freight varied according to the age of the ships and that older ships were more affected by changes in freight rates. We also found that smaller-tonnage vessels were more affected by changes in freight rates. In this respect, we took the literature one step further and led to different research questions.

The inaccessibility of age-related data is the biggest limitation of this study. We could only obtain data for newbuild, 5-year-old, and 10-year-old ship values, but dry bulk cargo ships can be 25–30 years old. We could not obtain data for ships more than 10 years old. If these data can be included in future studies, more comprehensive and satisfactory results can be obtained. Additionally, we applied this research only to the dry bulk market. Intermarket comparisons can also be made by analyzing vessels engaged in tanker and container transport.

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