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THE EFFECT OF FREIGHT RATES ON ASSET PRICE BUBBLES IN DIRTY TANKER MARKET

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Abstract:

Dirty tanker shipping is one of the most important parts of the international crude oil supply chain. So, it contains a large number of players and the market is very volatile. Therefore, making commercial decisions at the right time is very important both in terms of providing exceptional profits and holding on in the market. One of the market that this correct timing is most important is the second hand market, as the million-dollar fluctuations in the prices can be realized in a short time. The main determinant of the second-hand price is the freight levels in the market. Thus, it is very important to understand the interaction between the two variables. In this framework, in this study, it is aimed to determine the price bubbles in the second hand tanker prices and to determine the effect of the change in freight rates on the probability of price bubble formation. Generalized sup augmented Dickey-Fuller (GSADF) test is used for price bubble identification and logit regression model is used for probability calculation. Second hand tanker prices consist of VLCC, SUEZMAX and AFRAMAX tanker types, while the freight rates are based on the Baltic Dirty Tanker Index (BDTI). The data consist of 240 observations on a monthly basis covering the dates between August 1998 and July 2018. The results reveal that the increase in freight rates in the dirty tanker market by 1 unit (1000 points) increases the probability of price bubble formation by 80%, 70% and 55% respectively in 5 years old VLCC, SUEZMAX and AFRAMAX tanker prices. It is hoped that these results contribute to the existing maritime economics literature by approaching the subject from different perspective. In addition, it is considered that it is beneficial for the players in the market to take these results into consideration in their investment decisions in line with their targets.

Key words:
Dirty tanker market, Freight rates, Second hand ship value, Price bubble.

INTRODUCTION

Crude oil is commonly considered to be one of the most substantial commodities leading the global economic activities [1]. However, as in all other natural resources, this resource is also distributed throughout the world in random regions. Transportation between these regions can be carried out by sea, land and pipelines. The most common way of transporting is carried by sea, which is the most widely used and freed from political dependence by providing flexibility in energy imports. It constitutes about 18% of the tonnage of the transport made in 2016 [2].

The types of ships designed to carry out oil transportation operations are tanker ships which transport the commodity between producer areas and consumer markets [3]. The imbalance between supply and demand in various areas of the world is substantially eliminated under favour of tanker shipping. So, it plays an important role in the international supply chain [4]. Even tankers are so large that they are often used as oil stores. For instance, in the process that started in 2013, when oil prices fell to $ 30, most tankers were used to stock crude oil [5]. Because such a decline in oil prices was a rare occurrence during the history and this opportunity should have been evaluated. As a matter of fact, oil prices have risen after those years and now they are at $70 levels.

Global shipping markets are generally divided into four; freight market, sale and purchase market, new-building market and demolition market [6]. These each market has its own characteristics, but they all interact with each other at the same time. Therefore, tankers shipping has also four sub-markets. The main motivation of maritime transport is to obtain transportation revenue and the freight market affects all other markets.

Freight rates are formed by equilibrium between supply and demand in the maritime market [6]. This is similar in all other sectors, but the maritime market has some different characteristics. The main reason for this is that the ships used in transportation activities are very large structures, and their construction period is long and their operating costs are very high. The ordered ships can be delivered within two years on average, depending on the density of the shipyards. Therefore, the response of the completed vessel tonnage to the changes in freight is two years delayed [7]. This situation makes the ship supply inelastic after a certain point in the short run. That is, even if the demand continues to increase, the carrying capacity in the market cannot be increased. Therefore, even a small increase in demand causes incredible increases in freight rates [8]. The increase in demand for maritime transport may be due to the economic recovery or the increase in the demand for the ship's load. For example, the extreme fall in oil prices, which started in 2013, has increased the demand for VLCC type tankers. Time charter rates increased from $19.000 to $55.000, and second hand values increased $55 million to $84 million in three years [9]. As is seen, this inelastic condition causes very large fluctuations even in a short time. Due to the time-to-build effect encountered by the reason of shipbuilding time [10], second-hand ship prices are more volatile than new build prices [11]. Therefore, the second hand market is more active and liquid.

The most important factor affecting the second hand vessel price is the freight rates and understanding the mechanism between the two provides extraordinary gains. In maritime markets, freight rates and second-hand vessel prices tend to return to average, in other words they are mean-reverting [12]. Therefore, it is very important to take investment decisions correctly at the peak or deep. Because a short-sightedly investment decision can lead to melting or even loss of earnings. Decisions taken at the right time may relate to new ship orders, second-hand ship purchase, long-term ship chartering or ship demolition. However, this study aims to conduct an analysis of the only second-hand tanker market through 5-year-old vessel prices. In maritime transportation, profits are not provided only by transportation activities. In addition, large profits can be obtained from ship trading. There are studies in the literature that examine and model second hand ship prices. However, these studies do not give an idea about the timing of the investment. At this point, in this study, the relationship between 5-year-old ship prices and tanker freight rates is examined from a different framework. When the second hand tanker values reach the highest point in a cycle, it can be said that this point is placed in a price bubble. Because values at this points are much more than the real value and they are temporary. Therefore, especially hitting the time of the ship sale to the bubble period provides very serious profits to ship sellers. For example, the value of VLCC tanker's 5-year-old climbed from $ 53 million in February 2002 to $ 162 million in August 2008. Then, in October 2009, it decreased to $ 77 million [13]. It is clear that what the trading transactions performed at different times of this cycle have lost or brought to their counterparts.

In this direction, this study aims to determine the price bubbles in the 5-year-old values of the ships used extensively in dirty tanker transportation and to test the probability of formation of these price bubbles due to changes in freight rates. In this respect, it includes 3 basic research questions. First of all, are there any price bubble formations in tanker values? Second, do changes in freight have a significant impact on probability of price bubble formation? Thirdly, is there a differentiation in the probability of bubble formation according to the ship type? Our expectations support significance of these hypotheses. Firstly, there is a high probability of price bubbles in second-hand ship values, which are very volatile due to supply and demand imbalances, because at times in history, the value of the 5-year-old ship exceeded the new build value. Secondly, freight is the main source of income for maritime transport. Due to the increasing freight rates, second hand ship prices also increase. Therefore, the possibility of the change in freight rates to form a price bubble in ship values may be significant. Thirdly, ship size is a determining factor affecting their own asset values. In addition, large vessels are used as storage during the period of low oil prices. This situation may cause a further increase in large vessels freight rates. In this respect, it is possible that there is a variation in the probability of bubble formation according to the ship size. In this framework, firstly, price bubbles in the 5 year olds of 3 tanker types are determined with GSADF test. Then the bubble days are given a value of 1 to generate dummy variables. Logit regression models are estimated so that these dummy variables are dependent variable and the BDTI variable is independent variable. Thus, the effect of the increase in freight rates on formation of price bubble probability is determined for each selected tanker type. The results show that the increased freight rates are more likely to cause to the price bubble formation on larger vessels. It is also hoped that the results will enable the investors, ship owners and financial resource providers to see the market a little more clearly.

The rest of the study is structured as follows; the related literature is presented in the first section; the methods used in the study are introduced in the second section; the results from the analyses are presented in the third section; finally, the findings are discussed and some conclusions are made in the last section.

1 LITERATURE REVIEW

When the literature about the second-hand ship value is examined, the subjects that are covered in general are efficiency of ship prices [14], second hand ship valuation [15;16], trading volume and second hand price volatility [17], price dynamics in different sizes [18], and volatility analysis compared with new-building prices [11]. It is important to mention the results of the main ones in order to draw the framework of the study.

Alizadeh and Nomikos [16] have investigated the relationship between the volatility of the second hand ship prices and the trade volume in the dry bulk market. As a result of the study, they have found that the increasing trade volume in the market reduces the volatility in second hand vessel prices. They have also stated that price changes are a very appropriate variable in explaining the trade volume. Because increasing prices cause more transactions in the market. Similar subject was analysed also by Syriopoulos and Roumpis (2006) in the both dry bulk and tanker market. The researcher has found that volatility of the prices are negatively affected by the trade volumes.

Kavussanos [18] has analyzed the dynamics of the second hand prices of the dry bulk ships according to their types. As a result, he has found that the price fluctuations in larger vessels are more volatile than the fluctuations in small vessels. Moreover, he has determined that fluctuations in Panamax type vessels originate from old news, but that Handysize and Capesize fluctuations are more affected by current news. Pruyn et al. [19] have examined second-hand value estimation in maritime economics and stated that the value of the second-hand vessel should be modelled with variables such as, new-building price, orderbook size, profit, age and DWT.

The studies related new build prices are generally focused on their relationship with second hand prices [11], and on the factors that are affect them [17]. Adland and Jia [11] have analysed and compared the volatilities in second-hand and new-building prices of the ships. The authors have stated that the volatility in new-building prices is lower than the volatility in second-hand prices, and the reason for this is that the delivery of the new built ship takes time. Furthermore, they have stated that the difference between their prices is positively correlated with the opportunity cost of the operating in the freight market. In another study related to new-building prices, Dai et al. [17] have found that the greatest determinant of the volatility of the new building price is the volatility in freight rates.

As seen from the researches mentioned above, the prices of second hand and new-building ships are affected by many factors. However, the freight rates are very different from others, as ships are asset investments, and the investors who purchase them are hoping to gain more return. The main source of this return is the freight revenues obtained from the transport activities. As Lun and Quaddus [20] have stated, historical cost of building the ship does not form the second hand value of the ships. Their second hand values are based on the probability to profit now and in the future. So, the freight rates and ship prices are interdependent and jointly determined [21].

Besides, in the maritime market, large profits cannot be earned by only operating ships. One of the biggest earning opportunities in the market is ship trading at the right time. In fact, some investors think that ship trading is more important than transportation activities. These groups of investors are called as speculators and asset players [14]. In this context, the targeted results in this study provide important findings especially for such investors. In addition, it is thought that this kind of study cannot be determined in the literature and therefore an important contribution has been made.

2 METHODOLOGY

The GSADF test and logit regression used in this study are introduced in this section. In the first part of the study, price bubbles in the 5 years old tanker prices are determined by the GSADF method. Then, the effect of the dirty tanker freight index on the probability of bubble formation is examined with the logit model.

2.1 GSADF Test

Prices in the free market economy are constantly fluctuating and these fluctuations are continuing by restructuring the highest or lowest levels according to previous periods. In fact, sometimes these rises are so extreme compared to the previous periods that values are higher than the real values. These periods can be defined as periods of price balloons and are often temporary. Kindleberger [22] defines the bubbles as a bubble is a sharp rise in price of an asset or service. In other words, the price of the asset or service deviates from its fundamental value in a bubble [23].

Several methods have been developed recently to identify price bubbles in the series. Standard left-tailed unit root and cointegration methods are widely used. However, Evans [24] has stated that states that such tests have difficulty in detecting explosive bubbles in the series when there are periodic collapsing bubbles. Later, studies on this deficiency have been carried out and new methods have been developed.

Phillips et al. [25] have developed a number of methods about price bubble detections. Firstly, they have developed the sup augmented Dickey-Fuller (SADF) method which is partly strong in detection of periodically collapsing bubbles. Later, it was argued that the SADF method is effective when it is a single bubble in the series, however a series may contain more than one price bubble [26]. For instance, if the series contain two bubble and the duration of later one is shorter than former one, the SADF test cannot estimate the start and end date of the bubble consistently [27]. Thereupon, the generalized sup augmented Dickey-Fuller (GSADF) test is proposed by Phillips et al. [28] in a further study. In this test, a flexible moving sample test allows to consistently detect bubbles and their occurrence times. The test detects bubbles by recursively implementing ADF type regression with a fixed sized rolling window [29]. All these features put this test forward in the determination of price bubbles rather than other tests.

The procedure recommended by Caspi [30] has been used in the application of this test. It can be installed and used as an add-in in Eviews econometric software. In the next section, logit regression method is introduced.

2.2 Logit Regression

Many methods can be used to analyse econometric relations. One of them is the regression models and many different versions of them have been developed over time. But the underlying logic is simple and is to test whether one or several independent variables can statistically explain a dependent variable. Regression analysis helps researchers to determine how the mean of one variable systematically varies according to the levels of another variable. The former variable is often called a dependent variable or outcome variable and the latter an independent variable, predictor variable, or explanatory variable [31]. The results obtained from the estimated regression mode are used in estimating dependent variable or interpreting the theoretical validity of the spotted coefficients [32].

In the regression analysis, the dependent variable may be a time series or a cross-section data, or it can be composed of two options. This can be achieved by generating a dummy variable from qualitative variables. For example, if the dependent variable satisfies a specific situation the value of "1" is given, and if it cannot satisfy a specific situation the value of "0" is given, and so a dummy dependent variable is generated. Such predicted regression models are called linear probability models (LPM). But these kind of models have some difficulties such as estimating the dependent variable between 0 and 1, lower R2, non-normal distribution characteristics and heteroscedasticity of error terms. Therefore, some kind of regression models such as logit and probit have been developed [33].

Therefore, in this study, firstly bubbles in second hand ship prices of the three tanker ships are determined by GSADF method, and bubble times are given 1 value and so dummy variables are generated. Afterwards, logit regression models are estimated as the BDTI variable is independent variable to calculate the bubble formation probabilities for each 3 tanker types. The following process has been proposed by Emeç [34], and it is used for the calculation of the average marginal effects in this study. First, the regression equation (1) is estimated in accordance with the logit model. The variable consisting of 2 options is selected as the dependent variable which is "1" in the bubble days, and "0" in the remaining days.

$$Y_t = \beta_0 + \beta_1 X_1 + \varepsilon_t \tag{1}$$

Then the coefficients of the equation (1) and the mean of the independent variables they belong to are used to find Z by using the equation (2).

$$Z = \beta_0 + \beta_1 \overline{X_1} \tag{2}$$

Afterwards, equation (3) is used to calculate the standard logistic distribution function after the Z value is found. This function is represented by f(Z).

$$f(Z) = \frac{dp}{dZ} = \frac{e^{-Z}}{(1+e^{-Z})^2} \tag{3}$$

At the end of the process, marginal effects of each independent variable are calculated by (4) multiplying the logistic distribution function by their coefficients.

$$Marginal\ Effect_i = f(Z)\beta_i \tag{4}$$

Logit models can also present probability in certain conditions in independent variables. However, since marginal effects of independent variables are more important in the direction of this study, they have been taken into consideration. In the next section, the data set is introduced.

2.3 Data

Descriptive statistics of the data set used in this study are presented in Table 1. The data consist of 240 observations on a monthly basis covering the dates between August 1998 and July 2018. Vessel types used in carrying crude oil are Handymax (<50,000 dwt), Panamax (50,000-80,000 dwt), Aframax (80,000-120,000 dwt), Suezmax (120,000-200,000 dwt), VLCC (200,000-320,000 dwt) and ULCC (>320,000 dwt) in general [35]. The vessel types subject to this study are Aframax, Suezmax and VLCC, since the available date includes only these vessel types. When we investigate the volatilities by using rate of standard deviation to mean, it is 42% for BDTI, 33% for VLCC, 31% for Suezmax and 33% for Aframax.

***Tab. 1** Descriptive Statistics of the Variables*

	BDTI	VLCC	SUEZ	AFRA
Mean	1023.671	78.93340	55.03741	41.33477
Median	855.8955	70.03409	48.30909	37.82500
Maximum	3050.000	162.0000	99.00000	77.00000
Minimum	477.8421	47.69000	33.47182	23.66773
Std. Dev.	433.8369	26.54948	17.26932	14.00166
Skewness	1.557887	1.112655	0.968026	0.908376
Kurtosis	5.657288	3.408880	3.010335	2.648787

Jarque-Bera	167.6923	51.19185	37.48408	34.23938
Probability	0.000000	0.000000	0.000000	0.000000
Observations	240	240	240	240

Source: [13]

Figure 1 also presents a graphical representation of the variables. As can be seen, the value of the largest ship is at the top because the values are parallel with the ship dimensions. The value of the smallest ship is the lowest line. While the ship values generally follow parallel course, the BDTI value is continuously volatile and fluctuating. However, there is still a trendy parallelism with ship values. In the next section, the results obtained from the analysis are presented.

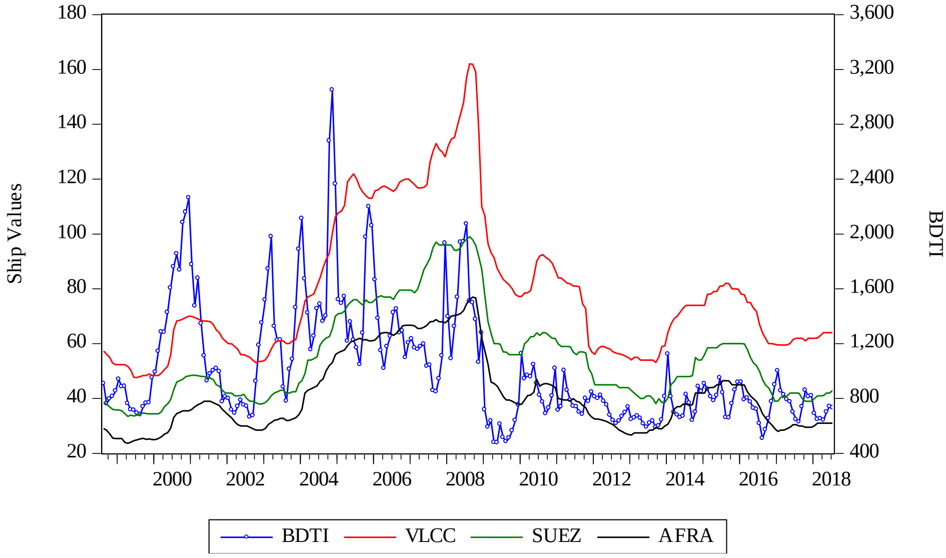

***Fig.1** Graphical Display of the Raw Variables*
Source: [13]

3 FINDINGS AND RESULTS

This section presents the results obtained from the GSADF test and subsequent logit regression analysis. Firstly, the bubbles in the prices of 5-year-old tankers are identified, and then a dummy variable is formed with these bubble dates, as "1" in bubble dates and "0" in remaining days. Then, the logit regression model is established as dummy is dependent variable and the BDTI is independent variable. The results of the whole process are presented below.

3.1 GSADF Test Results

In the GSAF test, the process developed by Caspi [30] is followed. The initial window size is selected as default value in the software which is 30. The null hypothesis of GSADF test is that there is no price bubble in the series. The critical values obtained for this test are calculated by the Monte Carlo simulation method in the Eviews software. According to the analysis results in Table 2, the null hypothesis for all the 5 years old tanker prices are rejected.

***Tab. 2** GSADF Test Results for VLCC*

		VLCC	SUEZMAX	AFRAMAX
t-Statistics		5.647509	3.731158	3.088304
Test critical values*	99% level		2.756310	
	95% level		2.116050	
	90% level		1.869677	

The graphs obtained from the analysis provide good possibilities for detecting and examining the bubble periods. According to the results obtained for the VLCC ship, 5 price bubble periods are discovered as seen in the Figure 2. The dates and durations of these identified bubbles in VLCC ship price are; 3 months between January 2001 and March 2001; 57 months between February 2004 and October 2008; 3 months between November 2011 and January 2012; 17 months between May 2014 and September 2015; and lastly 8 months between September 2016 and April 2017.

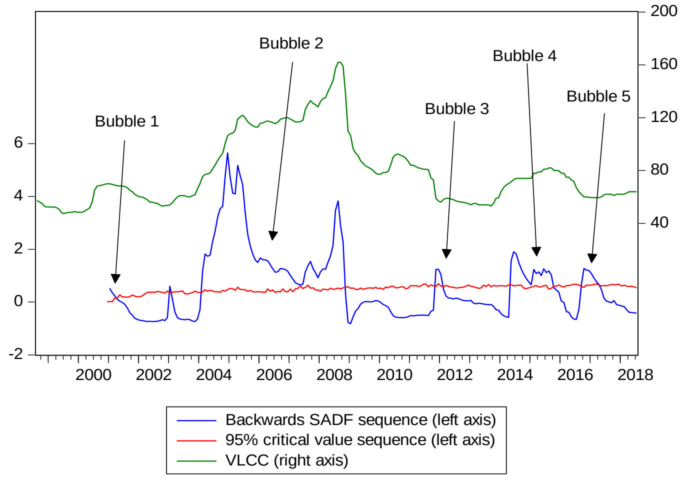

***Fig. 2** VLCC Price Bubbles*

According to the results obtained for the SUEZMAX ship, 6 price bubble periods are discovered as seen in the Figure 3. The dates and durations of these identified bubbles in SUEZMAX ship price are; 8 months between January 2001 and August 2001; 57 months between March 2004 and November 2008; 11 months between March 2009 and January 2010; 4 months between January 2012 and April 2012; 7 months between February 2015 and August 2015; and lastly 5 months between December 2016 and April 2017.

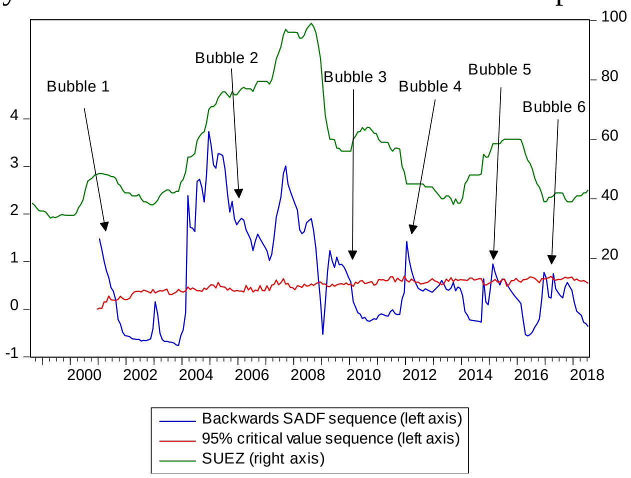

***Fig. 3** SUEZMAX Price Bubbles*

According to the results obtained for the AFRAMAX ship, 6 price bubble periods are discovered as seen in the Figure 4. The dates and durations of these identified bubbles in AFRAMAX ship price are; 10 months between January 2001 and October 2001; 56 months between March 2004 and October 2008; 12 months between March 2009 and February 2010; 6 months between August 2012 and January 2013; 16 months between June 2014 and September 2015; and lastly 7 months between November 2016 and May 2017.

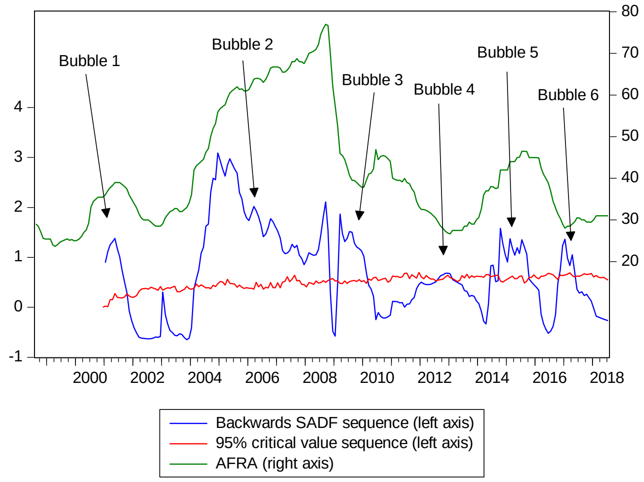

Fig. 4 *AFRAMAX Price Bubbles*

After the determination of the price bubbles belonging to the value of 5 years old tanker types included in our sample, the probability calculation part is started with logit regression model.

3.2 Logit Regression Results

It is important that the series should be stationary in the time series analysis, in other words they should not contain unit roots. Therefore, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests are applied to the BDTI variable before the regression analysis and the results are presented in Table 3. The null hypotheses of these tests are that the series contain unit roots. According to the results of both analyses, the null hypothesis rejected, which means that the series do not contain unit roots. Then, logit regression models are estimated.

Tab. 3 *Unit Root Test Results for BDTI*

Variable	Level Intercept	 Trend and Intercept
Augmented Dickey-Fuller	-4.696042	-5.504609
Phillips-Perron	-3.773016	-4.375562
Critical Value %1	-3.457747	-3.997083
Critical Value %5	-2.873492	-3.428819
Critical Value %10	-2.573215	-3.137851

The estimated logit regression model for each vessel type is as follows. The dummy variable for each vessel type are generated from the days when price bubbles are formed. They are placed in the model as dependent variable, and BDTI is placed as independent variable. Logit models for each type of tanker are estimated and the results are presented in the Appendices in order to simplify the results section. Also, the formulated process of calculation of marginal effect is presented only for the VLCC tanker to show the process. Direct results are given for the other two vessels.

$$BUBBLES = \beta_0 + \beta_1 BDTI + \varepsilon_t$$

The first logit model is estimated for the VLCC tanker and the results are presented in Appendix 1. According to the results, the model, constant term and independent variable are all significant. Then the process mentioned in the methodology section is followed for calculating the marginal effects in the logit model. After estimating the coefficients of the model, the value of Z is calculated using the equation (2):

$$Z = -3.5783 + 3.2937 * 1.0068 = -0.26192$$

The standard logistic distribution is then calculated using the equation (3) and the obtained variables are used in the calculation of marginal effect.

$$f(Z) = \frac{2.718^{-(-0.26192)}}{(1 + 2.718^{-(-0.26192)})^2} = 0.24576$$

The marginal effect is calculated using the equation (4):

$$ME_{VLCC} = 0.24576 * 3.2937 = 0.8094$$

According to these results, the increase of 1 unit (1000 points) of BDTI increases the probability of price bubble formation in the 5 years old VLCC tanker by 80%. The same process is repeated for the Suezmax tanker price and logit regression estimation result is presented in Appendix 2. According to the obtained results, marginal effect of the BDTI on probability of bubble formation in SUEZMAX tanker price is 70%. The regression equation for AFRAMAX is estimated and the results are presented in Appendix 3. The marginal effect value calculated for this tanker type is 55%. According to all these results, the increase in freight rates in the dirty tanker market by 1 unit (1000 points) increases the probability of price bubble formation by 80%, 70% and 55% respectively in 5 years old VLCC, SUEZMAX and AFRAMAX tanker prices.

According to the results we obtained, our research questions and hypotheses found their answers. Firstly, we aimed to determine whether the 5-year-old ship values have price bubbles. The results of the GSADF test we applied showed that the value of each ship in the sample had significant price bubbles in the period under consideration. This is reasonable because in the past there have been times when the value of the 5-year-old ship exceeded the value of the new ship [6]. Secondly, we aimed to determine whether the freight has a significant effect on the probability of formation of these price bubbles. As a result of the regression models we have established here, we have determined significant effects of freight rates on price bubble formation for each ship. Considering that freights are one of the most important determining factors for ship values [19, 36], it is usual that they also affect bubbles in value of the 5 years old ship. Because, as a result of increasing freight rates, the demand for second-hand ships is increasing and this causes investors to be willing to pay higher prices. Finally, we aimed to determine whether the probability of bubble formation differs according to the ship type. According to the results, by 1 unit (1000 points) increases the probability of price bubble formation by 80%, 70% and 55% respectively in 5 years old VLCC, SUEZMAX and AFRAMAX tanker prices. According to the results, the probability of bubble formation is higher in large ships. Since there is no similar study on bubble formation in the literature, these results can be evaluated with other studies. Kavussanos [18] has stated that the volatility in small ships is higher than in large ships. According to our data, volatilities are 33% for VLCC, 31% for Suezmax and 33% for Aframax. In this case, it can be stated that the probability of bubble formation is not parallel with the volatility for the tanker market. Another factor may be the trade volume in the second hand market, as indicated by Alizadeh and Nomikos [16] and Syriopoulos and Roumpis [37]. However, we could not obtain long-term statistics on sales transactions by tanker type from one source, because paid sources provide these data. Instead, we reached the fleet statistics, accordingly, as of April 2020 in the world, there are 810 VLCC, 668 Aframax and 571 Suezmax [38]. At this point, there appears to be a strong parallel between the fleet size and the probability of bubble formation rates. It can be said that large-sized ships are more preferred in the tanker market and this preference density contributes to the formation of bubbles in their prices. So larger vessels have larger probability of price bubble formation. The main reason for this preference may be due to the parcel size distribution function [6]. The main factors influencing this function are the advantage provided in per unit transport cost by using large ships, port structures and inventory costs. Accordingly, the use of large ships for transcontinental oil transportation may be preferred, as it significantly reduces the cost of transportation per unit. In addition, due to the inventory cost, when oil prices decrease, large vessels are more preferred for crude oil storage [39]. Buyers secure themselves against price increases by storing cheap crude oil in larger vessels. The main reason for this may be that large ships also provide an advantage in per unit storage cost due to the economies of scale.

4 CONCLUSIONS

Second-hand ship prices are affected by the freight market and act as continuous cycles since the maritime trade has been started. Ten million dollar movements can be experienced in small time units, because ship supply is inelastic in short run. In fact, there have been moments in the past that the price of a second-hand ship has exceeded the new-building price. Because second-hand ship prices are more concerned with the situation in the current market, but since the new construction process lasts an average of 2 years, it is not clear what the market conditions will be at that time.

However, it is not known when shipping cycles will start and end, and how high it will be. Therefore, it is important to understand the mechanisms of the second hand prices. As mentioned in the literature, there are many factors such as situation of the order book, new-building price, world economy, demolition prices and freight rates which affect second hand ship prices. However, freight rates lie at the heart of many of these factors. It is also difficult to generate such a multivariate model with many factors and achieve significant results. Therefore, this study examines the effect of freight rates on the possibility of bubble formation in second hand ship prices of the selected tanker ships. For this purpose, GSADF method, which is rarely used in maritime research, has been chosen. It has been shown in many studies that it gives very consistent and significant results in multiple bubble detections.

According to our results, it can be said that larger vessels are more affected by the freight rates and are more prone to price bubble formation. The investors who want to buy a ship and enter the transportation sector, the owners who want to sell his ship from existing fleet and generate resource for other investments, the asset players who are only interested in making big profits by purchasing and selling activities, the financial institutions who want to provide financial resource to ship purchase transactions may evaluate these results in order to see better the future of the second-hand tanker market. For example, it is more logical to invest in the VLCC ship type for the asset players, because the price of bubble is more likely in this type. This increases the chances of capturing the high price and making great profits for them. For an investor who may purchase the vessel by loan and enter the transport sector, AFRAMAX type tanker may be the most appropriate option in terms of risk. Because the price is unlikely to be in the bubble process, and hence the probability of fall in freight rates and probability of having problems in repayment period to the banks are low. Likewise, financial institutions are also less likely to suffer from repayment of resources in these type of ships.

In terms of contribution to the literature, a study that examines the price bubbles in second hand ship prices by GSADF method has not been spotted. Even this new method implementation to the shipping market makes contribution to the literature, logit models are also developed and the probability of price bubbles are identified for each tanker types. For these reasons, it is hoped that the literature is given a new perspective and important contributions have been made.

It is hoped that these results will be beneficial to reduce the risk of asset purchase decisions and increase profit opportunities in tanker shipping sector which is high risky, capital intensive and highly affected by political events. Further studies may also examine similar analyses in container, dry bulk and special cargo transportation markets. As a limitation of the study, it can be said that usage of single composite index for all tanker types may be reduce the power of the relations. Healthier results can be obtained by generating separate indices according to each type of tanker ship.

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App. 1 *Logit Estimation Results of the VLCC*

Variable	Coefficient	Std. Error	z-Statistic	Prob.
BDTI	3.293744	0.544688	6.047029	0.0000
C	-3.578315	0.546817	-6.543896	0.0000
McFadden R-squared	0.199148	Mean dependent var		0.421801
S.D. dependent var	0.495021	S.E. of regression		0.424317
Akaike info criterion	1.109504	Sum squared resid		37.62931
Schwarz criterion	1.141275	Log likelihood		-115.0526
Hannan-Quinn criter.	1.122346	Deviance		230.1052
Restr. deviance	287.3257	Restr. log likelihood		-143.6629
LR statistic	57.22047	Avg. log likelihood		-0.545273
Prob(LR statistic)	0.000000			
Obs with Dep=0	122	Total obs		211
Obs with Dep=1	89			

App. 2 *Logit Estimation Results of the SUEZMAX*

Variable	Coefficient	Std. Error	z-Statistic	Prob.
BDTI	2.827396	0.501879	5.633621	0.0000
C	-3.104710	0.508488	-6.105769	0.0000
McFadden R-squared	0.161874	Mean dependent var		0.426540
S.D. dependent var	0.495750	S.E. of regression		0.436346
Akaike info criterion	1.162690	Sum squared resid		39.79310
Schwarz criterion	1.194461	Log likelihood		-120.6638
Hannan-Quinn criter.	1.175532	Deviance		241.3275
Restr. deviance	287.9371	Restr. log likelihood		-143.9685
LR statistic	46.60956	Avg. log likelihood		-0.571866
Prob(LR statistic)	0.000000			
Obs with Dep=0	121	Total obs		211
Obs with Dep=1	90			

App. 3 *Logit Estimation Results of the AFRAMAX*

Variable	Coefficient	Std. Error	z-Statistic	Prob.
BDTI	2.234144	0.467320	4.780755	0.0000
C	-2.194908	0.464152	-4.728860	0.0000
McFadden R-squared	0.106924	Mean dependent var		0.497630
S.D. dependent var	0.501183	S.E. of regression		0.463080
Akaike info criterion	1.257004	Sum squared resid		44.81867
Schwarz criterion	1.288775	Log likelihood		-130.6139
Hannan-Quinn criter.	1.269846	Deviance		261.2278
Restr. deviance	292.5034	Restr. log likelihood		-146.2517
LR statistic	31.27559	Avg. log likelihood		-0.619023
Prob(LR statistic)	0.000000			
Obs with Dep=0	106	Total obs		211
Obs with Dep=1	105			