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RESP

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Freight Rate as A Determinant Factor of Ship Recycling Volume

Gemi Geri Dönüşüm Hacminde Belirleyici Bir Faktör Olarak Navlun Oranı

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ANAHTAR KELİMELER

Baltık Kuru Yük Endeksi
Nedensellik
Gemi Sökümü
Kuru Dökme Yük Piyasa

ÖZ

Gemi geri dönüşüm sektörü hem denizcilik piyasası hem de çelik piyasası için önemlidir. Dolayısıyla dinamiklerini anlamak, birçok sektör paydaşına katkı sağlamaktadır. Bu çalışmada kuru yük piyasasında navlun oranı ile geri kazanılan tonaj arasındaki ilişkiyi incelemek için Baltık Kuru Yük Endeksi (BDI) ve Geri Dönüştürülmüş Kuru Dökme Yük Gemisi Tonajı (RBT) değişkenleri tercih edilmiştir. Verilerimiz, 1985 yılının ilk çeyreğinden 2023 yılının ilk çeyreğine kadar olan dönemi kapsayan 153 gözlemden oluşmaktadır. Uygulanan Granger nedensellik analizi, navlun değişimlerinin geri dönüşüme gönderilen tonajı etkilediğini, navlunlarda beklenmeyen pozitif bir şokun tonaj üzerinde negatif etki oluşturduğunu ve bu etkinin üç dönem sonra etkisini kaybettiğini göstermiştir.

KEYWORDS

Baltic Dry Index
Causality
Demolition
Dry Bulk Market

ABSTRACT

The ship recycling sector is important for both the maritime market and the steel market. Therefore, understanding its dynamics contributes to many sector stakeholders. In our study, we preferred Baltic Dry Index (BDI), and Recycled Bulker Tonnage (RBT) variables to examine the relationship between freight rate and recycled tonnage in the dry bulk market. Our data consists of 153 observations covering the period from the first quarter of 1985 to the first quarter of 2023. Applied Granger causality analysis showed that changes in freight affect the tonnage sent for recycling, an unexpected positive shock in freights generates a negative effect on tonnage and this effect loses its effect after three periods.

1. Introduction

The ship recycling industry basically undertakes the task of dismantling old or obsolete ships and bringing them back to the economy. Although the ship recycling industry is not a prominent sector and often comes to the fore with the damage it causes to the environment, it has very important functions for the global trade, the global fleet, the ship owners, the environment, and the countries where recycling is made.

Although the recycling of old ships and the continuation of younger ones to operation in the sector reduce the supply in the short term, leading to an increase in freight rates, it becomes possible to carry out more efficient and low-cost trade with a renewed fleet in the long term. This is because new ships are starting to enter the market due to the decreasing supply and increasing freight rates. Thus, both the global fleet is renewed, and international trade is supported. There are also environmental benefits to the industry as it is an area where old ships are dismantled relatively safely, thus old ships do not have to be sunk or abandoned at sea. Although there are big question marks about the environment and worker safety in the countries where the dismantling process is carried out, it also generates a significant source of income and job opportunities for those countries.

There are many factors affecting the ship recycling industry. These can be listed as freight rates, second-hand ship prices, interest rates, steel prices, policy changes, market expectations, herd behavior, and international relations between countries. But the basic and most important factor

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is freight rates. For example, when renewing the ship considering the interest rates, the freight rates in the market will be taken as the basis for the payments. On the other hand, when steel prices rise, the shipbreaking industry will be more ambitious, but if the market freight rates are satisfactory, fewer ships will be sent for recycling. After market expectations are formed regarding freights, the ship will not be sent for recycling if an increase is expected, but the old ship will be sent for recycling as soon as possible if a decrease is expected. There are also trade embargoes between countries in some periods. In the former situation, smaller ships are preferred if transportation is carried out at shorter distances. However, if cargo needs to be transported further away due to the embargo, the demand will shift to larger ships. In this case, as the demand for smaller ships drops, their freight will also decrease, so they are more likely to be sent for recycling if they are old. On the other hand, a regulation related to the standards of ships may prevent certain types of ships from doing business in certain regions. For example, the banning of single-hull tankers in Europe. Thus, as the demand for this type of ships decreases, their income will decrease, and they will be sent for recycling. As can be seen, it is the freight rates in the market that also affect other factors. For this reason, studies that will facilitate understanding the mechanism between freight and recycling behaviors are valuable.

We discussed the relationship between freights and ship tonnage going to recycling with the causality approach in this study. The advantage of this approach is that it makes it possible to determine the direction of information flow and it can be analyzed how the shocks in the variables progress in the system. Since the relationship between variables cannot always be instantaneous, it is important to consider the lasting relationship as well. Similar studies have been done in the literature. In general studies on ship recycling, freight rates (Açık and Başer, 2017), general scrap prices (Alizadeh et al., 2016; Xiarchosa and Fletcherb, 2009; Kagkarakis et al., 2016), steel prices (Tunç and Açık, 2019), market conditions (Yin and Fan, 2018), ship recycling prices (Knapp et al., 2008), exchange rates (Karlis et al., 2016), volatility between demolition prices (Totakura et al., 2021), environmental effects (Hossain et al., 2016; Choi et al., 2016) were discussed. However, our study stands out because of the high frequency of the dataset, its focus on a specific maritime market, and its long-term coverage.

In the second part, after providing general information about the ship recycling market in the world, the relevant literature is summarized. In the third part, the data set used in the study was examined and the method was presented. In the last part, the findings obtained from the applied method are presented.

2. Ship Recycling in The World

The list of countries actively working in the ship recycling sector in the world is presented in Table 1, sorted according to their shares in 2021. The first thing that stands out is that the main countries in the sector are South Asian countries. The main reasons for its location in these countries are cheap labor, high demand for scrap metal and low regulatory regime. Bangladesh is in the first place with a share of 52% and it has been maintaining this first place for many years. The total market share of Bangladesh, Pakistan and India constitutes a huge amount with 89.5%. So to speak, almost 9 out of 10 ships were recycled in this region (UNCTAD, 2023). In these countries, dismantling activities are carried out by the beaching method (Galley, 2014:14). These countries also host approximately 23% of the world's population (World Bank, 2023). Because there is a large population and job opportunities are insufficient, they work in such unhealthy and dangerous jobs in bad conditions (Engels, 2013:19). Since 2009, 440 workers in South Asian countries have lost their lives during shipbreaking activities and many of them suffer from various cancer diseases in the long term because they work without protective measures. Finally, the environmental damage it does is invaluable. Due to insufficient legal inspections, toxic cargoes are sent to South Asian countries. 60,000 mangrove trees were cut down in Bangladesh alone to open a dismantling area and an area of 19 km on the coast was allocated for harmful shipbreaking activities (NGO, 2023).

After the South Asian countries, the most important actor in the market is Türkiye with a share of 6.8%. The shares of the remaining countries are not significant. China was also one of the important actors in the ship recycling industry. In 1993, nearly half of all ships in the world were recycled in China (Engels, 2013:27). However, due to environmental concerns and the country's policies for sustainable development, it quickly left this sector and its share decreased to 0.9%.

Table 1. World Ship Recycling Ranking (Gross Tonnage)

Country	2018	2019	2020	2021	Share 2021
Bangladesh	8,638,560	6,689,663	6,995,977	7,991,594	52.1%
Pakistan	3,985,841	327,828.2	3,099,877	3,027,959	19.8%
India	4,649,456	3,278,064	5,026,416	2,699,541	17.6%
Turkey	782,124	1,103,934	1,600,783	1,036,168	6.8%
China	465,710	343,112	195,486	140,112	0.9%
United States of America	63,889	64,471	35,298	76,566	0.5%
Denmark	16,352	3,838	17,207	70,441	0.5%
Canada	35,632	6,729	-	61,053	0.4%
Norway	1,939	4,739	68,423	29,514	0.2%

Korea, Republic of	2,649	7,100	27,993	27,230	0.2%
Venezuela	-	-	-	22,073	0.1%
Others	302,430	201,831	140,378	146,461	1.0%
World	18,944,582	12,031,309	17,207,838	15,328,713	100%

Source: UNCTAD (2023).

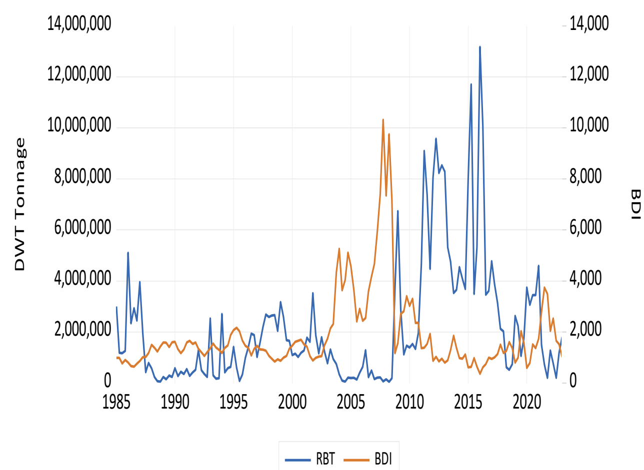
While ships are sent for recycling, a price per light tonnage is suggested by the shipbreaking centers and the ship owner decides in which country to deliver according to this price. Or there are intermediaries in this sector and the ship owner only deals with this intermediary. Offered prices for ships may differ between countries. For instance, as of April 2023, suggested prices for dismantling bulker ships are $585 in Bangladesh, $565 in India, $545 in Pakistan, and $335 in Türkiye (Athenian S.A., 2023). Due to tight controls, environmental measures, high labor costs, and high transportation costs in Türkiye, the prices paid by the recycling centers to the ships are much lower because the recycling center also has to make a profit by selling the scrap metal to the market (Engels, 2013:221).

3. Data and Methodology

In our study, we preferred Baltic Dry Index (BDI) (Capital Link, 2023), and Recycled Bulker Tonnage (RBT) (Braemar, 2023) variables to examine the relationship between freight rate and recycled tonnage in the dry bulk market. While the unit of BDI variable is index, the unit RBT variable is deadweight tonnage (DWT). Our data consists of 153 observations covering the period from the first quarter of 1985 to the first quarter of 2023. While converting BDI to quarterly, daily values are averaged quarterly. In the RBT variable, monthly recycled tonnages are summed up.

The movements of the variables in the period under consideration are presented in Figure 1. Visually, it can be said that they generally move in the opposite direction. When the correlation was examined, there was a significant correlation of -0.38. Decreased freights in the market cause old ships with high average transportation costs to be unable to do business and to be sent for recycling. Rising freight rates cause even old ships to become operational and remain in the market. Thus, theoretically, there is a negative relationship between the variables. In the BDI variable, it could not be caught again after the historical peak seen before the 2008 global economic crisis. The increasing demand could not be met due to the long construction times of the ships, and this shortage caused the freight to increase rapidly before the crisis. Ship orders placed in the bright period also formed an excess supply in the market in the following periods and the freights could not see the former high levels again. It is seen that the number of ships sent for recycling in the period when the freights broke the record decreased a lot. Even older ships were able to be operated profitably in commercial operations. However, it is seen that an incredible amount of tonnage was sent for recycling after the freight was crashed. The large number of new ships entering the market has increased the recycling traffic by causing old ships to become inoperable in a low freight environment.

Figure 1. Historical Movement of the Raw Variables



Source: Capital Link (2023), Braemar (2023)

Descriptive statistics of the variables in our study are presented in Table 2. In the period under consideration, an average of 2.1 million DWT ships were sent for recycling quarterly. The maximum date of the ship sent for recycling with 13.1 million DWT was the 2016 Q1 period. The period with the lowest DWT value was 2008Q2. There was a time when dry cargo ships had a very high utilization rate and almost no empty ships were left in the market. Therefore, very few ships were sent for demolition. While the average BDI value was 1881 points, the highest quarterly index average was reached in the 2007 Q4 period. This period, also called the China boom, is the period when China demanded very high raw materials and skyrocketed the dry cargo freight rates. The period with the lowest index was 2016Q1 coinciding with the period of the highest recycling volume.

When the log return series are analyzed, it is seen that the shipbreaking tonnage is much more volatile in terms of risk, because its standard deviation value (0.82) is much higher than that of the BDI (0.30). When we look at the quarterly maximum increases, it is seen that it is 71% for BDI and 298% for RBT. For maximum decreases, 180% for BDI and 213% for RBT are determined. This shows that both markets and especially the recycling market are very volatile, in parallel with the standard deviation values. The reaction of recycling tonnage to the change in freights is higher. The high skewness and kurtosis values also indicate that the distributions of the variables are fat-tailed. As can be seen from the skewness values, while the effect of negative shocks was greater in BDI, positive shocks were more effective in RBT.

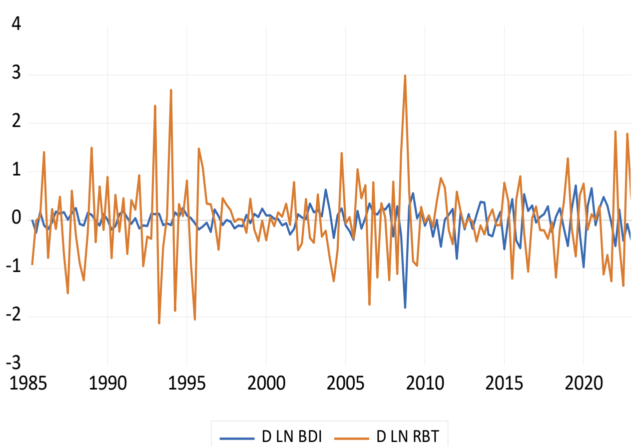
Table 2. Descriptive Statistics of the Variables

	BDI	RBT	ΔLN BDI	ΔLN RBT
Mean	1881.445	2187684.	0.000156	-0.003368
Median	1380.607	1313124.	0.039842	-0.021592
Maximum	10318.05	13168330	0.713100	2.983906
Minimum	358.4032	46620.00	-1.807005	-2.133672
Std. Dev.	1583.831	2470288.	0.300776	0.827155
Skewness	2.926207	2.000152	-1.684415	0.436503
Kurtosis	12.96969	7.270219	11.18315	4.459229
Jarque-Bera	851.9898	218.2622	495.9816	18.31276
Probability	0.000000	0.000000	0.000000	0.000106
Observations	153	153	152	152

Source: Capital Link (2023), Braemar (2023)

The graph of the log return variables is presented in Figure 2. The negative relationship between the variables can be clearly seen. When the correlation between them was examined, a significant negative correlation of 0.40 was determined. In addition, the RBT variable has wider volatility and carries greater risks.

Figure 2. Historical Movement of the Log-Return Variables



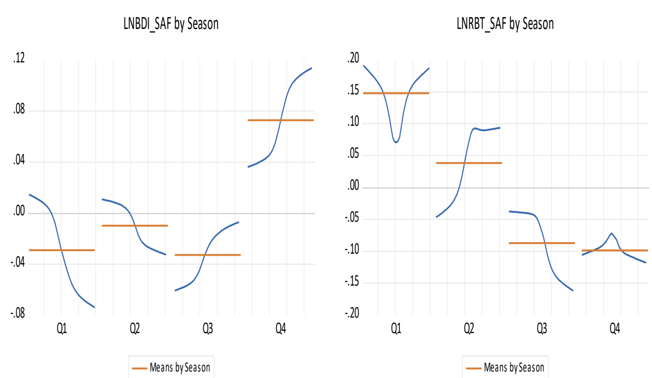
Source: Capital Link (2023), Braemar (2023)

Another important factor to be considered in time series analysis is that the series can exhibit seasonality. In order to obtain healthy results, the series should be examined and if there are seasonal effects, they should be removed from the series. For this reason, STL (Seasonal and Trend decomposition using LOESS) decomposition was applied to logarithmic BDI and RBT variables and seasonally adjusted series were obtained. The STL method separates the series into season, trend and remaining parts.

It is likely to have seasonal effects, especially since dry bulk cargo transport is heavily used for the transport of products such as grain and coal. Coal trade may vary according to the season, increasing in winter and decreasing in summer. Consumption in homes for heating purposes and consumption in power plants may increase during the winter months. In addition, since agricultural products are harvested in certain seasons, the demand for ships may increase at that time. Because these factors affect the demand for ships, they can also have a direct impact on freight levels in the market. The ship recycling sector, on the other hand, is likely to have seasonal effects as they are directly affected by freight.

The quarterly status of seasonal factors obtained as a result of STL decomposition is presented in Figure 3. The results show that the BDI variable increases seasonally in the fourth quarter, namely in October, November and December. This situation can be interpreted as the increase in demand for dry bulk ships by the harvested agricultural products and the coal stored for winter preparation. As a result, the seasonal effect turns negative in the following first quarter. On the other hand, in the amount of recycling, seasonality has a positive effect in the first quarter and a negative effect in the last quarter. This situation coincides with the situation in the freight market. Due to the increase in demand for ships in the last quarter, freight rates increase and ships can be operated profitably, thus reducing the amount of ships going for recycling. However, in the first quarter, since the demand and freight rates have decreased, the older ships cannot continue their profitable activities and they are sold for recycling. This negative relationship is also supported by the 0.50 negative significant correlation between seasonal adjustment factors.

Figure 3. Seasonal Characteristics of the Variables



The Granger (1969) causality test is concerned with whether the past values of one variable contribute significantly to explaining the future values of the other variable. When analyzing causality between variables X and Y, two models are estimated structurally. In one of the models, only the historical values of the X variable are included, while the other includes the historical values of both X and Y variables. If the Y variable improves the explanatory power of the model for variable X in the model in which the past values of two variables are included, it can be said that variable Y is the Granger cause of variable X (Yu et al., 2015). However, unlike its name, Granger causality analysis should not be interpreted as direct causality. It can be interpreted that there is an information flow from the past values of the variables to the current and future values (Kirchgässner and Wolters, 2007:103-120).

As a result of estimation, there may be no, unidirectional or bidirectional causal relationships. An example VAR model with 2 variables and 1 lag can be represented as in Equations 1 and 2:

$$y_t = \beta_{10} + \beta_{11}y_{t-1} + \propto_{11} x_{t-1} + u_{1t} \quad (1)$$
$$x_t = \beta_{20} + \beta_{21}x_{t-1} + \propto_{21} y_{t-1} + u_{2t} \quad (2)$$

The result of causality analyzes are sensitive to the fact that they contain unit roots and act together in the long run, and the results may be biased if these situations occur (Nazlioglu, 2019: 389). For this reason, unit root analyzes should be applied to the series and if the series are non-stationary, they should be made stationary by difference taking before the VAR analysis (Brooks, 2014:330). While estimating the models, it should be decided which delay is more appropriate according to the information criteria. The lag value that minimizes the appropriate information criterion value is considered optimal for the VAR model (Kočenda and Černý, 2015:151). Information criteria basically measure the balance between model fit and complexity. Too many lags can increase the explanatory power of the model, but it can produce too many parameters, and this can complicate the model. Therefore, information criteria are preferred to find the optimum balance between model fit and complexity.

After the model is estimated, the validity of the model should be verified by checking the cases such as AR roots less than 1 and the residuals of the model not containing autocorrelation and heteroscedasticity (Bo and Zing, 2011:125). The null hypothesis of this test indicates that there is no significant causal relationship. For a significant causality relationship, the null hypothesis must be rejected.

4. Results

Unit root tests are one of the most important preliminary analyzes in time series analysis. Stationary series have a fixed mean and variance, and the covariances of the observations are time independent. However, in series containing unit root, mean and variance change with time and there is time dependence. In addition, unit root tests help us understand how series behave in the face of unexpected events, in other words, shocks. The fact that the series is not stationary indicates that the effects of the shocks are permanent, while the reverse indicates that they are temporary.

When applying the Granger causality test, the series must be stationary. For this reason, we preferred to apply ADF (Dickey and Fuller, 1979), PP (Phillips and Perron, 1988) and KPSS (Kwiatkowski et al., 1992) tests to the series. According to all tests as shown in Table 3, the series were determined to be stationary at the level. This indicates that the effects of the shocks they are exposed to are temporary and that the series tend to return to the mean in the long run. However, when we consider the graphical movements and distribution characteristics of the series, we saw that they are volatile, have high kurtosis values and show non-normal distribution characteristics, so we decided to apply a non-parametric test in addition to the parametric tests to determine stationarity of the series. For this, we chose the variance ratio test.

Table 3. Unit Root Test Results

Test	Variable	Level		First Difference	
		Intercept	Intercept & Trend	Intercept	Intercept & Trend
ADF	**BDI**	-3.109^{**}	-3.059	-10.936^{***}	-10.920^{***}
	RBT	-3.881^{***}	-4.253^{***}	-14.254^{***}	-14.206^{***}
PP	**BDI**	-3.143^{**}	-3.107	-11.414^{***}	-11.387^{***}
	RBT	-3.782^{***}	-4.206^{***}	-14.874^{***}	-14.817^{***}
KPSS	**BDI**	0.193^{*}	0.168^{***}	0.039^{*}	0.023^{*}
	RBT	0.409^{**}	0.078^{*}	0.042^{*}	0.036^{*}

Notes: (1) CVs for ADF and PP are -3.473 for ***1%, -2.880 for **5%, -2.576 for *10% at Intercept, and -4.019 for ***1%, -3.439 for **5%, -3.144 for *10% at Intercept and Trend. (2) CVs for KPSS are 0.739 for ***1%, 0.463 for **5%, 0.347 for *10% at Intercept, and 0.216 for ***1%, 0.146 for **5%, 0.119 for *10% at Intercept and Trend. (3) Lag lengths were determined automatically by Schwarz information criterion in ADF. (4) Barlett kernel spectral estimation method and Newey-West Bandwidth were selected in PP and KPSS.

The variance ratio test is a non-parametric test used to test whether the series are martingale or not. The null hypothesis is that the series are martingale, that is, the observations are independent of each other and exhibit random walk (Bhar, 2010:16). In other words, accepting the null hypothesis indicates that the series contains unit root, while its rejection indicates that is stationary. The test results applied are presented in Table 4. The results show that the null hypothesis cannot be rejected at the level, and it is rejected when the first differences are taken. This indicates that the series are martingale and I(1), they carry shocks, and cannot be estimated using their historical values. This result was accepted as more robust considering the distribution characteristics of the series and the first differences of the series were used in the causality analysis.

Table 4. Variance Ratio Test Results

	Level	First Difference
BDI	1.271861	3.032466^{*}
RBT	2.018741	4.225874^{*}

Notes: (1) Test periods are 2, 4, 8, and 16. (2) Table includes joint test results. (3) Asymptotic normal probabilities were used. (4) Null of martingale was rejected at *1%.

In order to determine the most appropriate lag number of the VAR model to be estimated in the causality analysis, information criteria were applied, and the findings are presented in Table 5. The most appropriate lag was determined as 3 according to the LR, SC and HQ information criteria, and 4 according to the FPE and AIC information criteria.

Table 5. Lag Length Selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-197.7632	NA	0.054954	2.774488	2.815736	2.791249
1	-189.4741	16.23281	0.051776	2.714918	2.838660	2.765200
2	-177.8998	22.34472	0.046608	2.609720	2.815957	2.693523
3	-164.3327	25.81516*	0.040813	2.476844	2.765575*	2.594168*
4	-159.3924	9.263103	0.040290*	2.463784*	2.835010	2.614629
5	-157.4968	3.501606	0.041496	2.493011	2.946733	2.677378
6	-153.2298	7.763669	0.041359	2.489302	3.025518	2.707190
7	-150.4139	5.045009	0.042067	2.505749	3.124460	2.757158
8	-149.0592	2.389685	0.043672	2.542488	3.243694	2.827419

Notes: Suggested lags are shown by *. LR: Likehood Ratio, FPE: Final Prediction Error, AIC: Akaike Information Criterion, SC: Schwarz Information Criterion, HQ: Hannan-Quinn Information Criterion.

After determining the optimum lags considering the information criteria, we estimated the VAR model in Equation 3. We also estimated the same model for 4 lags.

$$recycling_t = \beta_{10} + \beta_{11}recycling_{t-1} + \beta_{12}recycling_{t-2} + \beta_{13}recycling_{t-3} + \propto_{11} bdi_{t-1} + \propto_{12} bdi_{t-2} + \propto_{13} bdi_{t-3} + u_{1t}$$

Then, it was examined whether the AR roots of these equations are inside the unit circle and the findings are presented in Figure 4. As can be seen, 6 parameters estimated for 3 lags and 8 parameters estimated for 4 lags are within the unit circles, that is, less than 1. The fact that the AR roots are larger than 1 may indicate that the model is not stationary, its stability is problematic, it has explosive properties, and its predictions are unreliable.

We also applied Portmanteau Tests for Autocorrelations, Serial Correlation LM Tests and Heteroskedasticity Tests to the residuals of both VAR models. According to the results, null hypotheses for all these tests were accepted at the 5% significance level, which supported the validity and reliability of the models.

After estimating the VAR models for 3 and 4 lags, we applied Granger causality analyzes and tested $H_0 = X\ does\ not\ Granger\ cause\ Y$. The results obtained are presented in Table 6. According to the results, there were significant causalities from BDI to Recycling variable in both 3 lags and 4 lags. In the opposite direction, no significant causality was detected. This situation reveals that the changes in freight significantly affect the amount of ships sent to ship recycling.

Since the Chi-square statistics were very close when we examined both VAR models, we checked the AIC value of the models to determine which model was better, and we found that the 4-lags model had a lower AIC value (2.40) than the 3-lags model (2.43). Therefore, we made our next applications based on 3-lags model.

Figure 4. Inverse Roots of AR Characteristic Polynomial

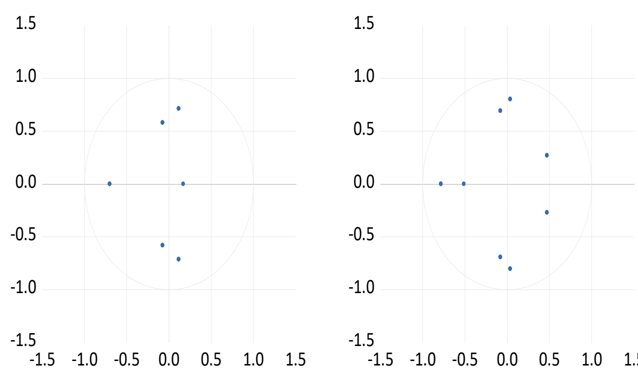


Table 6. Granger Causality Test Results

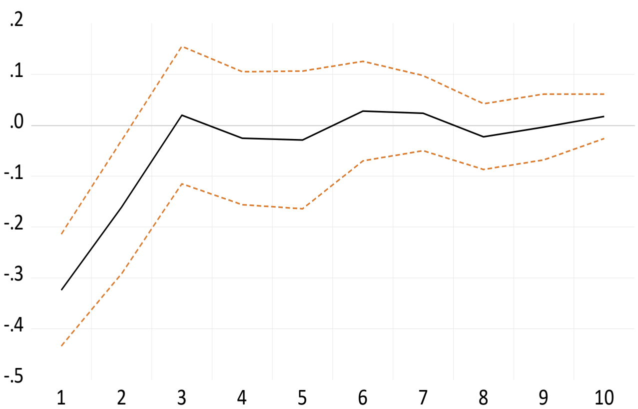
Null Hypothesis	Chi-Square Statistics	Degree of freedom	Probability
BDI does not Granger Cause RBT	33.591	3	0.0000*
RBT does not Granger Cause BDI	0.712	3	0.8704
BDI does not Granger Cause RBT	33.591	4	0.0000*
RBT does not Granger Cause BDI	5.144	4	0.2728

Notes: (1) Null of Non-causality was rejected at *1%.

In Figure 5, the reaction of the recycling to the 1 standard deviation shock in the BDI over time is shown by impulse & response analysis. The shock of increase in freights causes a decrease in the amount of ships going for scrapping. While there is a 30% decrease in the ships going for recycling in the first period when the shock first arrives, the effect of this shock is reset after about 3 periods, and it is removed from the system. Minor fluctuations remain in the system. This situation can be easily explained theoretically by the fact that old and uneconomical ships also get contracts due to the increasing freights, and the ships are operated instead of being sent for recycling.

When there is a shortage of supply in the maritime market, new ships are constructed, balancing the market. But the delivery time of the ships is very long. For example, the delivery of the ships ordered as of 2023 is shown between 2025 and 2027, depending on the complexity of the construction Athenian S.A. (2023). Therefore, the stabilization in the graph cannot be explained by this. This can be explained by the high volatility of dry bulk freight. Freights have a standard deviation of 82%, so the market can take shape very quickly.

Figure 5. Response of RBT to BDI



Note: Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

After the impulse & response analysis, we applied the variance decomposition analysis and presented the results in Table 7. Variance decomposition analysis helps to understand how much of the variation in the variance of a given variable over time is contributed by other factors. The table contains the decomposed values of the RBT variable. Accordingly, while the BDI variable explains approximately 21% of the changes in the RBT variable in the early periods, this ratio decreases to 18% over time. So, the market is balanced. Also, a large part of the variation in ship recycling is due to its historical values.

Table 7. Variance Decomposition of RBT

Period	S.E.	LN BDI	LN RBT
1	0.293070	21.00733	78.99267
2	0.294056	20.93113	79.06887
3	0.304202	20.19691	79.80309
4	0.304475	20.01124	79.98876
5	0.308374	18.85423	81.14577
6	0.309911	18.82150	81.17850
7	0.310874	18.85238	81.14762
8	0.311106	18.85614	81.14386

Note: Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

5. Conclusion

The ship recycling industry is basically positioned under a two-way influence. The first is the maritime side, and the second is the iron and steel side. On the maritime side, it is mainly concerned with the removal of old ships that cannot carry out their economic activities from the market and their return to the economy. Thus, it contributes to the renewal of the global fleet, to the reduction of transportation and insurance costs, and to the reduction of environmental risks caused by old ship accidents. On the iron and steel side, although its environmental dimensions cause irreversible damage, the ship recycling industry provides important inputs to both the labor force and the sectors in countries where steel use is intense. Besides it is used extensively in the construction and infrastructure sectors, it is also partially used in the automotive, production, containerization and construction of renewable energy structures. Hence, the sector also has important contributions to regional economies.

Freight rates are the factor that affects it the most in the maritime market because freight is the most important factor that determines the profitability of shipping companies. In other words, it is the price of the transportation service that companies sell. In addition, in the maritime market, especially in the dry bulk market, each ship can be considered as a separate business in a perfectly competitive market. The costs of each differ due to the age and size of their ships. In addition, the demand for each ship size can change rapidly depending on the type of cargo, the problems in the global supply chain, and the political relations between countries. Considering the ships as separate businesses, the average transportation (service production) costs of each are also different. Older ships have higher average costs due to increased maintenance & repair and insurance costs. Therefore, when the price of transport services (freight rate) in the market falls, the older ones are affected first. Since they cannot carry out profitable operations, they are sent directly to recycling or if they expect freight to rise, they operate at a loss to a point. However, as expected, if freight rates continue to be low, they will inevitably be sent for ship recycling. On the other hand, if freight rates are on the rise and there are expectations that they will be higher in the future, old ships will continue to operate, and their economic life will be extended for a few more months or years. In this case, the ship tonnage going to ship recycling decreases. Thus, freight rates are the most important determinant of traffic in the ship recycling industry.

In our research, we examined the relationship between freight rate and ship tonnage sent for recycling with a causality approach for the dry bulk market. When we analyzed the data, we saw that the volatility rates are high, especially the DWT variable has very high volatility and risk. This is basically related to the fact that the dry bulk market is close to the perfectly competitive market and the shipping cycles can change very quickly. Even the seasonal cycles in the market have a very high impact. It is also clearly seen in the graphic in which seasonal factors are presented. There is a significant increase in freights in Q4. In recycling, there is a significant decrease in Q3 and Q4. Shipowners who expect freight rates to increase in the last quarter may be delaying sending their ships to recycling. In the first quarter of recycling, seasonal increases occur in ship dismantling in parallel with the seasonal decreases in freight. We also verified that relationship by the correlation and found a negative relationship between the variables. Naturally, when the freight rates increase, the tonnage for dismantling decreases and vice versa. In the literature, there are studies that reveal this relationship with econometric methods. However, we aimed to differentiate from the others with a study that focused only on the dry bulk market and also modeled the possible lagged effects of the interaction.

In the standard unit root tests we applied, we determined that the series were stationary. However, due to the non-normal distribution of the series, we supported our results with the variance ratio test, which is a non-parametric test. This test showed that the series are martingale, that is, they move randomly. For this reason, we preferred to use the first differences of the series in the analyses. In addition, the fact that the series are not stationary also means that the shocks they are exposed to have permanent effects. In this permanence, the cycles in the maritime market and the herd behavior of the enterprises in the market are also effective.

As a result of the causality analysis, we found a unidirectional relationship from freight to recycling tonnage, as we expected. Theoretically, there may be an inverse relationship, because the decrease in ships in the market may decrease the supply and thus increase the freight rates. However, this relationship could not be statistically supported, probably because it was not very strong. In addition, in the impulse & response analysis, we found that a 1 standard deviation positive shock in freights had a negative effect on the recycling tonnage and this effect lost its effect after about 3 periods (quarter). We also saw that the impact of the shock was highest in the first period. In case of a negative shock in freight, the first reaction is the highest in the first period. This situation can be likened to a kind of shaking. In some cases, old ships are shaken off the market when the market is shaken, just as the ripe fruit falls off when the tree is shaken. This shaking keeps the fleet vigorous and dynamic.

In the variance decomposition analysis, we determined that most of the changes in the recycling tonnage were due to their own historical values. Freights account for an exchange rate of approximately 21%. This may be due to the close relationship of the recycling market with other markets. For example, when prices rise in the secondhand ship market, shipowners may continue to use their ships instead of sending them for dismantling. In addition, changes in steel prices also affect the demand for ships to be dismantled. At low steel prices, dismantling ships loses its financial advantage, as dismantling centers will also offer lower prices. International steel prices directly affect the profitability of dismantling centers. In addition, since the demand for scrap iron is narrower than crude steel in the sector, developments in the construction sector are of great importance for the shipbreaking demand.

In this study, we examined the relationship between freight and dismantling tonnage using a linear method. Since the distributions of the series are not normal, nonlinear methods may be preferred in future studies. In addition, panel models can be applied by considering variables related to other maritime markets such as containers and tankers. Thus, possible similarities and differences between shipping sectors can be revealed.

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