Received: 09.04.2023
Accepted: 22.10.2023
Published Online: 29.12.2023
DOI: 10.18613/deudfd.1279863
Research Article

Dokuz Eylül University
Maritime Faculty Journal
Vol:15 Issue:2
Year:2023 pp:166-188
E-ISSN: 2458-9942

ESTIMATION OF WORLD MARITIME TRADE VOLATILITY WITH DAY OF THE WEEK ANOMALY: BALTIC DRY INDEX APPLICATION

Erkan IŞIĞIÇOK[1]
Savaş TARKUN[2]

ABSTRACT

The Baltic Dry Index is one of the crucial indices, as it shows the average transportation of raw materials and freight prices by sea. While the high demand for dry cargo transportation indicates that raw material trade is increasing globally, raw material trade decreases when demand decreases. In the maritime industry, the excess or low tonnage of ships is one of the crucial factors affecting freight rates. This study examined the days of high and low volatility in the return series of the Baltic Dry index with the day-of-the-week anomaly. The findings obtained from the study show that the volatility of the return series of the Baltic Dry index increased on Tuesdays at a significance level of 0.05 and that the volatility decreased on Fridays. This shows that price movements deviate from the Efficient Market Hypothesis, and the market is inefficient. Therefore, it has been determined that an inefficient market has extraordinary profits from using past information and hiding information. This study is thought to contribute to foreign trade companies and the transportation sector by determining the days when earnings are high and/or low.

Keywords: *Heteroskedasticity, Volatility, ARCH Effect, Anomaly, Baltic Dry Index*

[1] Prof. Dr., Bursa Uludağ Üniversitesi, İktisadi ve İdari Bilimler Fakültesi, Ekonometri Bölümü, eris@uludag.edu.tr, ORCID: 0000 0003 4037 0869.
[2] **Sorumlu Yazar:** Dr., Bağımsız Araştırmacı, savastarkun@gmail.com, ORCID: 0000-0002-2684-184x.

HAFTANIN GÜNÜ ANOMALİSİ İLE DÜNYA DENİZ TİCARETİ OYNAKLIĞININ TAHMİNİ: BALTIK KURU YÜK ENDEKSİ UYGULAMASI

Hammaddelerin denizyolu ile taşınması ve navlun fiyatlarının ortalamasını göstermesi sebebi ile Baltık Kuru Yük Endeksi önemli endekslerden biridir. Kuru yük taşımacılığının yüksek talebe sahip olması, dünyada hammadde ticaretinin yükseldiğini gösterirken, talep azaldığında ise hammadde ticaretinin azaldığı söylenebilir. Denizcilik sektöründe, gemilerin tonajlarındaki fazlalık veya tonajın az olması navlun bedellerini etkileyen önemli faktörlerden biridir. Bu çalışmada ise Baltık Kuru Yük endeksinin getiri serisindeki oynaklığın yüksek olduğu ve düşük olduğu günler, haftanın günü anomalisi incelenmiştir. Çalışmadan elde edilen bulgular ise Baltık Kuru Yük endeksinin getiri serisinin 0.05 anlamlılık düzeyinde salı gününde oynaklığın arttığını ve cuma günlerinin ise oynaklığın azaldığı tespit edilmiştir. Bu ise Etkin Piyasa Hipotezinden sapan fiyat hareketlerinin olduğunu ve piyasanın etkin olmadığı sonucunu göstermektedir. Dolayısıyla etkin olmayan piyasanın geçmiş bilgiler kullanılarak ve bilginin gizlenmesi yoluyla elde edilen olağandışı kazançların olduğu tespit edilmiştir. Bu çalışmanın, kazancın yüksek ve/veya düşük olduğu günlerin belirlenmesi ile dış ticaret firmaları ve taşımacılık sektörüne katkı sunacağı düşünülmektedir.

Anahtar Kelimeler: *Değişken Varyans, Oynaklık, ARCH Etkisi, Anomali, Baltık Kuru Endeksi*

1. INTRODUCTION

The Baltic Dry Index (BDI) is one of the most essential indices used in the worldwide shipment of raw materials used in production and as a leading indicator of economic activities. Apergis and Payne (2013) stated in their study that BDI can provide predictions of the course of the real economy and that this is a connection between financial markets and the macroeconomy. This index measures the cost of transporting raw materials by sea. It is an important indicator that measures the changes in transportation costs of raw materials transported by sea. BDI is used by shipping companies as a strategic tool to monitor the daily movement of freight rates for bulk cargo transportation on predetermined routes for different bulk carriers.

The emergence of the index was announced by the London-based Baltic Stock Exchange; coal, iron ore, grain, etc. is defined as the index of average prices paid for the transport of dry bulk materials for 26 different shipping routes that carry out the shipment of many commodities (Radivojevic et al. 2021). Published by the Baltic Stock Exchange, BDI is also referred to as a "barometer" of shipping cargoes 2010) and is defined as an important indicator in the maritime industry, international trade, and the global economy (Pascali, 2017).

BDI calculations are obtained based on some types of ships engaged in offshore trade (Cihangir, 2018: 2). The calculation has a series of subdivisions, and some of these subdivisions are as follows: Capesize 125,000–219,999 Dwt[3], the carrying capacity is in the first place. The next type of ship is a Panamax ship. The carrying capacity of these ships is 60,000–79,999 Dwt; the capacity of the Supramax ship type is 50,000–59,999 Dwt; Handymax ships are 40,000–49,999 Dwt; and Handysize ships have a carrying capacity of 20,000–39,999 Dwt (Katris and Kavussanos, 2021).

The following information is taken into account when calculating BDI: The Baltic Capesize Index (BCI) is calculated according to the transport costs on the 10 available routes for the dry cargo ship, and each route is weighted according to the importance of the other 9 routes. The Baltic Panamax Index (BPI) is calculated on the basis of the 4 available routes for a Panamax dry cargo ship, each with the same weight (25%). Supramax ships have 6 sightseeing charter routes and 3 charter routes. However, the Supramax Index (BSI) is based on only 6 sightseeing rental routes. Only 2 routes weight 25%, while each of the other 4 routes weighs 12.5%. Finally, the Baltic Handysize Index (BHI) consists of a total of 6 routes. The weight of 2 of them is 25% for each; the weight of each of the other 4 is 12.5% (Geman and Smith, 2012: 100). Therefore, the BDI index is obtained by the arithmetic averages of these indices.

Freight rates for each of the above-mentioned dry cargo transportation industries are determined on a daily basis according to the current supply-demand conditions in each market where full or near-perfect competition conditions are considered to prevail. The Baltic Stock Exchange, according to the above types of ships, creates different routes for each of them, as well as freight rate indices for each section itself. The primary data used to create these calculations and indices is obtained from the most important shipbrokers repairing ships around the world (Katris and Kavussanos, 2021). BDI is created to reflect the overall freight rates earned in the dry cargo sector, especially in the maritime sector.

The dry bulk transportation industry provides a homogeneous and exchangeable transportation service with many participants, where freight rates for each of the above are determined daily according to the supply-demand conditions in each market, where perfect or near-perfect competition conditions are thought to prevail (Stopford, 2008). Therefore, when the information in the market reaches all participants and this does not affect the prices, the existence of the efficient market hypothesis can be said (Açık and Başer, 2018). However, the suitability of BDI for the

[3] Deadweight Ton Unit (Dwt): It is a weight measurement unit used in international maritime trade (Pepur, et al., 2022).

efficient market hypothesis has begun to be discussed. The traditional efficient market hypothesis (EHM) form of freight prices cannot be applied to freight prices when it is considered a non-storable and non-tradable transportation service. However, EHM can be applied to freight markets (Adland and Strandenes, 2006).

According to this hypothesis, extraordinary profits are unlikely to be achieved because prices reflect all information at any given time. However, EHM can be applied to freight markets (Fama, 1970). According to EHM, three different activity forms can be mentioned (Adland and Strandenes, 2006): First, it is called strong form if all public and private information can be reflected. Another is a semi-strong form that can reflect all publicly available information. In contrast, the last one can be mentioned as weak form efficiency if the current price of an asset can reflect all information in past prices. Therefore, according to EHM, technical trading rules that focus on historical data in buying and selling decisions should not result in extraordinary economic profits (Ådland and Koekebakker, 2004).

On the other hand, changes in BDI are associated with changes in commodity prices. Therefore, due to the fact that BDI's commodity prices change throughout its behavior, it is sensitive to the demand for raw materials and global trade (Kim, 2016; Höl et al. 2022). Due to the fact that there are futures contracts with BDI and the freight market can also reveal the speculative actions of market participants, it can be said that BDI also reflects speculative movements. In addition, BDI predicts the growth in global economic activity, and its contribution to revealing the connection between the fundamental and financial sectors is very high. For this reason, the growth rate of BDI is a familiar predictor of the returns of commodity indices and stock and commodity returns (Bakshi et al. 2012).

While the high demand for dry cargo transportation indicates that raw material trade is increasing worldwide, the decrease in demand for dry cargo transportation is an important leading indicator that shows that world raw material trade is decreasing. The primary motivation of this study is that the increase in the average of BDI over time indicates a growth in world raw material trade, while the decrease in the average indicates a contraction in world raw material trade. In this study, the days of the week on which there is an increase (return is high) and/or a contraction (return is decreasing) in raw material trade are discussed with the day-of-the-week anomaly.

In the following sections of the study, after reviewing the relevant literature, the concept of conditional heteroscedasticity model and anomaly is mentioned in the title of the application method. The following heading shares the findings obtained by adhering to the application method.

2. RELATED LITERATURE

This heading mentions studies carried out with BDI in the literature. Since this index is an essential reference, especially for the prices of ship charter contracts, it is vital to have information about its behavior. Modeling calendar effects in financial markets is essential for researchers and financial practitioners, especially regarding its applications in index return forecasting. For this reason, although anomaly studies on the Baltic Exchange are limited, volatility studies are more intense. Studies on the anomaly generally focus on financial instruments, and the validity of the efficient market hypothesis has focused on this area. Additionally, since the subject of the study is volatility and anomalies, studies on the applications of Autoregressive heteroscedasticity models related to the Baltic Exchange and studies specific to volatility and calendar anomalies are mentioned.

Fan et al. (2014) estimated the volatility of the Baltic Capesize (BCI) index, one of the sub-indexes of BDI, and as a result of trying various ARCH-GARCH models, they concluded that the GARCH (1,1) model was the most suitable model for this index. Hsiao et al. (2014) investigated the return lag and volatility between dry bulk cargo transportation and container shipping freight markets for the China Container Freight Index (CCFI) before the 2008 crisis, at the time of the crisis, and during the period after, and used the GARCH-BEKK model that allows volatility spillover. The findings concluded that BDI reflected the economic environment before CCFI during the financial crisis and that CCFI led BDI after the financial crisis. One study proposes a method based on empirical mode decomposition to investigate BDI volatility (Zeng and Qu, 2014). Kim's (2016) study examined the effects of exchange rate (USD/KRW) and BDI volatility, which is global economic activity, on the port cargo volume loaded in South Korea. According to the findings, it was concluded that BDI volatility was negatively affected, while increases in the exchange rate due to global economic activities had a positive effect.

Sariannidis et al. (2015) worked with daily data covering 2004–2014 and found that USD/Yen exchange rate volatility and BDI volatility significantly negatively affected the oil market. In a study, they used GARCH-MIDAS-X models for volatility and DCC-MIDAS-X models for dynamic correlation to investigate the impact on volatilities and correlations associated with BDI and the Chinese stock market. Their findings concluded that BDI is a critical determinant of the long-term component. that the correlation between the two markets gradually became They found negative (Li et al. 2017). In another study conducted with various commodities, they examined the volatility spread relationship between BDI, oil prices, gold prices, the dollar index, and the MSCI World

Index and found that BDI, oil prices, and MSCI spread volatility (Höl et al. 2022).

Adland and Strandenes (2006) examined the efficiency of the efficient market hypothesis of the dry bulk index. In a similar study, the validity of BDI's efficient market hypothesis was tested using data consisting of daily observations from 1985–2017. As a result of the study, they found that the efficient market hypothesis is not valid for the BDI market, and profit opportunities arise in the market (Açık and Başer, 2018). A study examining the efficient market hypothesis of the BDI market with an anomaly determined that the returns on Monday were positive compared to other days (Kasra, 2021).

Some of the studies carried out on calendar anomalies can be summarized as follows:

Examined the behavior of stock prices on Friday and Monday (Cross, 1973). A similar study examined the weekend effect specifically on stock returns (French, 1980; Lakonishok and Levi, 1982). Thaler (1987) investigated the January effect in his study. Doyle and Chen (2009) discuss the traveling weekday effect in major stock markets.

Barone (1989), in his study on a stock on the Milan Stock Exchange, obtained results showing that Friday and Monday are statistically significant. A study conducted for Asian markets found that the day-of-the-week effect is statistically significant in both returns and volatility (Choudhry, 2000). In another study on the Chinese stock market, one of the Asian stock markets, they proved that there are return differences on Tuesdays and Fridays compared to other days (Zhang and Li, 2006). A study conducted for the South African stock market revealed that Mondays were the days with the lowest returns, while Fridays were the days with the highest returns du Toit et al. 2018). In the day anomaly study carried out for the Australian market, they concluded that the return series of the Australian stock market was low on Tuesday and high on Friday (Davidson and Faff, 1999). In another study, a day of the week anomaly was performed for the S&P 500 market. According to the findings, the lowest volatility was on Friday and Wednesday (Kiymaz and Berument, 2001). One study examines the day-of-the-week anomaly for the quality-minus-junk (QMJ) market (Chiah and Zhong, 2019). In their study, Basher and Sadorsky (2006) examined the stock markets of the Philippines, Pakistan, and Taiwan, which are considered emerging markets, with the day-of-the-week anomaly. A study dealt with the day-of-the-week anomaly for the stock markets of East Asian countries, namely South Korea, Taiwan, Singapore, and Hong Kong (Chia et al. 2008).

Undoubtedly, it is possible to find studies on anomalies in the literature. As mentioned, calendar anomaly studies were carried out for financial instruments such as the stock market, stocks, and exchange rates.

The most important contribution that distinguishes this study from other studies is the examination of BDI, one of the important leading indicators of dry cargo transportation, with its volatility and day-of-the-week anomaly.

3. METHOD: AUTOREGRESSIVE CONDITIONAL HETEROSCEDASTICITY (ARCH) MODEL

Under this heading, information about the method examined in the study and some preliminary tests before the implementation of this method are presented.

3.1. Unit Root Tests

It is a preliminary test that should be considered in studies with time series. When these test findings are not considered in studies carried out with non-stationary time series, it may cause unreal relationships in the series, known as spurious regression. This study examined the unit root test with Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests. Accordingly, let the unit root tests, which include models with constants, constants, and trends, be represented by a time series such as y_t . In this case, the ADF unit root test is obtained with Equations 1 and 2, respectively:

Constant Model;

$$\Delta X_t = \mu + \delta \Delta X_{t-1} + \varepsilon_t \quad (1)$$

Constant and Trend Model;

$$\Delta X_t = \mu + \beta t + \delta \Delta X_{t-1} + \varepsilon_t \quad (2)$$

it is tested with. Based on these equations, the following hypotheses were tested:

$H_0: \delta \geq 0$ (The series is not stationary. There is a unit root)

$H_1: \delta < 0$ (The series is stationary. There is no unit root)

The Phillips-Perron test is the only way it differs from the ADF unit root test because it considers the autocorrelation between error terms. Since

ADF was tested with a hypothesis like the unit root test hypothesis, repetition was avoided.

3.2. Autoregressive Conditional Heteroscedasticity (ARCH) Model

Engle (1982) expanded the constant variance assumption in his study and introduced a new class of stochastic processes, defined as the ARCH (AutoRegressive Conditional Heteroscedasticity) process, to the literature. Engel says these processes with a zero mean do not have unconditional variance but vary depending on past-period errors. Therefore, the ARCH model includes both the mean and conditional variance in estimating time series variables, a stochastic process. Let the proposed model be a first-order autoregressive process (Engle, 1982: 987), as shown in Equation 3.

$$y_t = \gamma y_{t-1} + \varepsilon_t \tag{3}$$

ε_t in Equation 3 has a white noise process with zero mean and $V(\varepsilon_t) = \sigma_\varepsilon^2$. In Equation 3, the conditional mean of y_t is γy_{t-1}, while its unconditional mean is equal to zero (0). In addition, the unconditional variance of y_t is $\frac{\sigma^2}{(1-\gamma^2)}$, while its conditional variance is σ^2 (Engle, 1982: 988). In this proposed approach, conditional predictions are made since the variables include current and past observations in the model and, therefore, have a more minor prediction error variance (Nargeleçekenler, 2004: 155). According to this,

$$y_t = \varepsilon_t y_{t-1} \tag{4}$$

In Equation 4, the conditional variance is $\sigma^2 y_{t-1}^2$. Nevertheless, the unconditional variance is 0 or infinite. Therefore, the preferred model is as in Equation 5:

$$y_t = \varepsilon\sqrt{h_t} \tag{5}$$

And

$$h_t = \alpha_0 + \alpha_1 y_{t-1}^2 \tag{6}$$

is happening. In these equations, $V(\varepsilon_t) = 1$. ARCH models can be described as nonlinear models. Equations 5 and 6 can be rewritten to denote the information set at period t by Ψ_t:

$$y_t|\Psi_{t-1} \sim N(0, h_t) \quad (7)$$

$$h_t = \alpha_0 + \alpha_1 y_{t-1}^2 \quad (8)$$

Additionally, the conditional variance equation can be expressed more generally, as in Equation 9:

$$h_t = f(y_{t-1}, y_{t-2}, \dots, y_{t-p}, \alpha) \quad (9)$$

In Equation 9, p indicates the unknown degree of the ARCH process, while α is a vector of unknown parameters. Thus, the ARCH model introduced to the literature is as in Equation 10:

$$y_t|\Psi_{t-i} \sim N(x_t b, h_t)$$

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \cdots + \alpha_p \varepsilon_{t-p}^2 = \alpha_0 + \sum_i^p \alpha_i \varepsilon_{t-i}^2 \quad (10)$$

$$\varepsilon_t = y_t - x_t b$$

It is obtained as (Engle, 1982: 989). In the ARCH model, the variable y_t has a normal distribution, with an $x_t b$ conditional mean and an h_t conditional variance, depending on the information set Ψ_{t-i} (Işığıçok, 1994: 10). Additionally, there are some restrictions regarding the coefficients in the ARCH model. All $(\alpha_0 \; ve \; \alpha_i)$ coefficients in the model must be positive. Another important constraint is that α_i >1 (Engle, 1982: 993).

3.3. Anomalies

As mentioned in the introduction to EPH, there is transparency in the markets. Information about the markets is available to all parties. Therefore, it is impossible to obtain extraordinary returns from a financial instrument. Many studies have been carried out to test the existence of this assumption (French, 1980; Atakan, 2008; Doyle and Chen, 2009). However, essential findings from the studies reveal that returns constantly deviate from the average. Anomaly is defined as unusual movements contrary to the theory that known rules cannot explain (Thaler, 1987).

The anomalies existing in the markets can be grouped under three headings (Güç et al. 2016): There are calendar anomalies; another type of anomaly are company anomalies and price anomalies. Since the subject of this study is the calendar anomaly, it is briefly mentioned. According to EHM, the return on financial assets is utterly unrelated to time. Because it is not possible to see differences in returns over time. However, studies examining the subject have shown that the opposite of this situation exists.

It has been determined that this difference differs significantly from other periods in certain months, days, and holidays. Therefore, there are various calendar anomalies in the literature. These are (Aygün, 2021: 23): Different anomalies, such as day of the week anomalies, holiday anomalies, intra-month anomalies, month of the year anomalies, and lunar return anomalies, have been introduced.

3.4. Day of the Week Anomaly

This anomaly assumes that Fridays generally have positive average returns and Mondays have negative average returns (Cross, 1973). However, different types of these days can be seen, from not having differentiated returns to any day providing more returns than other days (Doyle and Chen, 2009).

4. APPLICATION

The study obtained BDI data based on 262-day data for 01/07/2021–01/07/2022 from the investing.com website (investing.com). This period was chosen as one year to determine the effects of the destruction caused by the COVID-19 epidemic on the world's raw material trade. Accordingly, the logarithms of the variables were taken from the BDI price variable to obtain the return series. In addition, the return series of the variable used in the study was affected by the fact that some negativities occurred in the periods subject to the study, and deviant values were encountered in the face of shocks arising from these negativities (Bruffaerts et al. 2014). One period difference of the price series, whose logarithm was taken, was obtained from the return series with the help of the following equation (Açık and Başer, 2017):

$$R_{BDI} = lnBDI_t - lnBDI_{t-1} \quad (11)$$

In this equation, $lnBDI_t$ is the index t. While $lnBDI_{t-1}$ represents the closing price on day $t-1$. Time path graphs of the index and return series in question are shown in Figure 1 and Figure 2.

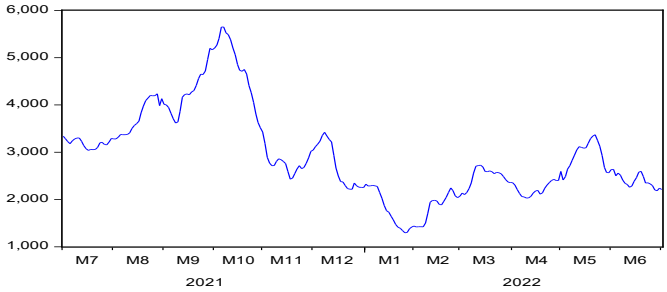

Figure 1: Time Path of the Baltic Dry Index

When Figure 1 is examined, it is observed that the normalization process after the COVID-19 pandemic, which shook the world in 2020, was quickly reflected in the world raw material trade in the third quarter of 2021. However, the decline from the last quarter of 2021 continued and reached its lowest levels in the first months of 2022.

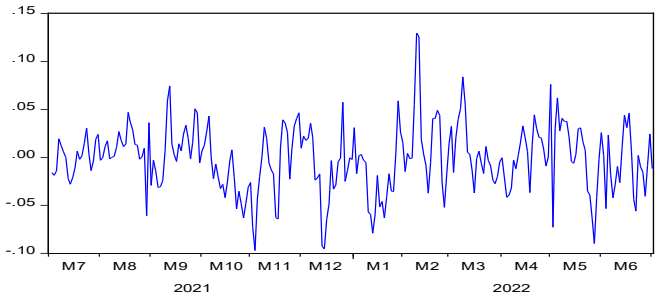

Figure 2: Return Series of Baltic Dry Index

When the R_{BDI} variable in Figure 2 is examined, the return series does not remain constant around the average. The findings of the ADF and PP unit root tests regarding the variable in question are presented in Table 1.

Table 1: Unit Root Test Findings

	PP		ADF	
At Level	**With Constant**	**With Constant & Trend**	**With Constant**	**With Constant & Trend**
R_{BDI}	-7.8804	-7.8651	-8.0097	-7.9956
(Prob)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Note: The lag length Schwarz information criterion was considered for the ADF unit root test. For the PP unit root test, band length Newey-West was considered.

When the unit root test findings of the R_{BDI} variable in Table 1 are examined, the t-statistic value calculated for the ADF unit root test for models with constant, constant, and trend, and the Adj. $t-stat$ values calculated for PP are less than the relevant critical values (1%, 5% and 10%) or in absolute value with the same meaning. It was concluded that the values are more significant than the critical values (and prob. values are less than 1%). Therefore, the null hypothesis in the stationarity hypothesis sets is rejected. According to this finding, there is no unit root in the R_{BDI} variable, and the series is stationary.

After the unit root test, an autoregressive moving average (ARMA) model was created by conducting various experiments to determine the average equation for the relevant variable (Nargeleçekenler, 2004). The information criteria findings of the best models selected from the estimated models regarding the R_{BDI} variable are presented in Table 2.

Table 2: Information Criterion Findings of Estimated ARMA Models

Criteria	**(1,1)**	**(1,2)**	**(1,3)**	**(2,1)**	**(2,2)**	**(2,3)**
AIC	-4.3310	-4.3240	-4.3236	-4.3314*	-4.3238	-4.3182
SC	-4.2899*	-4.2692	-4.2551	-4.2764	-4.2551	-4.2358
HQ	-4.3145*	-4.3019	-4.2961	-4.3093	-4.2962	-4.2850

Source: Created by the authors.

Note: Those marked * indicate the smallest values according to the information criterion.

To determine the appropriate average model, according to the AIC (Akaike Information Criterion) of the models temporarily selected from the predictions made and listed in Table 2, the most suitable model is ARMA (2,1), while SC (Schwarz Information Criterion). According to HQ (Hannan-Quinn Criterion), the ARMA (1,1) model has the smallest value. Since the ARMA (1,1) model gives the smallest value according to both

criteria, it was chosen as the average model of the ARCH model. For the appropriately selected ARMA (1,1) model, the existence of the ARCH effect was tested with the ARCH-LM test by substituting the errors obtained from Equation 12 below with Equation 13:

$$R_{BDI_t} = c + \theta_1 lnR_{BDI_{t-1}} + \theta_2 R_{BDI_{t-2}} \dots + \theta_p R_{BDI_{t-p}} + \varepsilon_t \quad (12)$$

$$\hat{\varepsilon}_t^2 = c + \alpha_1 \hat{\varepsilon}_{t-1}^2 + \cdots + \alpha_q \hat{\varepsilon}_{t-q}^2 + v_t \quad (13)$$

With the help of the equation above, the existence of the ARCH effect was tested with the following hypothesis:

H_0: $\alpha_1 = \alpha_2 = \cdots = \alpha_q = 0$

H_1: $\alpha_i > 0$ (at least one of them is nonzero)

The findings of the ARCH-LM test are as in Table 3.

Table 3: Heteroskedasticity Test: ARCH-LM Test

F-statistic	65.34611	Prob. F(1,257)	0.0000
T*R^2	52.50457	Prob. χ^2(1)	0.0000

Source: Created by the authors.

According to the results of the χ^2 value calculated with $T * R^2$ in Table 3, the null hypothesis was rejected, and it was determined that the variance of the R_{BDI} variable did not remain constant over time; therefore, the variance of this variable changed over time and carried the ARCH effect.

After determining the presence of heteroscedasticity in the ARMA (1,1) model with the ARCH-LM test, various variance equations (models) were created to eliminate this effect. To determine the day of the week anomaly, the following equations were used:

$$R_{BDI_t} = \mu + \phi_1 R_{BDI_{t-1}} + \theta_1 \varepsilon_{t-1}$$

$$h_t = \alpha_0 + \alpha_i \varepsilon_{t-i}^2 + D_{Monday}$$

$$h_t = \alpha_0 + \alpha_i \varepsilon_{t-i}^2 + D_{Tuesday}$$

$$h_t = \alpha_0 + \alpha_i \varepsilon_{t-i}^2 + D_{Wednesday}$$

$$h_t = \alpha_0 + \alpha_i \varepsilon_{t-i}^2 + D_{Thursday}$$

$$h_t = \alpha_0 + \alpha_i \varepsilon_{t-i}^2 + D_{Friday}$$

The results proceeded in two different ways. First of all, after determining the existence of the ARCH effect of the R_{BDI} variable, before

estimating various ARCH-GARCH models, the descriptive statistics of the R_{BDI} variable are shown in Table 4.

Table 4: Descriptive Statistics Findings

Statistic	$\mathbf{R_{BDI}}$
Mean	-0.00157
Median	-0.00044
Maximum	0.12962
Minimum	-0.09713
Std. Dev.	0.03446
Skewness	0.08925
Kurtosis	4.07308
Jarque-Bera	12.86913
Probability	0.001605
Sum	-0.41057
Sum Sq. Dev.	0.308743
Observations	261

Note: The Jarque-Bera test result is more significant than 5.99 (or Prob. Value is less than 0.05), so the relevant series does not exhibit a normal distribution (Karcıoğlu and Özer, 2017:466).

According to the results obtained from Table 4, a positive skewness value indicates that the series is skewed to the right. Additionally, a kurtosis value greater than 3 indicates that the series has a pointed structure (Brooks, 2008: 381).

In line with these results, various predictions were made with Autoregressive conditional heteroscedasticity models (ARCH, GARCH family). Specific to the period considered, the results in Table 5 were obtained by considering the restrictions on ARCH coefficients in the estimates brought.

Table 5: Day of the Week Anomaly Results

Parameter	**Mean Equation ARMA (1,1)**				
μ	-0.0021	-0.0011	-0.0022	-0.0023	-0.0026
	(0.5653)	(0.7452)	(0.5470)	(0.5303)	(0.4716)
ϕ_1	0.4900	0.4513	0.4879	0.4895	0.4814
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
θ_1	0.2996	0.3269	0.3137	0.3009	0.3319
	(0.0007)	(0.0001)	(0.0004)	(0.0006)	(0.0000)
	Variance Equation ARCH (1)				
α_0	0.0005	0.0004	0.0005	0.0005	0.0005
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
α_1	0.3164	0.3076	0.3307	0.3244	0.3756
	(0.0145)	(0.0127)	(0.0086)	(0.0124)	(0.0063)
D_{Monday}	-0.0001	-	-	-	-
	(0.3843)				
$D_{Tuesday}$	-	0.0006	-	-	-
		(0.0441)			
$D_{Wednesday}$	-	-	-0.0001	-	-
			(0.4237)		
$D_{Thursday}$	-	-	-	0.0000	-
				(0.9142)	
D_{Friday}	-	-	-	-	-0.0003
					(0.0021)
GED	1.4194	1.5159	1.4641	1.4399	1.4496
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
AIC	-4.4733	-4.5128	-4.4743	-4.4713	-4.4930
SIC	-4.3775	-4.4169	-4.3784	-4.3754	-4.3971
HQ	-4.4348	-4.4743	-4.4358	-4.4327	-4.4545
DW	2.2836	2.2638	2.3083	2.2851	2.3328
ARCH LM	4.0061	3.5832	2.5402	2.6258	1.1805
Prob. F	0.0464	0.0595	0.1122	0.1064	0.2783

Note: Values in parentheses are probability (prob) values. The μ parameter in the table is the constant term of the average equation, ϕ_1 is the parameter of AR(1), and θ_1 is the parameter of MA(1). α_0 in the variance equation represents the constant of the ARCH model, and α_1 represents the ARCH coefficient. D represents the dummy variable for the relevant day.

In the study, since the lines of the R_{BDI} variable did not exhibit a normal distribution and the kurtosis value was more significant than 3 (Table 4), the error terms of the ARCH model were estimated with Generalized Error (GED). According to the information in Table 5, it is observed that the Durbin Watson (DW) statistic being around 2 indicates that there is no autocorrelation, and according to the ARCH-LM test result, the heteroscedasticity problem is eliminated in all models except Monday at the 0.05 significance level. The coefficients of Tuesday and Friday, which were included in the model with the dummy variable, were found to be statistically significant at the 0.05 significance level. In addition, among the models in which days were included, it was determined that the model with the smallest value according to all three information criteria was the model belonging to Tuesday. From the models created according to days, it was obtained that the coefficient of Tuesday was positive and the coefficient of Friday was negative. Since the parameters of the dummy variables for Monday, Wednesday, and Thursday were found to be statistically insignificant, it was concluded that these days did not cause any volatility in the return series of the BDI variable.

5. CONCLUSIONS

The Baltic dry index meets market conditions of near-perfect competition. Because transportation transactions are carried out with many buyers and sellers, although the flow of information is limited, those with high bargaining power in this market do not seek to share information because their access to information and information capacity will benefit the interests of medium- and small-sized companies rather than their impact on the market. Therefore, this situation causes the effectiveness of BDI to be questioned.

The study investigated the volatility of the business day closing values of the BDI variable for the period 01/07/2021-01/07/2022. It revealed whether the volatility showed an anomaly on the days of the week. In the study, 262 data points were used, and the return series (R_{BDI}) was obtained by taking the logarithmic difference of the BDI index data.

Among the autoregressive moving average models applied to the R_{BDI} variable, the ARMA (1,1) model was chosen as the model that best fits the statistical and econometric criteria, and it was determined that there was an ARCH effect in this model. Later, the ARCH (1) model, one of the autoregressive conditional heteroscedastic models applied to the R_{BDI} variable, was selected as the model that best fits the statistical and econometric criteria, and it was observed that the ARCH effect disappeared in this model.

In addition, dummy variables were included separately in the variance equation in the ARCH (1) model for each day to avoid falling into the dummy variable trap and reveal each day's effect. From these models, it was seen that the parameters of the dummy variable for Tuesday and Friday were statistically significant. These findings concluded that Monday, Wednesday, and Thursday do not contain day anomalies, whereas Tuesday and Friday have an anomaly effect. This also shows that price movements deviate from the Efficient Market Hypothesis and that the market is inefficient. At this point, market participants' open and transparent access to information will contribute to re-establishing full competition conditions in this market. However, the findings have shown statistically that the information obtained does not reach the complete information, and the volatility in the return of BDI intensifies on Tuesdays and Fridays. Therefore, it will be possible to prevent the extraordinary gain obtained by using past information in an inefficient market and hiding the information.

A comprehensive study on the calendar anomaly for various indices in the Baltic Exchange has yet to be found in the literature. In this study, which examines the calendar anomaly with BDI, the most important index of the maritime economy, results parallel to the studies in the literature showing that BDI does not have the features of the efficient market hypothesis (Adland and Strandenes, 2006; Alizadeh and Nomikos, 2007; Açık and Başer, 2018; Kasra, 2021) were obtained. In other words, the findings in the study are parallel to the studies in the literature, as BDI is inconsistent with the efficient market hypothesis. Additionally, Kasra (2021) provides evidence in his study that Mondays positively affect the conditional variance model of BDI's return series. Since it is the last day of the week and the week is closing, the findings obtained from studies on financial markets are parallel to the fact that volatility decreases on Fridays. In other words, it is possible to come across studies showing that volatility decreased in the return series of financial instruments on Friday (Rossi and Gunardi, 2018; Zaremba, 2020).

The maritime sector has been and continues to be the driving force of the global economy and international trade. Because worldwide trade demand also impacts the demand for transport services, today's economies are inseparable from international trade. This makes transportation services important for increasing a country's economy and GDP. The existence of supply and demand for products is crucial for the effective functioning of trade and transportation. The findings obtained from the study will contribute to eliminating the negativities caused by the inefficiency of freight markets and competition for stakeholders. The continuation of inefficiency will also affect the emergence of additional costs arising from

transportation. A transparent market will bring cost savings, and the end consumer will be least affected by this situation.

In future studies, similar studies will be conducted for the sub-indices that constitute the components of the BDI index, and further investigation of which index causes inefficiency in the BDI index will contribute to this study and the literature.

Conflict of Interest

There is no conflict of interest between the authors in the study.

Financial support

No support was received from any institution for this study.

REFERENCES

Açık, A., and Başer, S. Ö. (2017). The relationship between freight revenues and vessel disposal decisions. *Ekonomi, Politika & Finans Araştırmaları Dergisi*, *2*(2), 96–112. https://doi.org/10.30784/epfad.363721

Açık, A., and Başer, S. Ö. (2018). Baltık Kuru Yük Endeksi etkin mi? [Is Baltic Dry Index efficient?]. *Journal of Yaşar University*, *13*(50), 140–149. https://doi.org/10.19168/jyasar.368149

Ådland, A. O. S., and Koekebakker, S. (2004). Market efficiency in the second-hand market for bulk ships. *Maritime Economics and Logistics*, *6*(1), 1–15. https://doi.org/10.1057/palgrave.mel.9100092

Adland, R., and Strandenes, S. (2006). Market efficiency in the bulk freight market revisited. *Maritime Policy and Management*, *33*(2), 107–117. https://doi.org/10.1080/03088830600612773

Alizadeh, A. H., and Nomikos, N. K. (2007). Investment timing and trading strategies in the sale and purchase market for ships. *Transportation Research Part B: Methodological*, *41*(1), 126–143. https://doi.org/10.1016/j.trb.2006.04.002

Apergis, N., and Payne, J. E. (2013). New evidence on the information and predictive content of the baltic dry index. *International Journal of Financial Studies*, *1*(3), 62–80. https://doi.org/10.3390/ijfs1030062

Atakan, T. (2008). İstanbul Menkul Kıymetler Borsası'nda haftanın günü etkisi ve ocak ayı anomalilerinin ARCH-GARCH modelleri ile test edilmesi [Testing the day-of-the-week effect and january effect anomalies at Istanbul Stock Exchange with Arch-Garch models]. *İstanbul Üniversitesi İşletme Fakültesi Dergisi Istanbul University Journal of the School of Business Administration Cilt*, *37*(2), 98–110. www.ifdergisi.org

Aygün, D. F. (2021). *Sermaye piyasalarındaki takvim anomalilerinin Borsa İstanbul'da test edilmesi [Testing the calendar anomalies of capital market in Istanbul Stock Exchange],* Yüksek Lisans Tezi, İstanbul Üniversitesi, Sosyal Bilimler Enstitüsü, İstanbul. http://nek.istanbul.edu.tr:4444/ekos/TEZ/ET002633.pdf

Bakshi, G. S., Panayotov, G., and Skoulakis, G. (2012). The Baltic Dry Index as a predictor of global stock returns, commodity returns, and global economic activity. *AFA 2012 Chicago Meetings Paper*. Available at SSRN: https://doi.org/10.2139/ssrn.1787757

Barone, E. (1989). The Italian stock market: Efficiency and calendar anomalies. *SSRN.* Available at SSRN: https://doi.org/10.2139/ssrn.512503

Basher, S. A., and Sadorsky, P. (2006). Day-of-the-week effects in emerging stock markets. *Applied Economics Letters*, *13*(10), 621–628. https://doi.org/10.1080/13504850600825238

Brooks, C. (2008). *Introductory Econometrics for Finance*. Cambridge University Press.

Bruffaerts, C., Verardi, V., and Vermandele, C. (2014). A generalized boxplot for skewed and heavy-tailed distributions. *Statistics and Probability Letters*, *95*, 110–117. https://doi.org/10.1016/j.spl.2014.08.016

Chia, R. C. J., Liew, V. K. Sen, and Wafa, S. A. W. S. K. (2008). Day-of-the-week effects in selected East Asian stock markets. *Economics Bulletin*, *7*(5).

Chiah, M., and Zhong, A. (2019). Day-of-the-week effect in anomaly returns: International evidence. *Economics Letters*, *182*, 90–92. https://doi.org/10.1016/j.econlet.2019.05.042

Choudhry, T. (2000). Day of the week effect in emerging Asian stock markets: Evidence from the GARCH model. *Applied Financial Economics*, *10*(3), 235–242. https://doi.org/10.1080/096031000331653

Cihangir, Ç. K. (2018). Küresel risk algısının küresel ticaret üzerindeki etkisi [The effect of global risk perception on global trade]. *İşletme ve İktisat Çalışmaları Dergisi*, 6(1), 1–10.

Cross, F. (1973). The Behavior of stock prices on fridays and mondays. *Financial Analysts Journal*, *29*(6), 67–69. https://doi.org/10.2469/faj.v29.n6.67

Davidson, S., and Faff, R. (1999). Some additional Australian evidence on the day-of-the-week effect. *Applied Economics Letters*, *6*(4), 247–249. https://doi.org/10.1080/135048599353447

Doyle, J. R., and Chen, C. H. (2009). The wandering weekday effect in major stock markets. *Journal of Banking and Finance*, *33*(8), 1388–1399. https://doi.org/10.1016/j.jbankfin.2009.02.002

du Toit, E., Hall, J. H., and Pradhan, R. P. (2018). The day-of-the-week effect: South African stock market indices. *African Journal of Economic and Management Studies*, *9*(2), 197–212. https://doi.org/10.1108/AJEMS-07-2017-0163

Engle, R. F. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica*, *50*(4), 987–1007. https://doi.org/10.2307/1912773

Fama, E. F. (1970). Efficient capital markets: A review of theory and empirical work. *The Journal of Finance*, *25*(2), 383–417.

Fan, Y. H., Xing, Y. W., and Yang, H. L. (2014). Prediction of Baltic Capesize Freight Index based on GARCH model. *Applied Mechanics and Materials*, *488*, 1494–1497. https://doi.org/10.4028/www.scientific.net/AMM.488-489.1494

French, K. R. (1980). Stock returns and the weekend effect. *Journal of Financial Economics*, *8*, 55–69.

Geman, H., and Smith, W. O. (2012). Shipping markets and freight rates: An analysis of the Baltic Dry Index. *Journal of Alternative Investments*, *15*(1), 98–109. https://doi.org/10.3905/jai.2012.15.1.098

Güç, E., Saçan, E., and Kaplan Yildirim, R. (2016). Borsa İstanbul'da haftanın günü anomalisinin ARCH, GARCH ve OLS modelleri ile test edilmesi [Testing the Day of the week effect anomalies at Istanbul Stock Exchange with ARCH-GARCH-OLS models]. *Uluslararası Sosyal Araştırmalar Dergisi*, 1084–1094.

Höl, A. Ö., Akyıldırım, E., Kılıçaslan, Ş., and Çınar, K. (2022). Baltık Kuru Yük Endeksi, petrol, altın, dolar, MSCI Dünya Endeksi arasındaki volatilite yayılımı [Volatility spillover between Baltic Dry Index, oil, gold, dollar, and MSCI World Index]. *Ekonomi, Politika & Finans Araştırmaları Dergisi*, *7*(2), 386–406. https://doi.org/10.30784/epfad.1089836

Hsiao, Y. J., Chou, H. C., and Wu, C. C. (2014). Return lead–lag and volatility transmission in shipping freight markets. *Maritime Policy and Management*, *41*(7), 697–714. https://doi.org/10.1080/03088839.2013.865849

Işığıçok, E. (1994). *Zaman Serilerinde Nedensellik Çözümlemesi*. Bursa: Uludağ Üniversitesi Basımevi.

Jacks, D. S., and Pendakur, K. (2010). Global trade and the maritime transport revolution. *The Review of Economics and Statistics*, *92*(4), 745–755.

Kasra, P. (2021). Monday effect in maritime financial variables: An anomaly in Baltic Exchange Dry Index. *International Journal of Maritime Technology*, *16*(Summer), 87–92.

Katris, C., and Kavussanos, M. G. (2021). Time series forecasting methods for the Baltic dry index. *Journal of Forecasting*, *40*(8), 1540–1565. https://doi.org/10.1002/for.2780

Kim, C. B. (2016). Impact of exchange rate movements, global economic activity, and the BDI volatility on loaded port cargo throughput in South Korea. *Asian Journal of Shipping and Logistics*, *32*(4), 243–248. https://doi.org/10.1016/j.ajsl.2016.12.008

Kiymaz, H., and Berument, H. (2001). The day of the week effect on stock market volatility. *Journal of Economics and Finance*, *25*(2), 363–380.

Lakonishok, J., and Levi, M. (1982). Weekend effects on stock returns: A note. *American Finance Association*, *37*(3), 883–889.

Li, S., Wei, L., and Wu, H. (2017). Stock market and the Baltic Dry Index: Volatilities and correlations in China's business cycle. *European Financial Management Symposium 2017*. https://www.efmaefm.org/0EFMSYMPOSIUM/2017/papers/paper for conference.pdf

Nargeleçekenler, M. (2004). Euro kuru satış değerindeki volatilitenin ARCH ve GARCH modelleri ile tahmini [Estimation of volatility in Euro exchange rate sales values with ARCH and GARCH Models]. *İstanbul Üniversitesi İktisat Fakültesi Mecmuası*, *54*(2), 153–179.

Pascali, L. (2017). The wind of change: Maritime technology, trade, and economic development. *American Economic Review*, *107*(9), 2821–2854. https://doi.org/10.1257/aer.20140832

Pepur, P., Peronja, I., and Laća, S. (2022). Global market factors that impact Baltic Dry Index. *Pomorstvo*, *36*(2), 242–248. https://doi.org/10.31217/p.36.2.8

Radivojevic, N., Muhovic, A., Joksimovic, M., & Pimic, M. (2021). Examining the impact of movements of the commodity price on the value of the Baltic Dry Index during Covid19 pandemic. *Asian Journal of Economics and Empirical Research*, *8*(2), 67–72. https://doi.org/10.20448/journal.501.2021.82.67.72

Rossi, M., and Gunardi, A. (2018). Efficient market hypothesis and stock market anomalies: Empirical evidence in four European countries. *Journal of Applied Business Research*, *34*(1), 183–192. https://doi.org/10.19030/jabr.v34i1.10111

Sariannidis, N., Galyfianakis, G., & Drimbetas, E. (2015). The effect of financial and macroeconomic factors on the oil market. *International Journal of Energy Economics and Policy*, *5*(4), 1084–1091.

Stopford, M. (2008). *Maritime Economics 3e*. New York: Routledge.

Thaler, R. H. (1987). Anomalies: The january effect. *Journal of Economic Perspectives*, *1*(1), 197–201. https://doi.org/10.1257/jep.1.1.197

Zaremba, A. (2020). Performance persistence in anomaly returns: Evidence from frontier markets. *Emerging Markets Finance and Trade*, *56*(12), 2852–2873. https://doi.org/10.1080/1540496X.2019.1605594

Zeng, Q., and Qu, C. (2014). An approach for Baltic Dry Index analysis based on empirical mode decomposition. *Maritime Policy and Management*, *41*(3), 224–240. https://doi.org/10.1080/03088839.2013.839512

Zhang, B., and Li, X. (2006). Do calendar effects still exist in the Chinese stock markets? *Journal of Chinese Economic and Business Studies*, *4*(2), 151–163. https://doi.org/10.1080/14765280600736999

Data Source: https://www.investing.com/indices/baltic-dry