

Multidisciplinary
SCIENTIFIC JOURNAL
OF MARITIME RESEARCH



University of Rijeka
FACULTY OF MARITIME STUDIES

Multidisciplinarni
znanstveni časopis
POMORSTVO

<https://doi.org/10.31217/p.36.2.8>

Global market factors that impact Baltic Dry Index

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ABSTRACT

The Baltic Dry Index is used as a strategic tool by shipping companies to monitor the daily movement of freight rates for the transportation of bulk cargoes on predetermined routes for the different types of bulk carriers. Therefore, the management of shipping companies pays great attention to the factors that can contribute to the prediction of the price movement of the Baltic Dry Index.

Main goal of this paper is to explore if stock market indices of United States of America (S&P 500 stock index) and China (Shanghai stock exchange Composite index), 10 Year bond yield, CRB index, WTI Crude oil and Gold as global market factors, but also as leading macroeconomic global indicators, have impact on movement of BDI. We explored period from January 1, 2003 to December 31, 2021, with monthly data for which the multiple linear regression method was used to analyse mentioned global market factors impact on BDI.

The research found that the movement of S&P 500 and SSECI stock indices and CRB index had a positive impact on the movement of BDI, while the movement of Gold and WTI crude oil had negative impact on BDI for the observed period. The scientific contribution of this paper is manifested through observation and exploring relationship of mentioned global market factors with BDI, previous papers observed shorter time period and included macroeconomic indicators which are lagging, together with some global market factors.

ARTICLE INFO

Review article
Received 15 September 2022
Accepted 11 November 2022

Key words:
Baltic Dry Index
Stock market performance
Economic activity
Stock indices

1 Introduction

World trade is defined as the exchange of goods and services between countries and allows consumers and countries to buy goods and services that are not available or are more expensive in their home country. In world trade, maritime trade is the most important, accounting for over 80% of total world trade [25]. According to Maritime Transport Report for 2021 issued by the United Nations Conference on Trade and Development [25], bulk carriers account for the largest share, about 43% of the total shipping fleet (measured in million tons deadweight (DWT)), followed by tankers for oil transport with about 29% and ships for container transport with about 13%, with the remainder of the shipping fleet consisting of ships for other types of transport. The Baltic Dry Index (BDI) was formed in 1985. at the Baltic Exchange, the world's only independent source of maritime information.

Baltic Exchange members contact ship brokers around the world to monitor freight rate changes by ship type and by predetermined shipping routes for each of the different ship types. Therefore, it can be concluded that the BDI is extremely important for world trade and the global economy as a whole, as its value directly reflects the movement of supply and demand for bulk cargoes and their transport prices.

Figure 1. shows the historical fluctuation of BDI from January 1st 2003 to December 31st 2021. For all the mentioned reasons before, it is no surprise that there was considerable effort among scholars and practitioners to find factors that could impact BDI price movement in the literature. The predictive performance can be improved when explanatory variables associated with BDI are taken into an account in a model as indicated by Cullinane et al. (1999). But also, there are many papers trying to use BDI

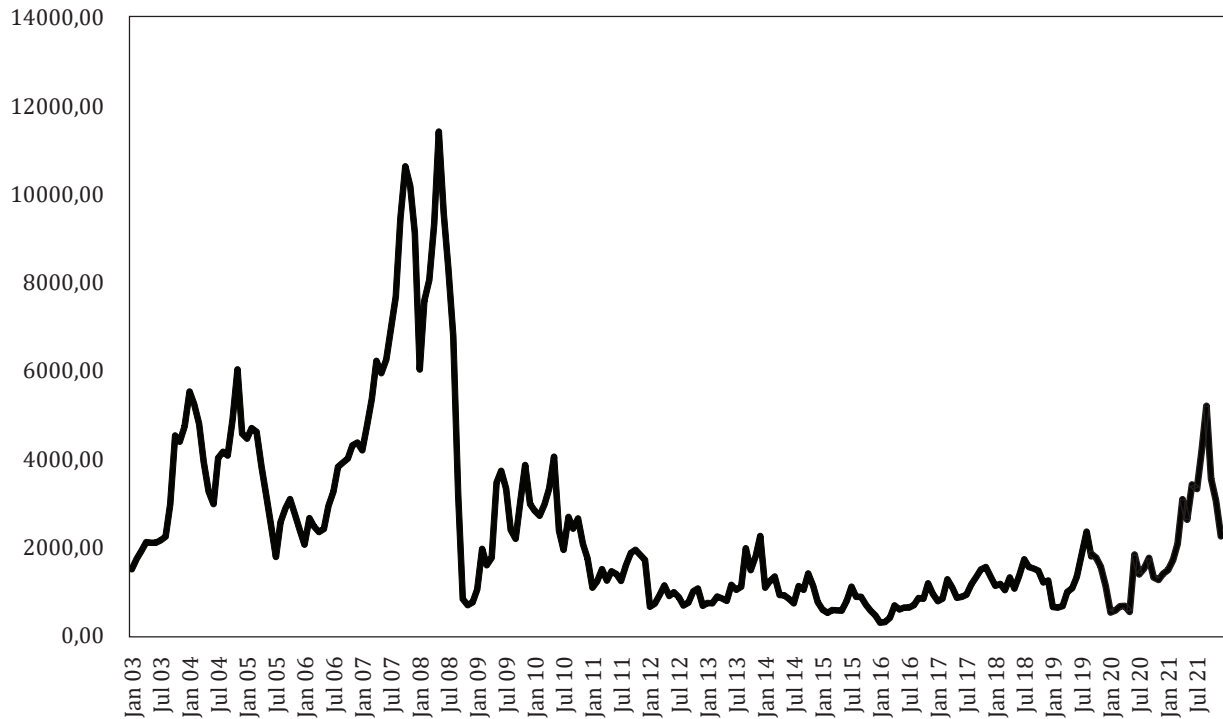


Figure 1 The movement of the BDI in the period from 01st January 2003 to 31st December 2021

Source: Adopted from [11]

as predictor of price movements in stock and commodities markets. Papers from Yildiz and Bucak (2017), Tsioumas et al. (2017), Kanamoto et al. (2019), Bandyopadhyay and Rajiba (2021), Liu et al (2022) all have tried to predict movement of BDI based on commodities prices, capacity supply side of ships, capacity demand side, macroeconomic factors (Chinese steel production) etc... Their papers found numerous factors that have statistically significant impact on BDI. On the other hand, papers from Bakshi et al. (2011), Lin et al. (2019), Giannarakis et al. (2017) tried to use BDI as a leading indicator to predict price or volatility movement of stock, commodities, currency and sustainability index.

For this paper, idea came from the paper of Wilmsmeier and Bergqvist (2013), in which they tried to predict the movement of the Baltic Dirty Tanker Index (BDTI) based on a movement of a stock market indices, the volatility of stock market and price movement of commodities index as market factors that could impact movement of BDI [2] using Wavelet Neural Networks [12] (hereinafter WNN). The factors that impact movement of BDTI were all market factors, the Amex Oil Index [27] (AMEX oil), the current crude oil price (Brent Crude oil), the volatility of the S&P 500 Index (VIX), the S&P Global 1200, the Dow Jones Industrial, and the MSCIAC world transportation index. Also, Sahan et al. (2018) attempted to choose the factors which affect BDI from financial markets, stock markets,

commodity markets and economic indicators. These papers set the framework for this paper.

Problem with all economic factors such as GDP movement, world industrial production, consumer price index, etc. is that they are all lagging indicators. Logic to use market factors as predictors of BDI price movement is based on Efficient-market hypothesis (hereinafter EMH) theory from Nobel laureate Fama (1970) whose main thesis is that financial markets are "information efficient" and reflect already all known information on the markets (future movement of all economic factors and BDI). Movement of financial markets represents leading economic indicators, which is confirmed with Comincioli (1995) paper. This paper attempts to set up a reliable linear model regarding predictive capacity of possible leading indicator data series. For the leading indicator series, stock market indices were chosen as factors that may have impact on BDI. The following stock indices were selected:

1. S&P 500 [26] – weighted average index representing the 500 largest American companies. This stock index is the best single gauge of large-cap US equities. This index is a leading indicator of the health of the economy of the United States of America as the largest economic power in the world (it accounts for about 25% of world GDP).
2. Shanghai SE Composite index (hereinafter SSECI) – is a stock market index of all stocks that are traded at the

Shanghai Stock Exchange [28]. This index is a leading indicator of health of the Chinese economy. Kim (2011) showed (measured through macroeconomic indicators) that growth in Chinese economy has impact on BDI growth.

In addition to stock indices, other factors that could affect the movement of BDI are also included in the research:

1. CRB index [23] – represents the index of the Commodity Research Bureau (CRB), which tracks the spot price movements in the global commodity market. This index consists of 19 commodities, of which 39% are energy products, 41% are agricultural commodities, 13% are industrial metals, and the remaining 7% are precious metals. There is no publicly free data on commodities or indices which would select all relevant commodities which were proven from previous researches as ones that have impact on price movement of BDI.
2. West Texas Intermediate (hereinafter WTI) Crude Oil [19] name of the standardized commodity contract for spot and futures trading at New York Mercantile Exchange. Crude oil is essential cost for any transportation industry, also for dry bulk ships.
3. 10 Year bond yield – it presents risk free rate bond of United States of America. It represents benchmark for all interest rates and is seen as a measure of investors sentiment about the economy. A falling yield indicates higher demand for bonds, which means that investors are on risk off mode (away from riskier assets such as stocks). A rising yield means the opposite.
4. Gold – is considered by investors as a “safe haven” asset. When on financial markets is present higher uncertainty, which implies higher volatility, investors usually buy Gold to preserve their wealth. Higher price of Gold implies higher uncertainty for world economy.

The aim of this paper was to examine the impact of the movements of two stock indices on the movement of the Baltic Dry Index, the movement of the price of the SSECI, and the movement of the price of the S&P500 Index. In addition to the stock indices, the price movement of an CRB Index, WTI Crude Oil, 10 Year bond yield and Gold were included as independent variables.

2 Review of relevant literature

This part of the paper presents review of the professional and scientific literature that investigated the factors influencing the movement of the BDI. This index has been the subject of many research by both regional and foreign researchers. In their work, Jurun et al. (2015) investigated the relationship between the BDI as an indicator of the cyclicity of the maritime market and the performance of selected shipping companies in the period from 1985 to 2013. Based on the conducted research, they concluded that there is a statistically significant correlation between the annual level of the BDI and the per-

formance indicators of the selected shipping companies. Počuča and Zanne (2011) investigated the influence of gross domestic product (GDP), fuel prices, and sea freight rates on the fluctuation of ship operating costs reported in Moore Stephens OpCost databases for the period from 2000 to 2009. The authors were able to demonstrate a significant correlation between economic cycles and fluctuations in ship operating costs for all types of ships. Among foreign researchers, it is important to highlight the work of Bakshi et al. (2011), who focused on BDI research using its three-month growth rate as a variable for the predictability of returns on global stock indices, the index of returns on commodity prices and the rates of movement of real economic activity for the period from May 1985 to September 2010. In their research, they demonstrated that the predictability of the three-month movement rate of the BDI for the returns of global stock indices is statistically significant. In addition, Bildirici et al. (2015) examined the relationship between the BDI and economic growth in the United States of America in the period from 1986 to 2014, dividing the entire observed period into three periods: a period of crisis, a period of mild growth and a period of high growth rate. They concluded that the increase in the BDI has a positive effect on economic growth when the growth rate falls into the high growth area. Papailias et al. (2016) in their paper researched BDI annual growth with cyclical analysis of the series at different levels. Also, their models showed very good statistical forecasting performance and it could be used for controlling financial exposure and risk to the BDI. Tsioumas et al. (2017) developed a multivariate Vector Autoregressive model with exogenous variables (VARX) with the Chinese steel production, the dry bulk fleet development and Dry Bulk Economic Climate Index (DBECI). They showed that a new indicator DBECI reinforces the robustness and predictive success of the proposed model. Giannarakis et al. (2017) explored the effect of BDI, Gold, Oil and USA trade balance on Dow Jones Sustainability Index World (DJSIW) and found that BDI affects positively the DJSIW. Kanamoto et al. (2019) explored a method to predict Baltic Cape-size Index (BCI) and satellite AIS data and various statistics with model to predict rise or fall of the BCI value after 30 days and found that simulation accuracy is improved by using satellite AIS data. In their paper, Yildiz and Bucak (2017) investigated the price trends of commodities that have a statistically significant impact on freight rates during the period from 2003 to 2016. Based on the collected data, they found a statistically significant influence of the price of phosphate rock and barley as variables whose movement has a positive impact on the movement of BDI, while the movement of the price of cement, crude oil and corn is statistically significant, but the movement of these commodities has a negative impact on the movement of BDI. A similar research was conducted by Bandyopadhyay and Rajiba (2021), who examined the relationship between the movement of BDI and the movement of current prices of eight commo-

ties most representative of bulk cargo for the period from 2006 to 2018. In their work, they proved that BDI is causing iron ore and coal in all market conditions, on the other hand BDI return had no influence on soy-bean return. Lin et al. (2019) investigated the effect of spot freight rates on the price volatility of shipping stocks, the US dollar index and commodity futures market and found that BDI drives the movements of the commodities, currency and equity markets and covariance among them. Liu et al. (2022) explored capacity supply side, capacity demand side (certain commodities) and macroeconomic factors on BDI and found that their model had high prediction accuracy and was very effective method to implement BDI prediction.

The starting point of the research in this paper is based on the work of Wilmsmeier and Bergqvist (2013), in which they tried to predict the movement of the Baltic Dirty Tanker Index (BDTI) using WNN. In determining the factors affecting the BDTI, they divided the factors into the Amex Oil Index (AMEX oil) and the current crude oil price (Brent Crude oil) (as supply and demand factors for oil), the volatility of the S&P 500 Index (VIX), the S&P Global 1200 and Dow Jones Industrial (as a factor of the world economy), and the MSCIA world transportation index (as a factor of ship supply). In their paper they found that WNN model can be a very effective method in forecasting BDTI. Thus, in contrast to the previously mentioned works, the aforementioned authors tried to predict the movement of the BDTI using the help of the price movement of stock indices and the movement of commodity prices. The initial assumption of the aforementioned paper that the movement of stock index prices had an impact on the movement of BDTI freight prices or, in this paper, the movement of BDI prices is based on the EMH theory. EMH theory and its relationship with BDI was explored by Sahan et al. (2018) with following variables commodity price index for minerals, ores and metals; commodity price index for agricultural commodities; crude oil prices; US 10-year bond yield; world industrial production; S&P 500 index, world consumer price index, Gold spot prices, silver spot prices and exchange rate for USD/Special Drawing Rights to predict movement of BDI. They found that price movement of 10-year bond yield, Gold, silver and ores are proposed as a useful tool to monitor BDI and economic conditions.

According to EMH theory, which goes back to the work of Fama (1970), financial markets are "information efficient" and the prices of traded securities such as stocks and bonds reflect all known information on the market. Therefore, the price of the movement and overlooking the movement of the BDI is already included in the stock prices on the financial markets. Based on the assumptions from the latter paper, the question arises whether the stock market is a leading economic indicator that anticipates future economic trends. Comincioli (1995) attempted to answer this question in his work, in which he examined the relationship between the movement of the

stock index and the economy in the period from the first quarter of 1970 to the third quarter of 1994 in the U.S. and found that the last period between the statistically significant results was between these two variables for all three quarters. Thus, the results confirmed that the movement of stock markets predicts future movements in the economy. The theoretical reasons why stock index movements can predict economic activity are partly hidden in the "wealth effect," because stock movements lead to economic activity because they directly affect what is currently happening in the economy. When stock indexes rise, consumers feel richer and spend more, and when stock indexes fall, consumers feel poorer and spend less, which translates directly into a decrease in economic activity. Considering all the mentioned works, this paper investigated the influence of the movement of named global market factors on BDI.

3 Material and method

The research covers data on the monthly movements of the BDI price and all the mentioned variables. Data was collected from the Thomson Reuters database and [11] for the period from 01st January 2003 to 31st December 2021, i.e. for 19 years (228 months). Data were processed in STATA statistical software using the statistical method of multiple least squares regression (OLS regression) to analyse whether the aforementioned factors have a statistically significant impact on the movement of the BDI.

This form of regression is useful because it allows the control of several factors that together affect the dependent variable. The multiple regression can mathematically be written using the following equation:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_k x_k + \varepsilon \quad (1)$$

where:

y is the dependent variable, the monthly price movement of the BDI from 01st January 2003 to 31st December 2021

$x_{1..6}$ are independent variables, the monthly movement of each of the variables from 01st January 2003 to 31st December 2021:

1. S&P 500 stock index
2. SSECI stock index
3. CRB index for commodities
4. WTI crude oil
5. 10 Year bond yield
6. Gold

β_0 is the intercept, and β_1 to β_k are the slope coefficients of each of the independent variables ε is a constant.

Descriptive statistics were obtained for all variables and presented in Table 1. Descriptive statistics were calculated on 228 observations for all variables.

Table 1 Descriptive statistics

Variable	Obs.	Mean	Std.Dev.	Min	Max
Baltic Dry Index	228	2439.11	2118.166	317	11,440
S&P 500	228	1866.31	890.5327	735	4,766
Shanghai Index	228	2643.985	890.2944	1060.74	5954.77
CRB Index	228	255.8804	66.68434	117.1958	462.7391
WTI Crude oil	228	66.74254386	1.551819682	18.84	140
10 Year bond yield	228	2.877092	0.076039	0.533	5.145
Gold	228	1131.4	29.63825	336.9	1985.9

Source: the authors calculation

Table 2 Correlation matrix

	BDI	SPX500	SSECI	CRB Index	WTI Crude Oil	10 Year yield	Gold
BDI	1						
SPX500	-0.25113	1					
SSECI	0.195852	0.467284	1				
CRB Index	0.562961	-0.60029	-0.18557	1			
WTI Crude Oil	0.229287	-0.15864	0.137489	0.725349	1		
10 Year yield	0.596741	-0.64887	-0.33962	0.594741	0.044724	1	
Gold	-0.46919	0.63778	0.445469	-0.31884	0.30144	-0.87475	1

Source: the authors calculations

4 Research results

The first step of the research was to check the correlation between all variables, which is shown in Table 2. There is negative correlation [coef. – 0.87475] between price of the Gold and 10 Year bond yield. When 10 Year bond yields go down that shows that investors are more worried about the health of the economy, so they are interested in buying 10 Year bonds and causing the yields to decline. Gold behaves in similar manner, when investors are risk averse, the price of Gold tends to rise. So, this negative correlation is expected. There is positive correlation between WTI crude oil and CRB index [coef.0.725349] because WTI crude oil [23] has 23% share in CRB index.

In addition, a multiple linear regression analysis was performed between all the mentioned independent variables and the dependent variable movement of the BDI. The Breusch-Pagan test for heteroskedasticity indicated the presence of a heteroskedasticity problem, and in order to eliminate this problem, robust errors were used in the model.

In addition, parameter estimation was performed using multiple least squares linear regression, which is shown in Table 3.

Robust standard errors are between parentheses.

Table 3 summarizes the final results of the research. All variables from the multiple regression were statistically significant (p-value is less than 1%, for WTI crude oil p-value is less than 5%) except 10 Year bond yield for which

Table 3 Estimation of parameters based on multiple least squares linear regression

Variable	BDI
S&P 500	0.9001318*** (0.1434847)
SSECI	1.111613*** (0.1439132)
CRB Index	26.7672*** (2.838213)
WTI Crude oil	-17.9102** (8.326487)
10 Year yield	-60.39685 (242.535)
Gold	-2.929322*** (0.7560616)
cons	-4345.73*** (949.8427)
R ²	0.6963
Model p-value	0
F-test	p value = 0.0000
Breusch-Pagan test for heteroskedasticity	chi2 = 36,40

*, **, *** Statistically significant at the; 10%, 5%, 1% level, respectively.

Source: the authors calculations

p-value was not statistically significant. From the table 3. it can be seen that stock market indices S&P 500 and SSECI movement had positive and statistically significant effect on BDI [coef. 4.971488 for S&P 500, coef. 1.127276 for SSECI]. The same can be stated for CRB index which had statistically significant effect on BDI [coef. 19.39231]. On the other hand, prices of WTI crude oil and price of Gold had negative and statistically significant effect on BDI [coef. -17.9102 for WTI crude oil, coef. -2.929322 for Gold]. For multiple linear regression there is present constant of -4345.73 for this model. From Table 3. it can be seen that value of R^2 indicates that the presented model explains 69,63% of variation in price of BDI.

5 Discussion

All market factors that were researched in this paper and results of this study, about their relationship with BDI have theoretical background. If stock market indices S&P 500 and SSECI rise, it is signal that investors are confident about future state of economy of USA and China which present almost 50% of world economy measured with GDP and more than 50% of the stock market capitalization of the stock market capitalization in the world. If price of CRB index rises it shows increase of demand for materials that are subject of transport for bulk carriers and it is logical that its increase would lead to the growth of BDI. This is also in line with previous researches. Increase in price of WTI crude oil has negative impact on BDI and this can be seen as increase of input cost for bulk carriers. Finally, decrease in price of Gold can be seen as increase of confidence of investors in global economy and if investors sell Gold this shows confidence in health of world economy.

Scholars and practitioners had tried to use price movement of BDI to predict price of stock market, it's volatility, commodities price, currency and sustainability index. Some (Bakshi et al., 2011) showed that BDI three-month growth rate as a variable to predict returns of global stock indices is statistically significant. Some (Lin et al., 2019) found that BDI drives the movements of the commodities, currency and equity markets and covariance among them. Others (Giannarakis et al., 2017) found that price of BDI positively impacts Dow Jones Sustainability Index World. Some researchers took the other path to predict movement of BDI based on commodities prices, capacity side of ships, capacity demand side, macroeconomic factors etc... They found many variables that can help in predicting movement of BDI. Finally, there is third path (Wilmsmeier and Bergquist, 2013; Sahan et al., 2018) for researchers who chose leading macroeconomic and financial indicators to predict movement of BDI. This path is based on EMH theory and for this paper authors chose this path. Sahan et al. (2018) found that yield of 10 Year bond, Gold, silver and ores had statistically significant impact on BDI for the monthly movement of variables for January 2010 until June 2017. Observed period was without great financial crisis (2007), so contribution of this paper was to collect data series for period with

financial stress (2007 and 2020 – covid). Because of longer time series it is expected to increase relevance of relationship between the variables. To get longer time series, we had to give up on data for specific commodities (Iron ore, Aluminum, Coal, Copper; Soybean, Wheat, Corn, Cotton) because there wasn't publicly available free data for observed period. Mentioned commodities were major factors to determine quantity transportation and freight rates (Bandyopadhyay and Rajib, 2021). It wasn't possible to group these commodities in agricultural or industrial commodities and to get more specific data, outside selected CRB index. Because of longer time series data new relationships between variables was shown. Stock indices as leading macroeconomic indicators had positive statistically significant impact on movement of BDI which wasn't shown in previous researches. Also, increase in price of CRB index had positive impact on price of BDI which is in line with previous researches. Sahan et al. (2018) had positive coef. for Gold, while in this study it was determined negative relationship between price of Gold and BDI, which has base in theoretical background, because Gold is seen as "a safe haven" asset and if investors buy Gold this shows low confidence in health of world economy. Finally, WTI crude oil had negative impact on BDI, which wasn't shown in previous researches and which means increase of input cost for bulk carriers which also has theoretical background.

6 Conclusion

This research is based on the EMH theory and the movement of market variables set in introduction, as leading macroeconomic indicators. All variables had a statistically significant impact on the movement of BDI with a p-value of less than 5%, except 10 Year bond yield. The movement of SSECI and S&P 500 stock indices and CRB index had a positive impact on the movement of BDI, while the movement of Gold and WTI crude oil had negative impact on BDI for the observed period. Collecting data for longer time period, some specific commodities (which were proven relevant in earlier researches) were left out of research. The shortcoming of this paper can be base for further research. Also, it would be interesting to get longer time series and maybe observe weekly price movement of all selected variables to see if relationships showed in this paper would be held. The data from this paper can be used by the members of the management of shipping companies that have ships for the transport of bulk cargo in their fleet, so that they could more easily predict the future movements of the Baltic Dry Index and use the above information for a better strategy when contracting charters for their bulk vessels.

Funding: The research presented in the paper was not financed from an external source.

Author Contributions: *Conceptualization, P.P., I.P., S.L., Methodology, P.P., I.P., S.L., Data collection and processing, S.L., Validation, S.L., Research, I.P., Writing, P.P., Review and edit P.P.*

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