

## EXPLORING THE RELATIONSHIPS BETWEEN RAW MATERIAL PRICES AND THE BALTIC DRY INDEX AMIDST COVID-19

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### Article Info

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### Abstract

This paper investigates the impact of changes in raw material commodity prices on the Baltic Dry Index (BDI). The BDI is a leading indicator of economic activity that reflects changes in supply and demand for imported raw materials used in manufacturing. We aim to examine whether changes in raw materials affect the value of the BDI and to determine the individual impacts of different raw materials on the BDI. Using the generalized method of moments and 2SLS estimators to analyze the data, we find that different raw materials have different impacts on the value of the BDI, suggesting that the value of raw materials that compose the BDI cannot forecast its movement based on individual movements. This study contributes to the literature by revealing the limitations of prediction models that rely on individual raw material movements and highlights the unique impact of key raw materials on the BDI.

**Introduction:** The Baltic Dry Index (BDI) is a leading indicator of economic activity that reflects changes in supply and demand for imported raw materials used in manufacturing. With its high volatility, the BDI responds promptly to economic crises, making it a supply and demand signal for the stock market. The index is composed of raw materials, such as iron ore, coal, and grains, which are transported on dry bulk carriers. There is an abundance of literature on the BDI that focuses on the development of more reliable procedures and models to predict changes in freight rates. However, few studies have focused on the relationship between raw material commodity prices and the BDI. This study aims to fill this gap by investigating the impact of changes in raw material commodity prices on the BDI. By analyzing the data using the generalized method of moments and 2SLS estimators, we examine the individual impacts of different raw materials on the BDI and find that their effects vary significantly. The findings of this study have important implications for policymakers, investors, and other stakeholders who use the BDI as an economic indicator. By shedding light on the unique impact of key raw materials on the BDI, this study contributes to the literature on the BDI and provides valuable insights into the behavior of this important economic indicator.

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## 1. Literature Review

There is an abundance of literature on the BDI that can be classified into two groups. The first group consists of papers that focus on the development of more reliable procedures and models to predict changes in freight rates. The development of various models is caused by fact that risk and uncertainty in the shipping market have increased dramatically. Interestingly, maritime freight rates fell by 50% on average, while global trade increased by 400% from 1870 to 1913 (Jacks & Pendakur, 2010). Driehuis (1970) was the first to design a good model for forecasting freight rates. Similar attempts were made by Marlow & Gardner (1980), and Beenstock & Vergottis (1989a) and Beenstock & Vergottis (1989b). Cullinane, Mason, & Cape (1999) applied the Box–Jenkins approach to forecast the movements of the Baltic Freight Index (BFI). More recently, Makridakis, Merikas, Merika, Tsionas, & Izzeldin (2020) presented a new model to predict changes in freight rates and apply it to the BDI. The findings they reported show that the new model was very successful in forecasting the BDI movement. Thalassinos, Haniias, Curtis, & Thalassinos (2013) used the false nearest neighbors (FNN) method to forecast the BDI, and Tsioumas, Papadimitriou, Smirlis, & Zahran (2017) used a multivariate vector autoregressive model with exogenous variables (VARX). Zeng, Qu, Ng, & Zhao (2016) developed a new forecasting approach in literature known as empirical mode decomposition (EMD). This approach is based on artificial neural networks (ANN). Geman & Smith (2012) investigated the BDI and suggested several diffusion models that are able to capture the unique features of its trajectories, such as large swings and high volatility.

The second group includes papers that examine the relationship between the BDI and various microeconomic and macroeconomic indicators and commodities. Tsioumas & Papadimitriou (2015) investigated the lead–lag relationship between China’s steel output and various Baltic Exchange indices and concluded that there is a significant causality effect of Chinese steel production on the dry bulk freight market. Similar results were presented by Tsioumas & Papadimitriou (2016). Their results provide evidence in favor of an existing significant causality between certain commodity prices and the freight rates of bulk carriers.

A significant part of these papers focuses on testing the hypothesis that the BDI functions as a signal that promptly responds to crisis effects. These papers focus on analyzing the BDI as a supply and demand signal for the stock market. Faqin & Sim (2013) examined the link between the BDI as a proxy for trade and income improvements for the 48 least developed countries. Since trade is endogenous in the determination of income levels, they used the BDI as a proxy for trade and developed a new measure of trade cost as an external source of variation in trade, which, in turn, is used to construct the within-country estimate of the causal effect that trade has on the income of the least developed countries. They found that a reduction in the BDI has a positive effect on the income of least developed countries through the trade channel; a 1% expansion in trade raises the GDP per capita by approximately 0.5% on average. This estimate is much larger than what was previously found in the literature and its quantitative significance emphasizes the importance of trade for the economic development of low income countries (Faqin & Sim, 2013). Papailias et al. (2017) found that variations in the BDI are strongly associated with fluctuations in commodity markets, such as coal, steel, iron, corn, and wheat markets. They also showed that it is possible, by applying trigonometric regression, to improve forecasting in the BDI movements, and thus movements of commodity markets. Similar studies were conducted by Adland & Cullinane (2005); Koekebakker, Adland, & Sødal (2006) and Batchelor, Alizadeh, & Visvikis (2007). They studied the BDI series as a whole rather than analyzing the spot or forward rates separately. Lin & Sim (2013) examined the relationship between the BDI and trade in Sub-Saharan countries, and they also investigated the impact of the BDI on the transitory negative income shocks. They found that there is a strong relationship between the BDI and trade and the impact of the BDI on the transitory negative income shocks. The seasonal properties and forecasting in the dry bulk shipping sector were the subject of research conducted by Cullinane et al. (1999); Kavussanos & Alizadeh-M (2001) and Kavussanos & Alizadeh-M (2002). The results of these studies imply that a considerable proportion of the BDI variations can be predicted by a combination of explanatory factors and the cyclical pattern that exists in the series. Kavussanos & Nomikos (1999) and Kavussanos & Visvikis (2004) studied the relationship between freight futures and spot prices using the VAR and VEC models. Kavussanos & Visvikis (2004) and Kavussanos,

Visvikis, & Menachof (2004) utilized a cointegration analysis to examine the predictability of the forward freight agreements (FFA) in the Panamax freight market.

Jurun, Ratković, & Moro (2015) examined the relationship between the BDI as the key indicator of economic and business activities, and the business results of shipping companies. They studied the relationship between the BDI and performance excellence of the representative shipping companies. The results of their study show that there is a strong relationship between the average annual BDI values as an indicator of the cyclical nature of the maritime market and results of the representative shipping companies. Jurun et al. (2015) used the adjusted Altman Z-score to measure business results. The conclusion of their study is that the BDI serves as a good signal for the buying or selling of certain shares. In other words, it provides a reliable basis for making decisions. They came to this conclusion based on the discovery a high correlation exists between short-term (quarterly) average BDI values and a company's business excellence.

All of the abovementioned papers suggest possible endogeneity problems.

## 2. Data and Methodology

As already mentioned, the aim of the paper is to examine the relationship between the BDI and major raw materials, such as corn, coal crude oil, iron ore, soybeans, copper, tin, wheat, aluminum, zinc, nickel, gold, rice and lead, whose freight prices enter the BDI. The raw materials were selected from the aforementioned empirical studies that confirm the link between the BDI and the major raw materials. Data were collected from the official Federal Reserve Bank of St. Louis and Bloomberg websites for the period between November 1999 and September 2020. For purpose of this study, monthly data was used.

This study used a multiple linear regression model on a set of explanatory variables as mentioned above. The econometric model is expressed below, with the BDI as the dependent variable.

$$BDI = \beta_0 + \beta_1 Cor + \beta_2 Coa + \beta_3 Cru + \beta_4 Iro + \beta_5 Soy + \beta_6 Lea + \beta_7 Cop + \beta_8 Tin + \beta_9 Whe + \beta_{10} Alu + \beta_{11} Znc + \beta_{12} Nil + \beta_{13} Gol + \beta_{14} Ric + \varepsilon \quad (1)$$

Where *BDI* is the Baltic Dry Index; *Cor* is corn price; *Coa* is coal price; *Cru* is crude oil price; *Iro* is iron ore; *Soy* represents soybeans; *Lea* is lead, *Cop* represents copper, *Tin* represents tin; *Whe* represents wheat, *Alu* is aluminum,

*Zin* is zinc, *Nil* is nickel, *Gol* represents gold, and *Ric* represents rice;  $\varepsilon$  is the model error.

According to Wooldridge (2003) and Radivojevic & Jovovic (2017), the ordinary least squares (OLS) model represents the most efficient estimator. However, it is true only if all the assumptions on which it is based are met. Otherwise, it will generate biased/unbiased and consistent/inconsistent estimates (some of these combinations) depending on which assumptions are not met. From the literature review on this subject, it was observed that researchers have concluded that this topic might run the risk of endogeneity. The problem of the possible endogeneity of one or more independent variables may be solved using the two-stage least squares (2SLS) method but the instrumental variables must not be weak. For that reason, the 2SLS method has been employed in this study. Mladenovic & Pavlovic (2003) warned that the 2SLS usually generates biased and consistent estimates. In addition, we have used the generalized method of moments (GMM). Unlike other estimators, the main advantage of the GMM is that it can be used even when the assumptions of other estimators are not satisfied. Generally speaking, the GMM can be viewed as a generalization of many other methods, and as a result, it is less likely to be misspecified (Chaussé, 2010). The GMM generates correct standard errors and p-values, provided that the specified moment conditions are valid. It is based on the simple idea that the estimations of parameters are done by solving a set of moment conditions. For the purpose of this study, a one-step IV-GMM was used. Since the GMM depends only on moment conditions, it is a reliable estimation procedure for many models in economics and finance, especially for models which suffer from endogeneity problems because it provides the efficient estimations of instrumental variables under “orthogonality conditions”, with the instrumental variables and the error term being orthogonal in the expectation sense (Radivojević et al., 2019).

### 3. Empirical Analysis and Discussion of Results

Table 1 shows the results of the descriptive statistics of the data set. As can be seen from Table 1, the BDI ranges from 306.9 to 10843.65, which indicates a very high disparity between the minimum and maximum index values. The very high value of the standard deviation of the BDI testifies to a large fluctuation in the value of this index, and this a similar case for the values of all commodities. The excess kurtosis ranges from 4.84 in the case of the BDI index to -1.09 in the case of copper. This indicates that the BDI index has significant leptokurtosis. The skewness of all the commodities and the index is different from zero, which indicates that they have asymmetric distribution.

**Table 1.** Descriptive statistics of selected variables.

	<b>BDI</b>	<b>Cor</b>	<b>Coa</b>	<b>Cru</b>	<b>Iro</b>	<b>Soy</b>	<b>Cop</b>	<b>Lea</b>
Mean	2268.77	164.72	73.21	60.62	67.44	336.30	5332.50	1621.46
Standard Deviation	2027.69	63.74	33.92	26.22	48.01	115.60	2353.37	753.00
Excess Kurtosis	4.84	0.13	0.02	-0.70	-0.61	-0.74	-1.09	-0.86
Skewness	2.14	0.89	0.52	0.43	0.63	0.30	-0.35	-0.23
Minimum	306.90	75.06	24.00	16.55	11.93	158.61	1377.38	412.61
Maximum	10843.65	333.00	195.19	133.88	187.18	622.91	9880.94	3722.61
No. obs.	251	251	251	251	251	251	251	251
	<b>Tin</b>	<b>Whe</b>	<b>Alu</b>	<b>Zin</b>	<b>Nic</b>	<b>Gol</b>	<b>Ric</b>	
Mean	14726.08	184.20	1902.17	1944.61	15341.74	958.33	391.55	
Standard Deviation	7022.54	64.56	414.70	798.11	7751.67	482.84	153.35	
Excess Kurtosis	-1.07	0.08	-0.07	-0.23	4.30	-1.31	1.04	
Skewness	-0.10	0.82	0.77	0.39	1.74	-0.06	0.69	
Minimum	3698.37	90.44	1283.53	748.81	4830.78	260.75	162.10	
Maximum	32347.69	403.81	3067.46	4381.45	51783.33	1971.17	1015.21	
No. obs.	251	251	251	251	251	251	251	

To identify a potential multicollinearity problem, the next step included an analysis of the matrix correlation; the results are presented in Table 2.

**Table 2.** Matrix correlation.

	<b>BDI</b>	<b>Cor</b>	<b>Coa</b>	<b>Cru</b>	<b>Iro</b>	<b>Soy</b>	<b>Cop</b>	<b>Tin</b>	<b>Whe</b>	<b>Alu</b>	<b>Zin</b>	<b>Nic</b>	<b>Gol</b>	<b>Ric</b>	<b>Lea</b>
BDI	1.00														
Cor	-0.03	1.00													
Coa	0.18	0.76	1.00												
Cru	0.29	0.80	0.79	1.00											
Iro	-0.23	0.82	0.71	0.70	1.00										
Soy	0.01	0.93	0.77	0.81	0.80	1.00									

Cop	0.15	0.80	0.81	0.85	0.79	0.78	1.00								
Tin	-0.09	0.83	0.85	0.75	0.86	0.87	0.88	1.00							
Whe	0.27	0.86	0.71	0.84	0.64	0.85	0.78	0.72	1.00						
Alu	0.55	0.46	0.63	0.69	0.33	0.38	0.76	0.48	0.57	1.00					
Zin	0.15	0.35	0.49	0.45	0.37	0.34	0.76	0.58	0.35	0.73	1.00				
Nic	0.58	0.40	0.40	0.58	0.30	0.33	0.66	0.37	0.52	0.84	0.64	1.00			
Gol	-0.31	0.78	0.67	0.56	0.86	0.79	0.78	0.88	0.59	0.26	0.51	0.19	1.00		
Ric	0.13	0.79	0.81	0.75	0.73	0.81	0.75	0.76	0.72	0.48	0.35	0.35	0.72	1.00	
Lea	0.17	0.70	0.78	0.72	0.70	0.76	0.90	0.88	0.71	0.62	0.75	0.55	0.78	0.69	1.00

As can be seen from Table 2, there is a strong correlation (above 0.800) between certain commodities.

For this reason, eight variables were excluded from further analysis (Cor, Coa, Cru, Soy, Cop, Tin, Gol and Alu).

As two different estimation methods are used, two different sets of results are illustrated in Table 3.

The 2SLS results in Table 3 show that there is: 1) a positive and significant relationship between the BDI and Nic – every 1% increase in Nic causes an increase of 0.217% in the BDI; 2) a positive and significant correlation between Ric and the BDI – for every 1% increase in the value of rice, the NPL's rate will rise by approximately 4.17%; 3) a positive and significant relationship between Lea and the BDI – every 1% rise in Lea leads to a 1.61% increase in its BDI value. These results are in line with those found by Papailias et al. (2017), Tsioumas & Papadimitriou (2015) and Tsioumas & Papadimitriou (2016).

The results obtained from the 2SLS also show that there is: 1) a negative and significant relationship between Iro, as one of the main commodities for international trade, and the BDI index – for every rise of 1% in Iro, the BDI value will decrease by 35.95%; and 2) a negative and significant correlation between Zin and the BDI – every 1% increase in Zin will decrease the BDI by 1.501%.

The one-step GMM method provided similar results: 1) there is a positive and significant relationship between the BDI and Nic – every increase in Nic of 1% causes an increase of 0.207% in the BDI; 2) a positive and significant correlation between Ric and the BDI – for every 1% increase in the value of rice, the NPL's rate will rise by approximately 3.8%; 3) a positive and significant relationship between Lea and the BDI – every 1% rise in Lea corresponds to a 1.45% increase in the value of the BDI.

**Table 3.** 2SLS and one-step GMM method results.

### 2SLS

Regressor	Coefficient	Std. Error	t-ratio	p-value	
Const	525.294	289.874	1.812	0.071	*
Iro	-35.952	2.378	-15.12	<0.0001	***
Whe	-2.633	2.246	-1.173	0.242	
Zin	-1.501	0.179	-8.386	<0.0001	***
Nic	0.217	0.014	15.610	<0.0001	***
Ric	4.178	0.791	5.280	<0.0001	***
Lea	1.610	0.240	6.695	<0.0001	***

R-squared = 0.71		Adjusted R-squared = 0.70			
Hausman test: Chi-square(1) = 4.41037; p-value = 0.035					
Weak instrument test - F-statistic (1,243) = 1110.79					
One-step GMM					
Regressor	Coefficient	Std. Error	z-ratio	p-value	
Const	300.320	381.020	0.790	0.431	
Iro	-36.24	3.550	-10.090	<0.0001	***
Whe	0.450	2.819	0.160	0.872	
Zin	-1.385	0.183	-7.560	<0.0001	***
Nic	0.207	0.021	9.570	<0.0001	***
Ric	3.800	1.344	2.830	<0.005	***
Lea	1.451	0.295	4.930	<0.0001	***

**Note:** \*\*\*, \*\*, \* indicate significance at the 1%, 5% and 10% levels, respectively.

The results obtained from the one-step GMM show that there is: 1) a negative and significant relationship between Iro and the BDI index – for every rise of 1% in Iro, the value of the BDI will decrease by 36.24%; and 2) a negative and significant correlation between Zin and the BDI – every increase in Zin of 1% will decrease the BDI value by 1.385%.

Both methods suggest that there is no significant relationship between Whe and the BDI index.

#### 4. Conclusion

This paper examined the relationship between the BDI and major raw materials, whose freight enters the calculation of the value of the BDI index. The aim of the paper was to examine whether the changes in the value of these raw materials affect the changes in the value of the BDI, and to what extent they affect it. For purpose of the study, a multiple linear regression model was used. To estimate the model parameters, the 2SLS and GMM estimators were used. The survey covers the period from the day the indexes were created to the present day. This period includes two major economic crises: the great economic crisis of 2008 and the current crisis caused by the Covid-19 pandemic.

The findings of this research suggest that iron ore has a crucial deterministic role for the BDI, unveiling that the value of this raw material is oppositely linked to the value of the index. Also, the findings of this research suggest that there is a negative and significant correlation between zinc and the BDI.

The results of the paper imply that there is a positive and significant relationship between the index and lead, nickel and rice. A significant relationship was not found between the BDI index and wheat. However, this result is not in line with abovementioned studies.

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