A Regression Model for Analyzing the Relationship between Baltic Dry Index and Economic Indexes

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Abstract: Baltic Dry Index (BDI) is one of the important indexes in the bulk shipping industry. It is very important for the ship-owners, charterers, and shipping carriers to understand the relationship between BDI and economic indexes. Based on the relationship between BDI and economic indexes, they can foresee the trend of freight rates in the shipping market and then make some important decisions such as charter-in, charter-out and risk-avoidance. Thus, this study employed a regression model to analyze the relationship between BDI and economic indexes. Finally, the Root Mean Square Percentage Error (RMSPE) is applied to evaluating the accuracy of this regression model.

Keywords: Maritime Transportation, BDI, Regression Analysis, Economic Indexes, Dry Bulk Shipping

1. INTRODUCTION

The Baltic Exchange was established since 1744. In 1985, the Baltic Exchange launched the Baltic Dry Index (BDI) which is an economic indicator of shipping freight rates for dry bulk cargoes, mainly consisting of raw commodities such as iron ore, coal, grain and other primary materials.

BDI is not only an indicator of shipping freight rates but also one economic index of international trade. The BDI which reflects the cost of bulk shipping transportation is especially relevant for the international trade and the income of the Sub-Saharan African (SSA) economies (Lin and Sim, 2014). The SSA economies consist of 49 countries, in which 33 are the least developed countries (LDCs). The exports from these SSA countries are mainly made up of primary goods such as cocoa, coffee, tea, cotton, timber and primary metals. Therefore, many of primary goods require various types bulk carriers for international maritime transportation. Some important conclusions were introduced in previous studies. As these products are transported internationally mainly by various bulk carriers, the BDI reflects an important component in the freight rates of international trade so that positive increases in the BDI will have a negative effect on the international trade of the SSA economies, and such negative effect then transmitted to income (Lin and Sim, 2014). This is one of the previous literature studies concerning on the relationship between the BDI, the international trade and the economic growth.

Few studies focused on the relationship between BDI and economy. Thus, this paper makes an attempt to explore the strength and the relationship between BDI and international economic indexes by using statistical regression technique.

2. LITERATURE REVIEW

Linear regression has been applied to many fields, for example, recycling behavior prediction (Vesely et al., 2016), predicting monthly reservoir levels prediction (Shamim et al., 2016), applications to aggregate indicators of economic development (Meng et al., 2016), prediction of occupational risk in the shipbuilding industry (Tsoukalas and Fragiadakis, 2016), office building cooling load prediction (Guo et al., 2015), forecasting groundwater temperature (Figura et al., 2015), mortality rate forecasting (Lin and Tsai, 2015), forecasting of import/export container volumes (Chou et al., 2008), transportation management (Maniquiz et al., 2009), and medical waste management (Jahandideh et al., 2009). Other various types of regression models also have been widely used to solve other problems, for example, micro-economic determinants of tourist expenditure (Marrocu et al., 2015), estimating transport accident deaths using logistic regression model (Klinjun et al., 2015).

Wen et al. (2008) examined the long-term equilibrium relationships between raw material prices and dry-bulk shipping freight indices by Johansen co-integration test and Vector Error Correct Models (VECM). Chang and Liu (2010) adopted a time series model for analyzing the relationship between the BDI and the prices of transport stocks in Taiwan and America. Chou and Lin (2010) analyzed the relationships between BDI and steel price index by constructing Vector Autoregressive (VAR) model. Chou and Chen (2013) investigated the relationship between Taiwan Bulk Shipping Index (TAIBX) and Baltic Dry Index (BDI) using Vector Autoregressive Moving Average model (VARMA). Chou and Lin (2017) analyzed the relationship between the BDI and global economic indexes by using fuzzy neural network model. Hsiao (2013) explore the relationships between Baltic Freight Index (BCI, BPI and BSI), bulk cargoes (including coal, steel, soybeans, wheat, and corn prices) and bunker prices. BCI is the Baltic Capesize Index, BPI is the Baltic Panamax Index, and BSI is the Baltic Supramax Index. The collected data is during the period of 2009-2013. The research methodology is the time series. Finally the results are tested by unit root test, cointegration test and error correction model. The study results show that BCI, BPI will be affect by coal, BSI will be affect by soybeans and bunker price. Soybeans, wheat, corn price will be affect by each other.

Based on the above literature, it is noted that various statistical regression models have been proposed to solve a lot of prediction and analysis problems in real world. Few studies applied statistical regression technique to analyze the relationship between economic indexes in the financial market and BDI in the bulk shipping market. Thus, this study makes an attempt to analyze the relationship between economic indexes in the financial market and BDI in the bulk shipping market by using statistical regression technique.

3. METHODOLOGY

Linear regression is an approach for modelling the relationship between a scalar variable y and one or more explanatory variables denoted as *x* (Draper and Smith, 1998). Linear regression associated with one explanatory variable is called simple linear regression. More than one explanatory variable is called multiple regressions.

Linear regression is simpler than nonlinear one. Linear regression is the initial type of regression analysis. This is because models which depend linearly on their unknown variables are easier to fit than those which are nonlinearly related to their variables.

Given a variable *y* and a number of variables $x_1, x_2, \ldots, x_i, \ldots x_n$ that may be related to *y*, linear regression analysis can be applied to quantify the strength of the relationship between

variables y and x_N, to identify which x_N may have direct relationship with y, and which x_N may have no relationship with y at all. Linear regression models are usually fitted using the least square approach. A brief description of the linear regression models and the estimation of their coefficients using the least square estimation are shown as follows.

In linear regression model, the dependent variable y_i is a linear combination of the parameters. For example, in simple linear regression for modelling N data points, there is an independent variable x_i, and two parameters β_0 and β_1.

$$y_i = \beta_0 + \beta_1 x_i + \varepsilon_i, \; i=1,\cdots, N. \qquad \text{Eq.(1)}$$

where ε_i is an error term. Given a random sample, the parameters are estimated and the linear regression model is obtained below.

$$\hat{y}_i = \hat{\beta}_0 + \hat{\beta}_1 x_i \qquad \text{Eq.(2)}$$

The residual $e_i = y_i - \hat{y}_i$, is the difference between the value of the forecasted dependent variable $\hat{y}_i$ and the true value of the dependent variable y_i. This technique obtains parameters estimates that minimize the sum of squares residuals, SSE.

$$\text{SSE}=\frac{1}{N}\sum_{1}^{N} e_i^2 \qquad \text{Eq.(3)}$$

In the case of linear regression, the formula for the least square estimates is

$$\hat{\beta}_1 = \frac{\sum (x-\bar{x})(y-\bar{y})}{\sum (x-\bar{x})^2} \qquad \text{Eq.(4)}$$

$$\hat{\beta}_0 = \bar{y} - \hat{\beta}_1 \bar{x} \qquad \text{Eq.(5)}$$

4. EMPIRICAL STUDY

This study collected the BDI monthly data during the period of January 2000 to March 2015. The other economic data including: global agriculture stock index (x_1), international metal price index (x_2), OECD combined leading index (x_3), global energy stock index (x_4), and US dollar index (x_5) are also collected during the period of January 2000 to March 2015. In fact, we not only collected the above-mentioned five major global economic indexes, but also other important global economic indexes. After pre-test, the results show that the regression model has better forecasting performance by inputting the above-mentioned five global economic indexes. A part of data is shown in Table 1. All the collected data are used to construct a regression model. The regression model is shown below. R^2= 0.86. A part of BDI forecast results is also shown in Table 1. The differences between the actual BDI value and the forecasted results are also shown in Figure 1.

$$y = -12772.62 + 3.518 x_1 - 49.212 x_2 + 225.853 x_3 - 9.719 x_4 - 69.907 x_5 \qquad \text{Eq.(6)}$$

Table 1 BDI and other major economic indexes

Year/ Month	Global energy stock index	International metal price index	Global agriculture stock index	OECD combined leading index	US dollar index	Actual BDI	Forecasted BDI
2002/09	743.97	52.51	604.47	99.126	108.24	1178	1571
2002/10	751.89	52.91	643.41	98.998	107.07	1365	1747
2002/11	768.58	55.22	690.46	98.891	105.04	1459	1917
2002/12	791.08	55.41	679.23	98.789	104.06	1666	1879
2003/01	764.43	57.02	672.79	98.684	101.34	1694	1979
2003/02	769.18	58.55	682.65	98.594	100.44	1674	1983
2003/03	760.69	57.49	634.58	98.558	100.74	1850	1828
2003/04	760.14	55.53	674.50	98.605	99.15	2056	2191
2003/05	842.51	57.84	721.95	98.731	95.22	2227	2450
2003/06	843.50	58.69	731.17	98.918	92.40	2136	2674
2003/07	815.36	59.74	800.21	99.147	94.30	2192	2851
2003/08	853.64	60.71	872.67	99.405	97.35	2286	2884
2003/09	854.51	60.75	884.14	99.679	95.98	2469	3074
2003/10	871.55	64.32	1014.98	99.950	92.42	4162	3693
2003/11	886.86	66.90	1022.60	100.191	91.53	4260	3693
2003/12	1003.33	70.93	1161.51	100.386	88.46	4609	4139
2004/01	1005.89	75.89	1118.40	100.527	86.56	5227	3897
2004/02	1058.08	80.60	1192.03	100.610	85.47	5450	3987
2004/03	1083.71	81.39	1202.22	100.645	88.81	5145	3738
2004/04	1069.88	81.33	1044.40	100.641	90.06	4730	3058
2004/05	1061.44	77.04	1082.33	100.613	91.00	3596	3345
2004/06	1100.28	79.54	1128.98	100.571	89.09	2916	3480
2004/07	1135.64	81.93	1149.37	100.521	87.99	3774	3466
2004/08	1123.37	80.79	1213.97	100.466	87.96	4169	3778
2004/09	1221.13	81.98	1329.86	100.420	89.15	4142	3954
2004/10	1240.37	85.94	1297.31	100.386	87.09	4539	3751
2004/11	1311.13	86.60	1455.79	100.362	84.00	5303	4447
2004/12	1283.86	87.42	1437.16	100.334	81.63	1344	4528
2005/01	1306.58	93.14	1433.82	100.288	83.06	4502	4115
2005/02	1487.04	95.76	1621.21	100.217	83.59	4620	4432
2005/03	1450.29	99.75	1499.94	100.136	82.12	4677	3908

Sources: Clarksons, https://clarksonsresearch.wordpress.com
Dry Bulk Market Outlook, http://www.newportshipping.com
FOREX, http://www.forex.com/uk/cns
IMF, http://elibrary-data.imf.org
OECD, http://www.oecd.org
StockQ, http://www.stockq.org

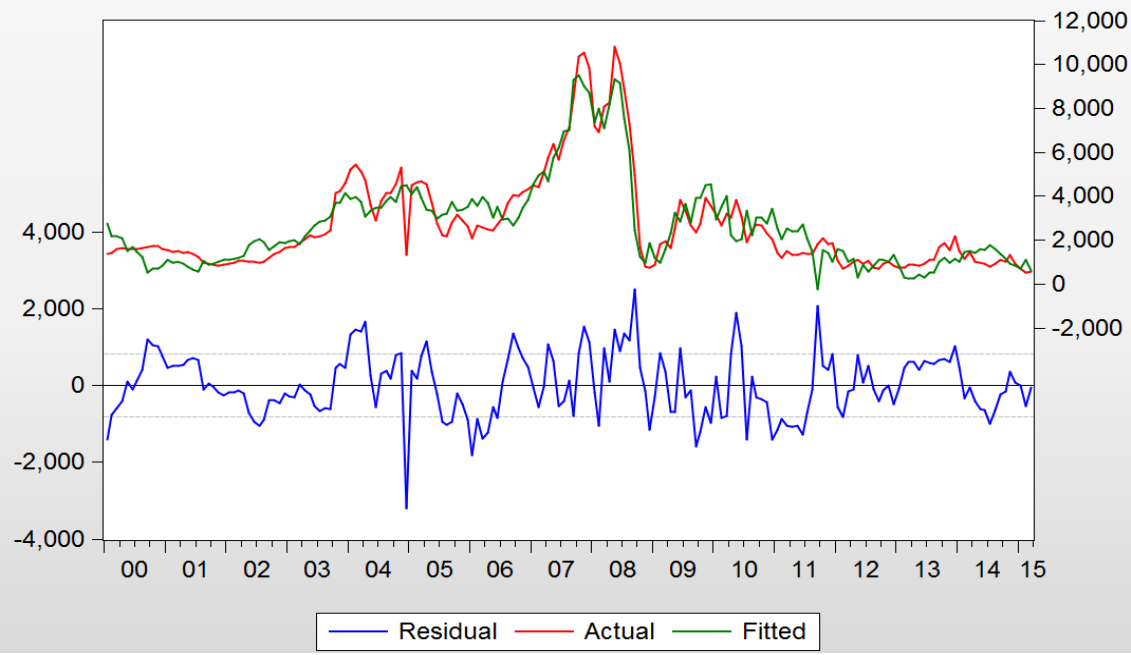

Figure 1. BDI Forecast result by using regression model

Finally, the Root Mean Square Percentage Error (RMSPE) is applied to evaluating the accuracy rate for this regression model. The RMSPE is calculated as follows. RMSPE= 46.49% is smaller than 50. This means the regression model is a reasonable analysis model.

$$\text{RMSPE}=\sqrt{\frac{1}{183}\times\left(\frac{(1371-2773)^2}{1371}+\frac{(1405-2183)^2}{1405}+\ldots+\frac{(576-636)^2}{576}\right)}\times 100\,\%=46.49\%$$

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5. CONCLUSION

This paper investigates the relationship between BDI and economic indexes by linear regression technique. RMSPE was applied to evaluate the accuracy performance of this linear regression model, and the results show that the proposed linear regression model has reasonable accuracy performance of forecasting. Other various analysis approaches would be applied to the analysis of the relationship between BDI and economic indexes in the future works.

This study suggests that the importers and exporters of international trade bulk cargo, shipping carriers in the shipping market, and bulk carrier characters could pay more attentions to the global economic indexes and to find out and forecast the future BDI in advance to avoid the risks resulting from BDI.

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