The determining factors of the dry bulk market freight rates

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***Abstract*—**As an inherently volatile industry, shipping is characterized by a high risk – high return profile, making its rates and prices difficult to forecast. In shipping industry, investment decisions are taken on a proper risk measurement and management basis, since they are long-term decisions with important financial implications. Taking in consideration the importance of risk measurement and management within the investment environment, the purpose of this study is to provide a proper risk measurement solution for freight-rate risk.

***Keywords*—**BDI, Freight, GDP, Regression.

I. INTRODUCTION

The maritime industry represents a vital link in international trade, providing an efficient method of transporting large volumes of basic commodities and finished products. In 2012, more than one-third of all international seaborne trade consisted of dry bulk cargo. The importance of the dry bulk industry lies in the fact that without the estimated 4 billion tons of dry bulk cargo transported by sea, global trade and industry would not be maintained.

Dry bulk shipping can be defined as the maritime transportation segment associated with transporting commodities in bulk, rather than containerized or palletized. Dry bulk cargo is shipped in large quantities and can be stowed in a single hold with diminished risk of cargo damage. Dry bulk cargo is categorized as either major bulk or minor bulk. Major bulk cargo represents the vast majority of dry bulk cargo by weight, and comprises, among other things, iron ore, coal and grain. Minor bulk cargo represents the balance of the dry bulk industry, and comprises agricultural products, mineral cargoes, cement, forest products and steel products. Dry bulk shipping covers a variety of trades and the main of them are represented by iron ore, coal, grain plus bauxite, alumina and phosphates. Iron ore, steam coal and grains are affected by seasonal demand fluctuations. Bulk cargo can be very dense, corrosive or abrasive causing safety problems.

Dry bulk shipping is segmented by ship size, with the largest ships being capable of carrying over 300 000 tonnes of cargo. The first specialized bulk carrier was built in 1852, and since then, the process of development continued, causing the ships to grow in size and sophistication in order to maximize capacity, safety and efficiency. The main types of bulk carriers include Handies, Panamax and Capesize. Other dry cargo ships comprise OBOs (ore/bulk/oil carriers or Combination Carriers) and VLOCs (very large ore carriers). The “Vale Brasil” holds the title of the world’s largest dry vessel with a deadweight of 402 347 tonnes.

The dry bulk carrier demand is determined by the underlying demand for commodities transported in dry bulk carriers. During the 1980s and 1990s seaborne dry bulk trade increased by approximately 2% on an average annual basis and between 1990 and 2006 the overall increase was of 35%. The dry bulk carrier demand is indirectly influenced by trends in the global economy and more specific by changes in gross domestic product and industrial production. Sometimes, the evolution of the dry bulk carrier market is driven by certain powerful economies such as Japan and China.

The dry bulk carrier supply is influenced by vessel deliveries and loss of existing vessels through scrapping or other circumstances requiring removal. The supply of dry bulk carrier is also the result of the operating efficiency of the worldwide fleet.

The balance between vessel supply and demand acts as a function for dry bulk charter rates computation. Dry bulk charter rates are different from one charter contract type to another and also from one vessel type to another. Generally, charter hire rate of larger ships are more volatile than those for smaller vessels. The most representative charter hire rate references of the dry bulk shipping market are the freight rate indices produced by the Baltic Exchange, which are calculated every market day from data supplied by a panel of independent shipbrokers.

II. LITERATURE REVIEW

In spite of the dry bulk shipping importance, research papers on dry bulk market rates are scarce.

As the freight charge of dry bulk cargo holds a major share of supply chain cost, it is important for supply chain participants to understand the determining factors of the bulk freight market. Shen and Lo (2012) investigate the short-term and long-term causality relationship between the Baltic Dry Index and the gross domestic product of the BRIC (Brazil, Russia, India and China) countries by applying the equilibrium analysis and Granger’s causality test. Their research confirms the existence of short-term and long-term equilibrium relationships between BDI and GDP in the case of China. Also, no significant causalities were found between the BDI and the GDP of Brazil, Russia and India.

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Jing et al. (2008) analyze the characteristics of volatility in dry bulk freight rates of different vessel sizes by applying GARCH and EGARCH models on a sample of daily returns of freight rate indices collected for the period 1999 – 2005. The authors noticed that the shocks will not decrease but have the tendency to strengthen. Moreover, external shocks on the market have a different influence on volatility in different types of vessel due to their distinct flexibility. They have also investigated the asymmetric impact between past innovations and current volatility, noticing that the asymmetric characters are distinct for different vessel size segments and different market conditions due to the different flexibility and different commodity transport on different routes.

Merikas et al. (2013) apply copula models on the Clarkson's dataset for the last 20 years in order to reconstruct joint distribution of time charter rates for dry bulk ship. The authors have implemented a system of criteria for copula selection based on goodness-of-forecast criteria. Also, they have used a homogenous dataset in terms of copula structural shifts' absence. According to the research results, dry bulk time charter rates weekly returns exhibit symmetric distribution. The analysis performed in this paper is useful for portfolio optimization.

The global economic crisis has strongly affected the international shipping industry. In this context, the freight rates for the dry bulk market have sharply decreased. Li et al. (2009) investigate the features of the dry bulk market taking in consideration the market deteriorating conditions. The authors analyze the demand and the supply, providing predictions and suggestions for dry bulk shipping companies to help them face risks. According to their research, the demand is shrinking, while the supply is affected by the aggravated financial situation of carriers.

Guo et al. (2009) examine the international dry bulk freight rates during 2003 - 2008 by applying qualitative analyses on the composing factors of the dry bulk shipping market. Moreover, they investigate the features of mutual action of the world dry bulk demand and supply by applying structural equation model. The research results highlight the fact that, from the perspective of demand and supply, the dry bulk fleet supply market is of a greater impact for freight transport, making the international dry bulk cargo transport market a seller's market.

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III. DATA AND METHODOLOGY

In this study, a multiple OLS regression was applied in order to analyze the relationship between the Baltic Dry Index and the most important determining factors of the dry bulk market rates, namely the worldwide dry bulk demand, the worldwide dry bulk supply and the worldwide gross domestic product. The annual data series of Baltic Exchange Dry Index, worldwide dry bulk demand, worldwide dry bulk supply and worldwide gross domestic product for the period 1985 – 2012 were used for the empirical study. Data were collected from Baltic Exchange database and UNCTAD database and the analysis was performed with EViews 7. This kind of analysis may provide a better understanding of the dry bulk shipping market by revealing information regarding the mechanism and the determining factors of the dry bulk market rates.

A multiple OLS regression is concerned with the relationship between a dependent variable and a series of "m" independent variables. This type of regression is useful because it allows the analyst to control for the multiple factors that simultaneously affect a dependent variable. Mathematically, a multiple OLS regression can be represented as follows:

$$y_i = b_0 + b_1 x_{1,i} + b_2 , x_{2,i} + ... + b_m x_{m,i} + \varepsilon_i \quad (1)$$

where the coefficient b_0 is the vertical intercept and the "m" coefficients b_1 to b_m are the slope coefficients. Each coefficient b_j for j>0 represents the change in y_i induced by a change in variable $x_{j,i}$ holding all other variables constant.

In order to achieve the goal of the research analysis, the following multiple OLS regression was build based upon the dependent variable represented by the Baltic Exchange Dry Index and three independent variables represented by the worldwide dry bulk demand, worldwide dry bulk supply and worldwide gross domestic product:

$$BDI = b_0 + b_1 * demand + b_2 * \sup ply + b_3 * GDP + \varepsilon \quad (2)$$

The Baltic Exchange Dry Index was chosen as the image of dry bulk market rates because, according to Alizadeh and Nomikos[1], this index is widely used by practitioners as a general market indicator reflecting the movements in the dry bulk market, being considered as the "barometer" of dry bulk shipping.

IV. EMPIRICAL ANALYSIS

Firstly, the ADF test (Augmented Dickey-Fuller) was applied in order to verify the stationarity of time series. A time series is said to be stationary if its mean, variance and its covariances remain constant over time. From an economic point of view, shocks to a stationary time series are temporary and, over time, the effects of the shocks will dissipate. According to Table 1, the existence of a unit root was estimated for the original data and the absence of a unit root for the first-difference logarithmic data (BDI, demand and GDP) and for the second-difference logarithmic data (supply). Usually, the econometric analysis is performed with logarithmic series because it facilitates the interpretation of regression coefficients. Therefore, the variables BDI, demand and GDP are integrated of order 1 and denoted by l(1), and the variable supply is integrated of order 2 and denoted by l(2).

Table 1. ADF test logarithm

BDI		**Demand**		**Supply**		**GDP**	
l(0)	**l(1)**	**l(0)**	**l(1)**	**l(0)**	**l(2)**	**l(0)**	**l(1)**
H0: The time series has a unit root (non-stationary)							
0.3524	0.0013	0.9485	0.0001	1	0.0002	0.5919	0.0065

If the probability is lower than the significance level, the null hypothesis is rejected. It can be observed that the first-

[1] Amir H. Alizadeh and Nikos K. Nomikos – Shipping Derivatives and Risk Management, Palgrave Macmillan, 2009

difference logarithmic data is stationary for a 5% significance level (BDI, demand and GDP) and the second-difference logarithmic data is stationary for a 5% significance level (supply).

After testing stationarity, the model of the multiple OLS regression can be created by using the stationary logarithmic time series.

Table 2. The output of the multiple OLS regression

Variable	Coefficient	Std. Error	t-Statisti
C	-0.299038	0.106784	-2.80040
DL_DEMAND	0.434638	1.251157	0.34738
D2L_OFFER	-8.512831	3.246002	-2.62255
DL_GDP	5.380939	1.268717	4.24124

R-squared	0.520918	Mean dependent var	
Adjusted R-squared	0.455589	S.D. dependent var	
S.E. of regression	0.300581	Akaike info criterion	
Sum squared resid	1.987680	Schwarz criterion	
Log likelihood	-3.467732	Hannan-Quinn criter.	
F-statistic	7.973718	Durbin-Watson stat	
Prob(F-statistic)	0.000884		

Source: own estimations

According to Table 2, the probabilities of t-Statistic test are lower than the 5% significance level for all the coefficients, which means that the null hypothesis is rejected. Thus, all the coefficients are statistically significant. These results are confirmed by F-statistic test, which assesses how well independent variables explain the evolution of the dependent variable. The probability of F-statistic test is lower than the 5% significance level, which means that the null hypothesis is rejected. Therefore, at least one of the coefficients is statistically significant.

According to Table 2, R-squared is higher than 50%, which means that the independent variables explain over 50% of the dependent variable's variance. Thus, the model of the regression can be considered adequate.

The model of the regression is considered to be valid, if certain hypotheses are accepted. The first hypothesis tests the normality of residuals (Figure 1). The probability of Jarque-Bera test is higher than the 5% significance level, Skewness is ≈ 0 and Kurtosis is ≈ 3, which means that residuals have a normal distribution.

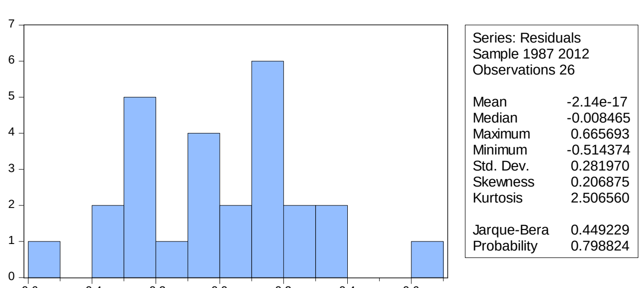

Fig 1. Normality of residuals

The second hypothesis tests the autocorrelation of residuals. According to Figure 2, the probabilities of Q-Stat are higher than the 5% significance level, which means that there is no serial correlation of residuals. The absence of autocorrelation of residuals is confirmed by the Breusch-Godfrey LM Test whose probabilities are higher than the 5% significance level.

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.005	-0.005	0.0007	0.978
		2	0.007	0.007	0.0023	0.999
		3	0.293	0.293	2.7121	0.438
		4	0.095	0.108	3.0100	0.556
		5	-0.260	-0.288	5.3467	0.375
		6	0.173	0.089	6.4420	0.376
		7	0.082	0.063	6.6980	0.461
		8	-0.424	-0.361	13.970	0.083
		9	-0.040	-0.083	14.040	0.121
		10	-0.081	-0.187	14.335	0.158
		11	-0.168	0.100	15.708	0.152
		12	-0.123	0.015	16.492	0.170

0.574441 Fig. 2 Autocorrelation of residuals

0.767994

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.000977	Prob. F(2,20)	0.9990
Obs*R-squared	0.002540	Prob. Chi-Square(2)	0.9987

Fig. 3 Breusch-Godfrey LM Test

The last hypothesis tests the homoskedasticity of residuals (the existence of ARCH terms) through autocorrelation of squared residuals. According to Figure 3, the probabilities of Q-Stat are higher than the 5% significance level, which means that there is no serial correlation of squared residuals. The absence of autocorrelation of squared residuals is confirmed by the ARCH Heteroskedasticity Test whose probabilities are higher than the 5% significance level.

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.195	-0.195	1.1115	0.292
		2	-0.159	-0.205	1.8776	0.391
		3	0.045	-0.035	1.9426	0.584
		4	0.117	0.095	2.3952	0.663
		5	0.025	0.086	2.4168	0.789
		6	-0.168	-0.115	3.4405	0.752
		7	0.019	-0.039	3.4537	0.840
		8	0.166	0.113	4.5740	0.802
		9	-0.108	-0.054	5.0724	0.828
		10	-0.276	-0.276	8.5295	0.577
		11	0.290	0.183	12.600	0.320
		12	-0.105	-0.143	13.178	0.356

Fig. 4 Homoskedasticity of residuals

Heteroskedasticity Test: ARCH

F-statistic	0.912868	Prob. F(1,23)	0.3493
Obs*R-squared	0.954369	Prob. Chi-Square(1)	0.3286

Fig. 5 Heteroskedasticity Test ARCH

Finally, if the previous hypotheses are accepted, the stability of the equation and its coefficients can be tested. Fig 6 shows the CUSUM test which computes the cumulative sum of the equation's recursive residuals. It can be noticed that the

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equation and its coefficients are stable because the cumulative sum fluctuates between the two critical lines.

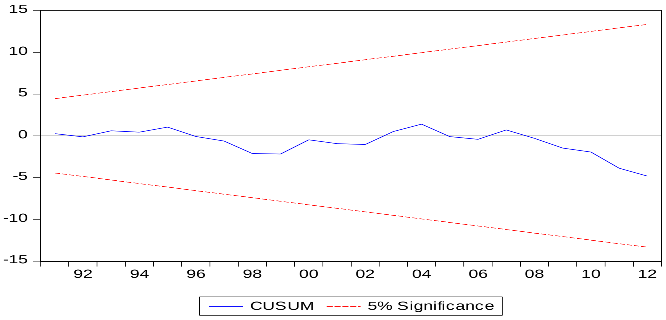

Fig. 6 CUSUM stability test

V. CONCLUSIONS

The results of the empirical analysis show that the relationship between the Baltic Dry Index and the most important determining factors of the dry bulk market rates, namely the worldwide dry bulk demand, the worldwide dry bulk supply and the worldwide gross domestic product, can be expressed as follows:

$$BDI = -0.299 + 0.435 * D - 8.513 * S + 5.381 * GDP + \varepsilon \quad (3)$$

The worldwide demand has a positive influence on the dry bulk freight market while worldwide dry bulk supply has a stronger influence on dry bulk market rates, but with a negative sign, due to the fact that an increasing extra-capacity of vessels will lead to smaller freight rates. However, the influence of demand and supply on dry bulk freight rates should be analyzed by taking in consideration the market price mechanism which balances the forces of the two variables, leading to an equilibrium price.

Shipping industry is vital for international trade because it accounts for the highest volume of transported commodities and finished products. The development of international trade depends on the development of the world economy. Therefore, the worldwide gross domestic product has a positive influence on freight rates.

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