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THE REACTIONS OF VESSEL SPEEDS TO BUNKER PRICE CHANGES IN DRY BULK MARKET

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Abstract:
The biggest operational cost of vessels in shipping is fuel costs. As the ship's sailing speed increases, the fuel consumption also increases in cubic and incurs an incredible cost to the shipowners. For this reason, when the market is not alive and the fuel price is high, the vessels tend to sail in slow steam and save costs. From this point of view, a nonlinear causal relationship between fuel price and vessel sailing speed is inevitable. The purpose of this study is to determine the causal relationship between fuel prices and vessel speeds in the dry bulk market. In this direction, asymmetric causality test is used, considering that market agents give different responses to different news. Asymmetric causality test allows to determine the causal relation between the positive and negative shocks in different variables by separating them as positive and negative. The data set consists of 122 observations on a monthly basis covering the period from May 2008 to June 2018. The results revealed, there is an asymmetric causality from positive shocks at fuel prices to negative shocks at average vessel speeds. This indicates that shipowners are reacting instantly to positive fuel prices shocks by slowing down vessel speeds as the fuel costs constitute large share of operational costs. But the flexibility of not responding to a drop in fuel prices instantaneously by increasing vessel speed can stem from commercial strategies and competitive concerns. At this point, this study has an important contribution to the literature in terms of examining this relationship on the basis of causality and observing the asymmetric relations between bunker price and vessel speed at a more macro scale.

Key words:
Bunker price, vessel speed, asymmetric causality.

INTRODUCTION

In recent times when globalization has reached its peak, various transport systems have emerged in maritime transport, which increases speed and efficiency. One of these system is passenger liners which transports passengers between the certain cruise ports; the other one is cargo liners which transported cargoes on a widespread network of regular services; and the last one is tramp shipping which carry spot cargoes on routes not served by liner services, or when any cargo available in the market [1]. Today, tramp shipping has evolved to become more used for bulk cargo ships. Because these loads are demanded in large quantities irregularly, and they are heavily influenced by the changes in the prices of the products. Tramp shipping can also be likened to taxi service as a system [2] since the ship operator tracks the available cargo for maximizing profit and this transport does not take place on a fixed route [3]. The relationship ends at the port where the cargo owner has wanted to carry the cargo, and a search for a new cargo begins for the ship operator. Industrial transportation is also similar to tramp shipping, the only difference is that the shipowner and the cargo owner are the same entity/person in the industrial one [4].

Increasing competition with the decline of the global maritime market have put a great deal of pressure on the revenues of shipping companies lately. Moreover, increased safety regulations and increased fuel prices significantly increase the operation costs of the vessels [5]. But the effect of the fuel price on operational costs of the ships is very different from the others since a large part of the daily operating costs consists of fuel price [3]. Thus, ships' fuel consumption amounts directly affect the operational costs of the ships and generate a vital situation for shipowners.

Fuel consumptions of the vessels are strongly dependent on their speeds [2]. Because the ship's fuel consumption does not increase in proportion to its speed, fuel consumption increases much more [6]. So it is very important to determine the speed of voyages in terms of costs. The determination of speed in tramp shipping is usually dependent on two input parameters; these are fuel prices and freight rates on the market. In depressed market conditions and at high fuel prices the vessels tend to sail at a slow steam. On the contrary, the vessels tend to sail faster in boom periods and at low fuel prices. At this point, there are both advantages and disadvantages of the higher sailing speed. The advantages are that the amount of cargo carried on an annual basis is larger and inventory costs associated with shipping are lower. The disadvantage is that the amount of fuel burned is much higher as previously mentioned [7]. In parallel to these, the advantage of slow steaming can be stated as a decrease in fuel costs [8].

The impact of a change in the speed of a vessel on its operational costs may be quite impressive [9]. At this point, the speed of the vessel is very much affecting the profitability. Because increasing the speed makes it possible to carry more spot loads. However, reducing speed also reduces costs by causing less fuel consumption [8]. So there is a trade-off between steaming faster to carry more and steaming slower to reduce bunker costs. In other words, there is a tradeoff between income lost through speed reduction and bunker savings by not increasing the speed [4].

The concept of optimum speed has gained great importance due to the combination of low freight rates in the maritime market and volatile high fuel prices [10]. If we consider that a ship burns thousands of dollars a day, then at optimal speed it can save millions of dollars annually. And it may also make it possible for the company to hold on to the market instead of bankruptcy in depressed market conditions [4]. These benefits are vital as long as the maritime market is stagnant and fuel prices are on the increase [7]. Especially nowadays this importance is increasing even more since fuel prices are high and freight rates are depressed [5]. Besides these benefits, it is also thought that maintaining the speed at the optimum level is also beneficial for environmental factors [5, 7, 8, 9, 11], however economic concerns often preclude environmental concerns in today’s world.

According to the theoretical framework drawn up to this point, the results that the researcher aims to achieve are two different ways; firstly, positive shocks at fuel prices are thought to cause negative shocks at average vessel speeds; secondly, negative shocks in fuel prices are thought to cause positive shocks at average vessel speeds. In this direction, the asymmetric nonlinear causality test designed by Hatemi-J [12] is used that allows to test the causal relationship between shocks by separating the shocks in the variables as positive or negative. According to the results obtained, positive shocks in fuel prices led to negative shocks at average vessel speeds, but the opposite scenario has not been supported. This shows that, when the fuel costs increase, the operation costs increase too much, therefore lowering the ship's speed becomes a necessity for shipowners. However, when fuel prices fall, the ship owners are able to act more flexibly due to commercial strategies and competitive concerns. Because speed-up decisions are directly influenced by freight rates and demand for vessels on the market.

Studies in the literature have usually focused on the fleet speed of the container market [6]. Some others have studied programming tools and scenarios to determine the optimal speed on different routes, different market conditions, different bunker prices [10, 2, 9, 3]. Besides, empirical studies have been carried out which show the relation between optimal speed and fuel price within the frame of speed-varying bunker consumption [4]. The originality of this study is the first to examine the causality between fuel prices and the average speeds of ships in the dry bulk market where the ships in this market do not follow on a particular route and are flexible. Also examining the causality between shocks in the variables using nonlinear asymmetric causality instead of the linear causality test has another originality of the study.

The remainder of the study is organized as follows; the theoretical framework of the study is drawn in the first section; the method used in the study is introduced in the second section; the results are presented in the third section; and lastly, findings are presented and discussed in the last section.

1 THEOROTICAL BACKGROUND

It is helpful to examine the equation (1) developed by Evens and Marlow [13] to further the theoretical part of the study. *S* is the optimum speed in miles per day, *R* the voyage freight rate, *p* the price of fuel, *k* the ship’s fuel constant, and *d* distance.

$$S = \sqrt{\frac{R}{3.p.k.d}} \tag{1}$$

All of these variables are factors affecting the speed, and the positions in the equation are useful to explain the theoretical relationship between them. For example, if the freight rate increases (R), the optimum speed of the ship increases since it is positioned on top of the fraction. One of the other variable, the fuel price, is located at the bottom of the fraction, which means that when the fuel price increases the optimum speed decreases as the lower part of the fraction grows. The last variable we want to mention is the distance (d) variable. Since it is also positioned under the fraction, an increase in it causes a drop in optimum speed. All these samples are sampled between a variable and the optimum speed, and the variables outside the sample are assumed to remain constant.

Taking into account all of these, it is a reasonable assumption to think that positive shocks at fuel prices are causing negative shocks at average vessel speeds, assuming that shipowners behave rationally. The relationship between speed and fuel consumption lies in the basis of this hypothesis. The relationship between these two variables is explained by the Stopford [1] with cubic rule which is demonstrated in equation (2).

$$F = F^{*}\left(\frac{S}{S^{*}}\right)^{a} \tag{2}$$

Actual fuel consumption per day is represented by F in this equation. F^* is the design fuel consumption, S is the actual speed, S^* is the design speed. The exponent value a varies according to the engine type, 3 for diesel engines and 2 for steam turbines. As can be understood from this, fuel consumption is very sensitive to vessel speed, water resistance is one of the main factors in this situation. So it is not rational for shipowners to raise the speed except the cases of rise in freight rates and the decline in oil prices, as can be also understood from equation (1). Stopford [1] exemplifies that when a Panamax bulk carrier sails at 16 knots per hour, it consumes 44 tons of fuel oil per day. However, when it reduces its speed to 11 knots per hour, consumption of the ship reduces to 14 tons of fuel oil per day. This example also contributes to emphasizing how important this is to maritime industry. In the next section, the method used in the study is introduced and the data set is examined.

2 METHODOLOGY

Since fuel consumption of the ships can be approximated by a quadratic function of their speed, the case becomes non-linear [8]. So a linear analysis of the relationship between fuel and speed variables may prevent achieving the desired level of results. In addition, the reactions given by market agents can vary depending on whether the news is good or bad [12], which is already the logical view. Therefore, in this study, asymmetric causality test developed by Hatemi-J [12] is applied to try to obtain the intended results. Its codes are written in GAUSS software by him, and the analysis of this study is implemented by these codes.

The asymmetric causality test determines asymmetric causality by constructing cumulative sums of positive and negative shocks [14] to separate the causal impacts of these shocks [15]. The data do not have to be stationary in this analysis but the order of integration degree need to be known as the test involves a Toda and Yamamoto [16] procedure [17]. If the unit root is detected in a series, a certain number of differences of it must be taken in order to become stationary. The highest number of differences in the variables is called the maximum order of integration degree and is added to the established unrestricted VAR model. Then the critical values are obtained by bootstrap and the significance is tested according to these values in the analysis. It is important to examine the descriptive statistics of the data to make fine adjustments to the causality test.

Descriptive statistics of data set used in the study are shown in Table 1. The unit of bunker price is ton/$, while the unit of speed is knot. Bunker prices are based on Los Angeles Long Beach 380 cst prices (N6LA380). There is no specific reason for this choice, the price of this region has been chosen in terms of data accessibility. The data set consists of 122 observations on a monthly basis covering the period from May 2008 to June 2018. Natural logarithms of the data have been taken since this facilitates their processability and makes the discrete data continuous. Also, this helps to ensure better distributional properties [15].

Tab. 1 *Descriptive Statistics of the Variables*

	Bunker	Speed	Ln Bunker	Ln Speed
Mean	488.3217	8.224870	6.142214	2.098561
Median	459.7479	7.642391	6.130675	2.033710
Maximum	742.4091	10.43474	6.609900	2.345140
Minimum	237.1957	7.135000	5.468885	1.965012
Std. Dev.	148.1668	1.115689	0.319406	0.129747
Skewness	0.072358	0.817962	-0.256432	0.743268
Kurtosis	1.627236	2.052502	1.833055	1.940292
Jarque-Bera	9.685908	18.16784	8.259353	16.94157
Probability	0.007884	0.000113	0.016088	0.000210
Observations	122	122	122	122

Source: [18]

The graphical representation of the fuel price and speed variables is presented in Figure 1. A clear linear relationship between the two variables cannot be observed. However, this does not change the fact that there may be a non-linear relationship. Because the agents in the market can react differently to different news depending on whether the news is good or bad [12].

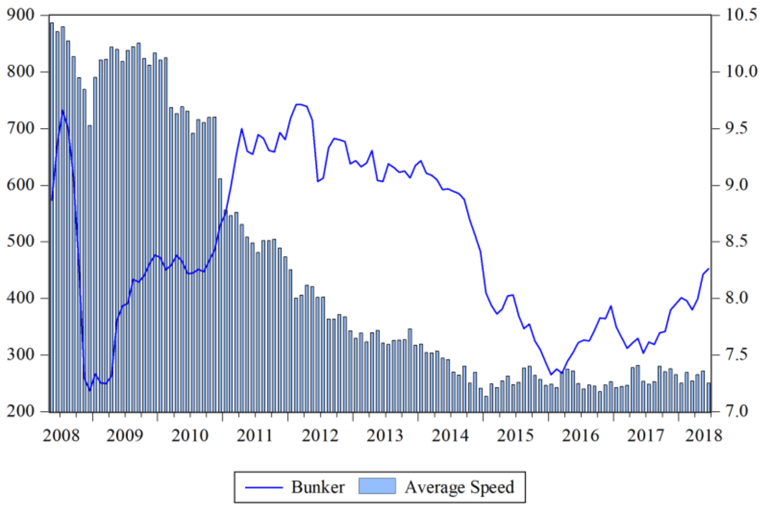

Fig. 1 *Graphical Display of the Variables*
Source: [18]

Another point related to the data is that it is arguable to examine the combined bulk market under a single data set. However, according to market conditions, there is high load transit in dry bulk market. Some ships may be able to lose their cargo to other ships under different freight conditions, even if they are designed for special loads. For these reasons, examining the market as a whole is a constraint, but it is not a major obstacle to achieving meaningful results.

According to these evaluations, the maximum lag value in the analysis is found to be 12 since the data set consists of monthly observations. It is also decided that the value of the bootstrap simulations used in the calculation of the critical values should be 1000. In the next section, the mentioned method is applied and the results obtained are presented.

3 FINDINGS AND RESULTS

Analyses begin with unit root tests first. In the asymmetric causality test performed, the series do not have to be stationary, but the maximum degree of integration must be known. Augmented Dickey-Fuller (ADF) unit root test is applied for the detection of unit roots and the results are presented in Table 2. The bunker price is I (0) and the average speed is I (1) according to the obtained results, and therefore the maximum degree of integration is spotted as 1.

Tab. 2 *Augmented Dickey-Fuller Unit Root Test Results*

	Level		First Difference	
Variable	**Intercept**	**Trend and Intercept**	**Intercept**	**Trend and Intercept**
Bunker Price	-2.587^{*}	-2.528	-7.000^{***}	-6.994^{***}
Bulk Carrier Average Speed	-1.847	-0.972	-10.761^{***}	-10.932^{***}

Critical values: -2.57 for *10%, -2.88 for **5%, -3.48 for ***1% at Intercept; -3.14 for *10%, -3.44 for **5%, -4.03 for ***1% at Trend and Intercept.

Analysis are carried out using GAUSS program codes written by Hatemi-J [12]. The analysis process requires some pre-determined values. In this case, the maximum lag value is selected as 12. The additional lag to be added to the VAR equation in the case of inclusion of any unit root in the variables is determined as 1 since the variables become stationary when the first differences are taken in the unit root analyzes. AICc, which is a different version of the Akaike information criteria (AIC) used in small samples, is used as the information criteria for determining the goodness of fits of the estimated models.

According to the results, positive shocks in fuel prices causes the negative shocks at average vessel speeds in the dry bulk market. However, negative shocks in fuel prices do not cause positive shocks at average vessel speeds. Also causal relationships between positive-positive or negative-negative shocks are insignificant unsurprisingly.

Tab. 3 *Asymmetric Causality Test Results*

		Bunker => Speed			
		$B^{+}S^{+}$	**$B^{+}S^{-}$**	**$B^{-}S^{-}$**	**$B^{-}S^{+}$**
Optimal Lag; VAR(p)		1	1	1	1
Additional Lags		1	1	1	1
Test Stat (MWALD)		0.00	2.80	2.04	0.94
Asym. chi-sq. p-value		0.94	0.09^{*}	0.15	0.33
Critical Val.	1%	11.1	8.61	9.13	12.2
	5%	3.93	4.00	4.20	3.88
	10%	2.52	2.52	2.51	2.57

*Significant at 10%

4 CONCLUSIONS

This study tests the causal relationship between the fuel price and the average vessel speed, which has a sound infrastructure in theory but lacking in terms of empirical testing. The studies in the literature are approaching in terms of route optimization or fleet optimization. However, this study tests this relationship at a more macro level. The asymmetric causality test designed by Hatemi-J [12] also provides the interpretation of the results in line with the objectives of the study by separating shocks in the variables as positive and negative, and testing causal relationship between them.

The results fit the theoretical framework that is generalized in the literature. Positive shocks in fuel prices are the cause of negative shocks at average vessel speeds. This situation can be seen in every market situation but it is the first method that shipowners who are adversely affected by low freight rates especially in depressed market conditions apply to save costs. Another reason for this is that the increase in fuel prices is causing a fake rise in freight rates for shipowners. Because the costs increase due to positive shocks from fuel prices, then they have to give a higher price, which can be perceived as a freight increase in the market and affect the demand for transportation services. Therefore, they may be trying to compensate for the positive shocks from the fuel price by lowering the sailing speed.

But the opposite situation, which indicates that the negative shocks in the price of fuel are not causes of positive shocks at average vessel ship speeds, can be attributed to some other factors. As fuel prices increase, shipowners' operation costs also increase, so they have to reduce their sailing speeds to save bunker costs. The first of these factors, competition is very high as dry bulk market shows similar characteristics to the perfect competition market. Thus, when there is a negative shock in fuel prices, shipowners may not want to go to a cost increase by increasing their speed that may move them away from competitive prices in the market. The second of these factors, there is an optimum point where each ship consumes the least amount of fuel and shipowners are not inclined to go up from this point as long as there is no excessive demand increase. Negative shocks on fuel prices, on the other hand, lead to a decline in operation costs and increase their profitability, assuming freight rates remain constant. At this point, shipowners are not willing to increase their speed, which reduce their profitability.

The major limitation of the study is the lack of separated data set by ship types. At this point, further studies can examine this relationship according to the ship types on the dry cargo market. It is also worth investigating this relationship in other markets such as container and tanker.

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