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Risk and Volatility Spillover Between Commodity and Freight Markets: An Application on Capesize Freight Market

Emtia Fiyatları ve Navlun Oranları Arasındaki Risk ve Oynaklık Yayılımı: Capesize Navlun Piyasası Üzerine Bir Uygulama

Abstract

Uncertainty in freight rates poses great risks for ship and cargo owners. Identifying the factors that affect the volatility of freight is of great importance in reducing risks arising from uncertainty. The aim of this study is to investigate the volatility spillover and risk transmission between commodity prices and freight rates in Capesize market through the causality in variance test. In the study, 3 different transportation routes are included for Capesize freights, while the prices of the 3 main cargo carried in the dry bulk market are considered as commodity prices. Dataset consists of 234 monthly observations and covers the dates between January 2000 and June 2019. According to the results obtained, while unidirectional significant causalities are determined from both iron ore and coal prices to all freight routes, bidirectional significant causalities are determined between wheat prices and freights.

Keywords: Commodity price, volatility spillover, causality in variance.

JEL Codes: C58, Q02, R40.

Özet

Gemi ve yük sahipleri için navlunlarda yaşanan belirsizlik büyük riskler oluşturmaktadır. Navlunların oynaklığını etkileyen faktörlerin tespit edilmesi, belirsizlikten kaynaklı risklerin azaltılmasında büyük önem arz etmektedir. Bu çalışmanın amacı, emtia fiyatları ile Capesize piyasasındaki navlun fiyatları arasındaki oynaklık yayılımını ve risk transferini varyansta nedensellik testi aracılığıyla incelemektir. Çalışmada Capesize navlunları için 3 farklı taşımacılık rotası içerilirken, emtia fiyatları olarak ise kuru dökme yük piyasasında taşınan 3 ana yükün fiyatları ele alınmaktadır. Veri seti 234 aylık gözlemlerden oluşmaktadır ve Ocak 2000 ile Haziran 2019 dönemi arasını kapsamaktadır. Elde edilen sonuçlara göre hem demir cevheri hem de kömür fiyatlarından tüm navlunlara anlamlı nedensellikler tespit edilmişken, buğday fiyatı ve navlunlar arasında ise karşılıklı anlamlı nedensellikler tespit edilmiştir.

Anahtar Kelimeler: Emtia fiyatı, oynaklık yayılımı, varyansta nedensellik.

JEL Kodları: C58, Q02, R40.

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Introduction

Commodities have a very important place in the world industry and therefore in the world economy. Some are the raw materials of industrial production, while others meet needs of both industrial sectors and households as energy sources (Chevallier and Ielpo, 2013:320). A huge part of the global commodity trade is carried out by sea transportation, since approximately 90-95% of international trade is done by seaborne activities (Parameswaran, 2004:1). One of the commodity types that constitute a large transaction volume in sea transportation is dry bulk cargo. These cargoes mainly consist of iron ore, grain, coal, phosphates and bauxite, which are also called five major bulk cargoes (Stopford, 2009:64), and forms the 27% of the total seaborne trade volume (UNCTAD, 2019a).

Dry bulk market is thought to be similar to perfect competition market due to some features, which are; no entry barriers (except large capital requirements), many buyers (shippers) and sellers (shipowners), clearance of the price in the market for everyone (Lun and Quaddus, 2008). In this way, there is a high competition in the market, and the fact that the transported cargoes are almost homogeneous increases this competition even more. In this highly competitive environment, changes in the demand for maritime transport are immediately felt in the market. Since the supply of the ship is inelastic in the short run (Koopmans, 1939), the freights that remain insensitive to changes in demand up to a certain point react increasingly to changes in demand after exceeding this point. This structure has led to continuous cycles in shipping (Stopford, 2007:105) and poses risks for ship and cargo owners due to the future uncertainty in the market (Kavussanos et al., 2010). Reducing the risks arising from this uncertainty is an important research question for the sustainable commercial activities of cargo and ship owners.

It is clear that commodity prices affect the demand for them and are affected by this demand. In this case, it is inevitable that maritime transport, which has a derived demand structure (Marcus, 1987:1), may be also related to commodity prices. From a different angle, as the prices of dry bulk products are generally below $ 100, their trade is very sensitive to transportation costs (Buxton et al., 1978:25). In this case, it is likely that there is a relationship between commodity prices and freight rates, which are basically a reflection of the demand for maritime transport. This relationship has formed the research question of many researchers in the literature (Kavussanos et al., 2010; Kavussanos et al., 2014; Chou et al., 2015; Tsioumas and Papadimitriou, 2018; Açık and Başer, 2019a; Açık and İnce, 2019; Açık and Başer, 2020; Angelopoulos et al., 2020), which have also achieved significant results. We aimed to examine the relationship between iron ore, coal and grain prices, which are the three main cargoes in the dry bulk market, and Capesize freights in three different routes. Our study differs from these previous studies while examining the relationship between commodity price and freight based on a similar research question.

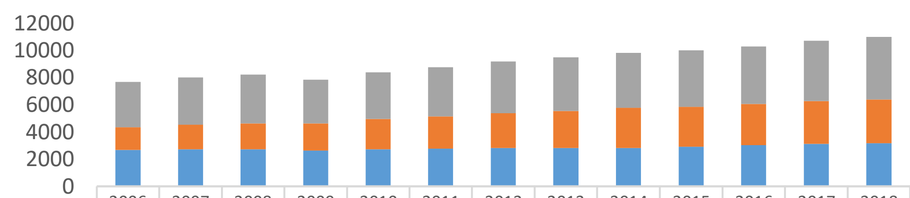
First of all, the method we use has not been encountered in such studies before. The causality in variance test developed by Hafner and Herwartz (2006) is an advanced method to detect the volatility spillover and risk transmission between variables. Secondly, previous studies have used freight indices to represent freight rates. Unlike these, we applied separate analyzes for different individual routes for the Capesize ship type, in order to obtain more specific results. Our results reveal that the effects of commodity prices on Capesize routes differ from commodity type. They also show that volatility spillover and risk transfer are often observed from commodity prices to freights. These results reveal that Capesize type ships are also affected by other commodity prices, although they are specialized in iron ore transportation.

In the second part of the study, starting from the general trade in the world by seaborne, the share of major dry bulk cargoes in this trade is examined. In addition, the transportation rates of these major cargoes according to the ship types are evaluated and the specialization rates of the vessels are examined. In the third part, the formation of commodity prices and freight rates, which are the subject of our study, are briefly examined, as these formations are important to define the volatility of the prices and rates. In the fourth part, the studies on previous similar topics are reviewed and the literature is summarized Also, our study is positioned in the current literature. After the method and dataset used in the research are presented in the fifth part, the results are evaluated in the last part.

1. Seaborne Commodity Trade In The World

The function of maritime transport is basically transporting goods from places where benefits are low to places where benefits are high (Branch, 2007:2). It is the realization of economic exchange in globalizing environment (Wilmsmeier, 2014:1). The amounts of cargoes transported by sea around the world are presented in Figure 1 for the years 2006-2018. The term of tanker covers crude oil, refined petroleum products, gas and chemicals cargoes; main bulk covers the iron ore, grain and coal cargoes; and other dry cargo covers bauxite/alumina, phosphate, minor bulks, containerized trade and residual general cargoes. Main bulks accounted for about 27% of the world's total cargoes on average in the period mentioned (UNCTAD, 2019a), and this ratio accounts for a large portion of the international seaborne trade.

Figure 1. Seaborne Trade



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Other Dry Cargo	3328	3478	3578	3218	3423	3626	3791	3951	4054	4161	4228	4419	4601
Main Bulks	1676	1811	1911	1998	2232	2364	2564	2734	2964	2930	3009	3151	3210
Tanker	2698	2747	2742	2641	2752	2785	2840	2828	2825	2932	3058	3146	3194

Source: UNCTAD, 2019a.

In dry bulk cargo transportation, specialized ship types have been formed on certain cargoes. The selection of these ships can also be explained by the Parcel Size Distribution function mentioned in the following sections. Table 1 shows the transport rates of approximately 3 major bulk cargoes. Capesize type vessels are specialized in iron ore transportation and so they carry approximately 70%-80% of the world's iron ore cargo. Panamax type vessels are commonly used in Coal (40%-50%) and Grain (40%-50%) cargoes, while Handymax type vessels are mostly used in Grain (45%-55%) transportation (Meersman et al., 2014).

Table 1. Three Types of Main Cargoes of Three Main Bulk Carriers

	Iron Ore	**Coal**	**Grain**
Capesize	70%-80%	30%-40%	0%-5%
Panamax	10%-20%	40%-50%	40%-50%
Handymax	10%	10%20%	45%-55%

Source: Meersman et al. (2014)

The important factors affecting the specialization of ship types according to the cargoes are the economies of scale and the parcel size distribution (PCD) function Economies of scale is often useful over long distances and is achieved by reducing the cost of transport per unit by using larger sized vessels (Wilmsmeier, 2014:17). In this respect, a positive relationship can be mentioned between distance and ship size for some cargoes such as coal (Açık and Başer, 2017). PCD, on the other hand, is related with which cargo should be carried by which ship and is generally affected by 3 factors; inventory levels of cargo owners, draft levels of loading and unloading ports, and cost advantage using larger ships (Stopford, 2009:75). Depending on these factors, small-sized ships may be more suitable for some cargoes, and large-sized ships may be more suitable for some other cargoes. Within this framework, ship owners and cargo owners carry out their activities by choosing the type of ship suitable for their investment and commercial strategies.

2. Formation of The Commodity Prices and Freight Rates

In order to understand the possible relationship between freights and commodity prices, it may be useful to make a brief assessment of how prices occurred in both markets. In this context, starting from the general structure of commodity prices, the situation is evaluated by moving to the freight market, since maritime transport has a derived demand structure and the demand for commodities indirectly affects the demand for it.

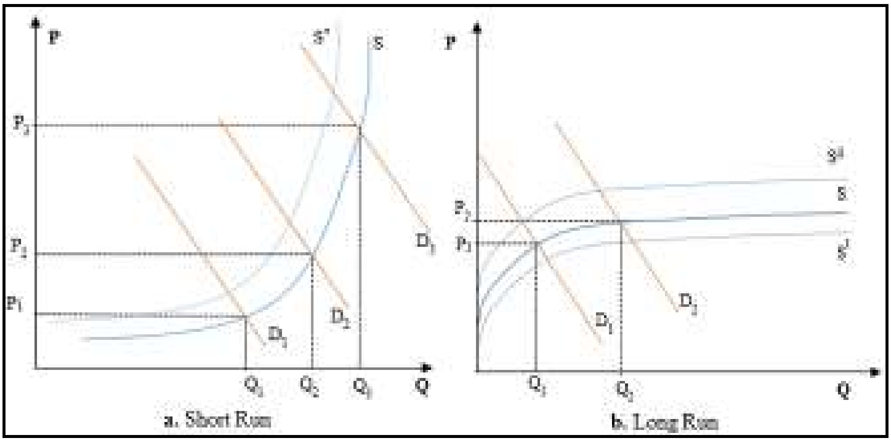
2.1. Commodity Price

While examining the mechanisms of commodity prices, the situation can be analyzed in two ways, short run and long run. The structure of short run commodity supply is similar to that of supply in freight markets in the short run. In section a of Figure 2, the short-run structure is visualized. Equilibrium price is formed at point P1 and this point may differ for each company. The factors that cause this difference are the differences in location, natural resources, administrative efficiency and cost structure. Considering that the production capacity is limited in the short run, the supply curve may represent variable costs determined by the production level. Therefore, variable cost differs according to the production level, higher production costs occur at higher demand levels.

Demand for commodity may increase and shift to D2 due to factors such as economic growth, business cycles, expectations, and speculative aims. In this case, since the use of resources for production increases, costs increase and prices move upwards. This may likewise arise when supply capacity cannot be used effectively which can be caused by agricultural pests, climatic factors, strikes or accidents (Radetzki, 2008:57).

In the long run, the production capacity is variable and the supply curve can be interpreted as the average total cost of the marginal product. In this case, the increase of the cost curve to a certain level is related to the increase of the cost of obtaining additional amount of commodities. Later on, it's straight movement is related to the abundance of the commodity obtained when the high cost is incurred. On the other hand, when the demand increases in the long run, the supply curve may shift up and this may lead to an increase in costs. In addition, new technologies that develop in the long run can reduce the supply curve by lowering production costs. These two situations cancel each other's effects in the long run, causing the supply curve to remain stable (Radetzki, 2008:59).

Figure 2. Short Run and Long Run Commodity Price Formation



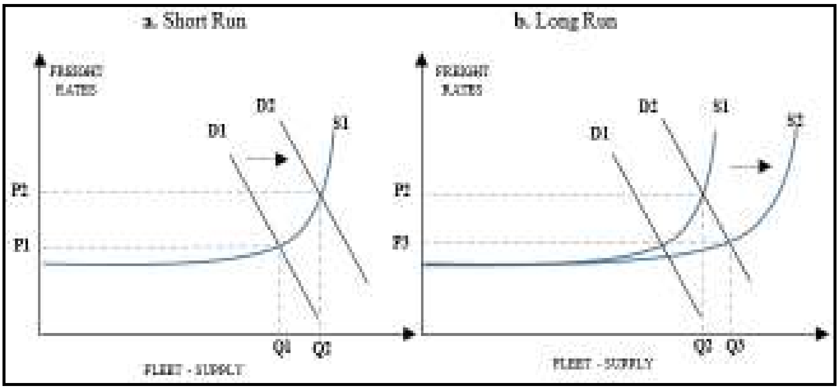
2.2. Freight Rate

The structure of freight formation is mainly formed by the balances / imbalances between supply and demand sides. Stopford (2009: 136) indicates that five factors affect the supply of maritime transport services, which are fleet size in the world, fleet productivity, shipbuilding outputs, demolition and loses and freight levels, and five factors affect demand of shipping services, which are world economy, commodity trade by sea, average haul, random shocks, and transportation costs. All of these factors cause imbalances between supply and demand in the formation of freight rates, resulting in deviations in favor of ship owners or cargo owners.

Ships used in maritime transportation are capital assets that are both high in cost and long in construction due to their huge sizes (Bendall and Stent, 2005:13). This situation leads to delayed ship entrances to the market, although dry bulk market is considered as a perfect competition market by some researchers (Harlaftis and Theotokas, 2002; Lun and Quaddus, 2008). For this reason, ship supply in the short run in sea transportation is considered as inelastic (Koopmans, 1939). An order placed according to today's market conditions can only be completed after 1-3 years and delivered to the ship owner (Başer and Açık, 2018). Uncertainties are high regarding how the market will be when the transaction is completed (Tsolakis, 2005). In this context, when the activities in the economy increases the demand for commodities, that is demand for maritime transportation, the supply of more carrying capacity cannot be offered after a certain point. This situation is visualized in part *a* of Figure 3. While the demand increases up to *Q1* do not provide a remarkable movement in the freight levels, when the transition from *Q1* to *Q2* is occurred, there is a slight jump in the freight levels. Since shipbuilding activities take a long time, there is a slow flow of ship entrance to the market and freights increase. The only way to increase the supply in the short run is to increase the speed of the ships (Karakitsos and Varnavides, 2014).

In the long run, ordered ships enter the market and cause an increase in the transport capacity of the market. This shifts the supply curve to the right from *S1* to *S2*, resulting in the balance freight price going down again from *P2* to *P3* as seen from the part *b* of Figure 3. This process is constantly experienced throughout history (Beenstock and Vergottis, 1993:64), causing maritime cycles of different characteristics. After each increase, a downward descent is observed and this situation can be interpreted as the freight has a mean-reverting feature (Tvedt, 2003).

Figure 3. Short Run and Long Run Freight Rate Formation



3. Literature Review

Studies examining the relationship between commodity prices and maritime markets are summarized in Table 2. In general, if these studies are to be grouped according to their relationship with commodity markets, they can be categorized as those related to the freight market (Chou et al., 2015; Tsioumas and Papadimitriou, 2018; Açık and Başer, 2019; Açık and İnce, 2019; Açık and Başer, 2020; Angelopoulos et al., 2020), those related to the derivatives market (Kavussanos et al., 2010; Kavussanos et al., 2014), those related to the second hand market (Başer and Açık, 2019), and other types of studies (Açık and Başer, 2018a; Açık and Başer, 2018b).

In freight related studies, Chou et al. (2015) examined the relationship between Baltic Capesize Index (BCI) and Asian Steel Index (ASI) and found that the BCI variable is the leading indicator of the ASI variable. This situation can be interpreted as the positive demand for commodities reflected positively on the freights and positively affecting the prices of the final products. In the other study, Tsioumas and Papadimitriou (2018) investigated the relationship between major bulk ship types, which are Capesize and Panamax, and major dry bulk cargo types, which are ore, coal and grain. The researchers found a bidirectional causality relationship between Capesize freights and iron ore and coal prices. They also identified a one-way causality relationship from wheat price to Panamax freights. These results reveal that the relationship of freights to commodity prices may vary depending on the type of cargo and ship. In addition, we presented in a study (Açık and Başer, 2019a) that this relationship may also change according to the global economic situation. We examined the relationship between Capesize freight and iron ore price before and after the 2008 crisis. According to the results obtained, the impact of the commodity price on the freight was realized from positive shocks to positive shocks in the pre-crisis, and after the crisis it was realized from negative shocks to negative shocks. In the research carried out by Açık and İnce (2019), the sample size was partially expanded and Handymax type ships were added to the ship sampling and unidirectional asymmetric relations were examined with the prices of three basic bulk cargoes. They found that ore and wheat prices effect both Capesize and Panamax markets, while ore and coal prices effect Handymax market by different kinds of shocks. This study reveals that the results can differ according to the type of cargo and the type of ship too. In our study where we analyzed the relationship between freights and commodity prices in a more regional way (Açık and Başer, 2020), we analyzed the unidirectional asymmetric relationship between İSTFİX freights and commodity prices that are intensively transported in the region, which are coal, steel and wheat. As a result of the analyzes that we applied considering the non-linearity in the series, significant causal relationships were found between the positive-positive shocks and the negative-negative shocks from the coal and steel prices to the freight index. However, the situation differs in wheat and positive shocks in the commodity cause negative shocks in the index and negative shocks in the commodity cause positive shocks in the index. These results are very important in terms of showing that the relationship can differ according to the commodity type. In a similar study conducted by Angelopoulos et al. (2020), information pass through between commodity prices and freight rates was investigated. As a result of the research, they found that commodity prices significantly affect the freight rates and commodity prices are informationally leading to freight rates. The increase in the prices of the cargoes in dry bulks causes an increase in the freight rates in the dry bulk market, while the increase in the prices of petroleum products causes a decrease in the tanker market.

In order to prevent fluctuations in freight in the long term, the markets where the parties reach agreements through future transportation activities are called derivative markets and risks of uncertainty are reduced thanks to these markets. In this context, the possible relationship between commodity and freight derivatives has formed research questions of some researchers. Kavussanos et al. (2010) examined the information flow between Panamax derivative markets and commodity derivatives markets, which are grain, iron ore, coal, bauxite, sulphur. The findings of the study revealed that grain futures markets are an important indicator for freight future markets. In another study conducted by Kavussanos et al. (2014), the sample was enhanced to include Capesize and Supramax ships as well. The results of the study revealed that the commodity derivative markets are the pioneers in terms of return and volatility to the freight derivative markets. These studies also state that commodity prices lead freight both in the past and in the future.

Another maritime market, which is very liquid like the freight markets, is the second hand market. Ship values contain information on the market situation, directly affected by freight rates. In a study where we also examined the possible effect of commodity price on the second hand values of the ships (Başer and Açık, 2019a), we examined the relationship between 5-year-old Capesize ship value and iron ore price, since the majority of the iron ore cargoes carried by this kind of ships. Our results showed that positive shocks in commodity prices are the reason for positive shocks in ship value, and negative shocks are the reason for negative shocks in ship value. This indicates that the increasing/decreasing commodity prices due to their increasing/decreasing demand increased/decreased the demand for maritime transport, therefore the increasing/decreasing freight reflected positively/negatively on the ship value.

Situations that occur in freights and cause a temporary increase outside the trend can be considered as price bubbles. In a study where we evaluated the factors affecting these freight bubbles (Açık and Başer, 2018a), as a result of our examination of the market reports, we have reached the conclusion that the increasing commodity prices are also effective. It is also stated in these market reports that commodity prices rose in response to rising demand for them. In our another study examining the relationship between commodity price and demand in the tanker market (Açık and Başer, 2018b), we examined how the tanker market reacted to rapidly falling oil prices. According to our results, we found that second hand values and freights increased significantly in response to falling oil prices. This situation can be evaluated as the price of oil, which was reduced for a possible political reason, increases the demand and the demand for sea transportation increases indirectly. Thus, the tanker market revived with the increase in transportation activities.

Table 2. Commodity Price Related Studies in the Maritime Literature

Authors	Research Question	Method	Findings
Kavussanos et al., 2010	Are there spillover effects between commodity and freight derivatives, and in which direction?	Co-integration, GARCH Models	There are significant spillover effects between freight and commodity derivative markets, and grain futures are important indicators for Panamax Forward Freight Agreements (FFA) markets.
Kavussanos et al., 2014	Whether there are economic spillovers between the freight and commodity derivatives markets.	Co-integration, GARCH Models	Commodity futures lead the FFAs in both in returns and volatilities
Chou et al., 2015	Whether there is a causal relationship between Baltic Capesize Index (BCI) and Asian Steel Index (ASI).	Granger Causality Analysis	BCI causes the ASI and therefore it is the leading indicator of the ASI.

Tsioumas and Papadimitriou, 2018	Whether the prices of coal, iron ore, and wheat are effective on freight rates of the most widely used vessel size for each commodity.	Granger Causality Analysis, Impulse Response Analysis	There is bidirectional relationship between the BCI and the price of iron ore and coal, and one-way relationship between BPI and wheat price.
Açık and Başer, 2018a	Which factors cause minor bubbles in Dry bulk freight market?	GSADF Test and Content Analysis	Commodity price increases cause freight increases
Açık and Başer, 2018b	How the oil price changes effect tanker market in the short run?	Correlation	There is a negative correlation between crude oil price and 3 tanker markets (freight, secondhand, newbuilding?
Açık and İnce, 2019	How do shocks in ore, coal and wheat prices effect Capesize, Panamax and Handymax freight markets?	Asymmetric Causality Test	Ore and wheat prices effect both Capesize and Panamax markets, while ore and coal prices effect Handymax market.
Açık and Başer, 2019	Does effect of iron ore price on freight market change before and after 2008 crisis?	Unit Root Test with Structural Breaks, Asymmetric Causality Test	Positive shocks are causes of positive shocks in the pre-crisis, and negative shocks are causes of negative shocks in the post crisis.
Başer and Açık, 2019	How do shocks in iron ore price effect the 5 years old Capesize value?	Asymmetric Causality Test	Positive shocks in ore prices are causes of positive shocks and negative shocks are causes of negative shocks in ship values
Açık and Başer, 2020	Price shocks in commodities mostly transported in ISTFIX region effects the freight levels in the region?	Asymmetric Causality	Positive and negative shocks in coal and steel prices are symmetrically causes of the positive and negative shocks in ISTFIX, while the impact of wheat price is asymmetric.
Angelopoulos et al., 2020	Whether the freight rates are directly or inversely proportional to the commodity prices.	Generalized dynamic factor model	Commodity prices informationally lead freight rates and the relationship between them is different for dry bulk and tanker markets.

In general, there are few studies in the literature that have achieved few and significant results. Our study differs from this literature as a method and data set. In our study, we examined the effects of commodity prices on 3 individual Capesize routes. The indices may be unhealthy to study the effects of commodity prices, as they are composite variables consisting of different combinations of many different routes. Because the weights of the routes in the index are different and these weights can make the effects of other routes insignificant. In this respect, it is important to examine the relationships individually and to determine the risk and volatility spillover correctly.

4. Methodology

In the research, causality in variance test is applied to determine the volatility spillover between the variables. The data set and analysis methods used in the study are introduced in this section.

4.1. Data

Capesize dataset covers the dates between January 2000 and June 2019, and consists of 234 monthly observations. SALBE refers to Capesize route from Saldanha (South Africa) to Beilun (China), TUBQINQ refers to Capesize route from Tubarau (Brazil) to Qingdao (China), TUBROT refers to Capesize route from Tubarau (Brazil) to Rotterdam (Netherlands). The routes covered were selected in terms of data availability. Since other routes could not be reached, analyzes were carried out over these three routes. The unit of these three routes are $ per metric tons. Iron ore, coal and wheat prices are per ton prices obtained from the World Bank (2019) database.

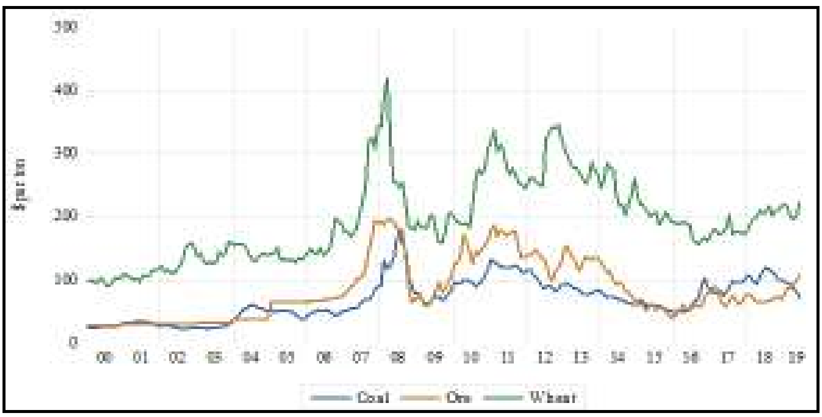
Table 3. Descriptive Statistics for the Capesize Dataset

	COAL	ORE	WHEAT	SALBE	TUBQINQ	TUBROT
Mean	69.76	83.46	195.53	17.61	23.55	12.34
Median	67.51	69.55	187.81	13.40	19.31	9.11
Maximum	180.00	197.12	419.61	77.02	97.51	53.53
Minimum	22.25	28.79	90.87	4.07	5.53	2.75
Std. Dev.	32.24	47.74	66.81	12.89	16.91	9.02
Skewness	0.44	0.74	0.65	2.29	2.21	2.17
Kurtosis	2.75	2.49	2.91	8.98	8.61	8.36
Jarque-Bera	8.21	23.93	16.55	556.0	499.3	465.3
Probability	0.01	0.00	0.00	0.00	0.00	0.00
Obs.	234	234	234	234	234	234

Source: Worldbank, 2019; Bloomberg, 2019.

The visual of the commodity prices used in the study is presented in Figure 4. It is seen that the prices rose especially before 2008, when the market is buoyant, and then followed a decreasing trend in the recent times. The increase in the pre-crisis period could be attributed to the increasing demand for raw materials in the economy. Due to the imbalances between supply and demand, commodity prices are very volatile and vulnerable to the unexpected shocks.

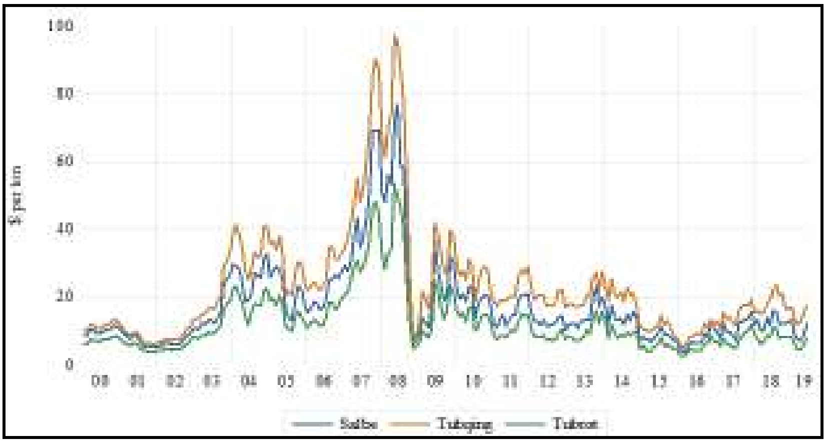
Figure 4. Commodity Prices Included in the Study



Source: Worldbank, 2019.

Since the maritime market has a derived structure, the demand for the transported cargoes directly affects the demand for maritime transport. In this context, the rise in commodity prices was reflected in the maritime markets in 2008 and incredible increases were observed in freight rates as seen from Figure 5. It can be said that the freights crashed after the crisis are relatively low in the recent times. The freights are very volatile, as they are highly dependent on the situation in the commodity markets, and ship supply and oil prices in the world cannot be controlled.

Figure 5. Capesize Routes Included in the Study



Source: Bloomberg, 2019.

4.2. Causality in Variance

Causality in variance analysis allows to determine the volatility and risk spillover among the variables as a result of the analyzes made by using the variance of the variables. It is especially important for determining transmission in financial markets with high volatility (Koseoglu and Çevik, 2013) thanks to its function related to determination of volatility spillover (Bayat et al., 2015). The change of variance shows how new information comes and how it is evaluated in the market (Cheung and Ng, 1996). The foundations of the method were formed by Cheung and Ng (1996) and then improved by Hafner and Herwartz (2006). By using the LM approach, the weak sides of the method were eliminated and robustness was achieved (Nazlioglu et al., 2013).

Series must be stationary in order to use causality in variance analysis. Therefore, unit root tests should be applied. In this context, in this study, unit root tests, which take into account possible breaks in the series, are preferred because the breaks in the series may cause results as if they include unit root, although they are stationary. One break ADF test developed by Zivot & Andrews (1992), one break LM test developed Lee & Strazicich (2013), two break ADF test developed by Narayan & Popp (2010), two break LM test developed by Lee & Strazicich (2003) are applied to the series which take into account possible breaks in level and level and trend. GAUSS statistical software and codes are used in the analysis.

Also, since this method is a non-linear test, the linearity of the series should be tested. Unexpected events and shocks, which are common in the globalizing world, disrupt linearity in the structure of variables (Bildirici & Turkmen, 2015). These factors may cause the variance of the variables to be time dependent and the disappearance of the constant variance assumption (Månsson and Shukur, 2009). In this respect, trying to get results for nonlinear series by linear methods may lead to misleading findings. In order to test nonlinearity in the series, BDS Independence (Brock et al., 1987) is mainly used. Also, ARCH LM (Engle, 1982) and Ljung-Box (1978) tests are applied to the series as supplementary linearity methods. In the next section, analyzes are applied and results are presented.

5. Findings

In this section, the tests mentioned in the methodology section are applied and the results are presented. First of all, the logarithms of all series have been taken, because their processability increases and the discrete data becomes continuous data. Since the causality in the variance test requires stationarity and non-linearity, related tests are applied. After the appropriate conditions are checked, the causality test is applied and the results are presented.

5.1. Unit Root Test Results

In causality in variance test, the series should be stationary. For this reason, the unit root tests with structural break are applied as structural breaks can cause unit root tests to give erroneous results. Tests are applied to freight routes first, and then to commodity prices, and the results are presented respectively.

The unit root test results for Capesize freight routes are presented in Table 4. The Capesize freight from Saldanha to Beilun (SALBE) variable is stationary according to one break ADF test (Zivot & Andrews, 1992), one break LM test (Lee & Strazicich, 2013) and two break ADF test (Narayan & Popp, 2010). The freight from Tubarau to Rotterdam (TUBROT) variable is stationary according to one break ADF test (Zivot & Andrews, 1992), one break LM test (Lee & Strazicich, 2013), two break ADF test (Narayan & Popp, 2010) and two break LM test (Lee & Strazicich, 2003). The Capesize freight from Tubarau to Qingdao (TUBQINQ) variable is stationary according to one break LM test (Lee & Strazicich, 2013) and two break ADF test (Narayan & Popp, 2010). The results obtained indicate that all the series are stationary when the structural breaks in them are taken into account.

Table 4. Unit Root Tests with Structural Breaks for Capesize Freight Market

Test Items	Mod A Salbe	Mod C Salbe	Mod A Tubrot	Mod C Tubrot	Mod A Tubqinq	Mod C Tubqinq
			One break ADF test (Zivot & Andrews, 1992)			
ADF Stat	-4.608*	-5.740***	-4.723**	-5.811***	-3.795	-4.751
Break Date	2003M6	2008M7	2003M6	2008M7	2002M7	2008M7
Fraction	0.17	0.44	0.17	0.44	0.13	0.44
Lag	1	1	1	1	9	9

Test Items	Mod A Salbe	Mod C Salbe	Mod A Tubrot	Mod C Tubrot	Mod A Tubqinq	Mod C Tubqinq
One break LM test (Lee & Strazicich, 2013)						
LM Stat	-3.312	-4.832**	-3.405	-4.979**	-2.54	-4.403**
Break Date	2003M6	2008M8	2014M11	2008M8	2008M9	2008M8
Fraction	0.19	0.44	0.76	0.44	0.44	0.44
Lag	1	1	1	1	9	9
Two break ADF test (Narayan & Popp, 2010)						
ADF Stat	-5.411***	-6.537***	-5.45***	-6.668***	-4.503**	-6.212***
Break Date	2008M7, 2014M9	2008M7, 2014M10	2008M7, 2013M11	2008M7, 2014M10	2009M10, 2014M9	2008M6, 2015M8
Fraction	0.44, 0.75	0.44, 0.76	0.44, 0.71	0.44, 0.76	0.50, 0.75	0.43, 0.80
Lag	1	1	1	1	9	9
Two break LM test (Lee & Strazicich, 2003)						
LM Stat	-3.779	-5.316	-4.016**	-5.493*	-2.875	-5.116
Break Date	2003M6, 2010M6	2008M7, 2016M11	2010M6, 2014M11	2008M7, 2016M11	2008M9, 2014M11	2003M8, 2009M11
Fraction	0.19, 0.53	0.44, 0.86	0.53, 0.76	0.44, 0.86	0.44, 0.76	0.18, 0.50
Lag	1	1	1	1	9	9

Mod A refers to break in level, Mod C refers to break in level and trend., H_0 rejected ***99%, **95%, *90%.

The unit root test results for commodity prices are presented in Table 5. The ore, coal and wheat price variables are stationary when the structural breaks in level and level & trend were considered according to two breaks ADF test (Narayan & Popp, 2010). These tests generally determined level and trend breaks in 2007, and the series are stationary considering these structural breaks.

Table 5. Unit Root Tests with Structural Breaks for Commodity Prices

Test Items	Mod A Ore	Mod C Ore	Mod A Coal	Mod C Coal	Mod A Wheat	Mod C Wheat
One break ADF test (Zivot & Andrews, 1992)						
ADF Stat	-3.78	-3.56	-3.41	-3.88	-4.42	-4.20
Break Date	2001M4	2006M11	2012M11	2007M4	2014M11	2007M2
Fraction	0.71	0.35	0.66	0.37	0.76	0.36
Lag	2	2	1	1	1	1
One break LM test (Lee & Strazicich, 2013)						
LM Stat	-1.97	-3.22	-2.51	-3.57	-2.73	-3.91
Break Date	2012M7	2011M8	2008M1	2007M10	2014M5	2013M1
Fraction	0.64	0.59	0.41	0.40	0.73	0.67
Lag	2	2	1	1	1	1

Test Items	Mod A Ore	Mod C Ore	Mod A Coal	Mod C Coal	Mod A Wheat	Mod C Wheat
Two break ADF test (Narayan & Popp, 2010)						
ADF Stat	-4.89**	-.4.60*	-4.69**	-5.33***	-5.31***	-6.66***
Break Date	2004M11, 2014M3	2007M6, 2009M8	2012M11, 2015M1	2007M8, 2013M11	2007M2, 2014M11	2007M4, 2010M5
Fraction	0.25, 0.73	0.38, 0.49	0.66, 0.77	0.39, 0.71	0.36, 0.76	0.37, 0.53
Lag	2	2	1	1	1	1
Two break LM test (Lee & Strazicich, 2003)						
LM Stat	-2.16	-4.29	-2.69	-5.23	-3.03	-4.97
Break Date	2012M7, 2015M6	2007M3, 2014M7	2003M11, 2008M1	2011M1, 2016M5	2014M5, 2014M12	2007M2, 2014M11
Fraction	0.64, 0.79	0.37, 0.74	0.20, 0.41	0.56, 0.84	0.73, 0.76	0.36, 0.76
Lag	2	1	1	1	1	1

Mod A refers to break in level, Mod C refers to break in level and trend., H_0 rejected ***99%, **95%, *90%.

Unit root tests applied for both freight routes and commodity prices show that all series are stationary when the structural breaks are considered. In this case, the series can be used in analysis without applying any difference taking operations. After the unit root tests, the nonlinear structures in the series are analyzed.

5.2. Nonlinearity Test Results

Since the method used is a nonlinear one, linearity tests should be applied. In this framework, firstly ARMA models are estimated for each variable, and the residuals of the model are separated and some tests are applied on these residuals in order to examine nonlinear structures. The results of the BDS independence test with high validity are presented collectively in Table 6.

Selected model for Ore price is ARMA (0, 1) with -2.05265315386 AIC value. There is ARCH effect for lags of 2 and dependence in the Q square stats. BDS test indicates nonlinear structure in the series. Selected model for Coal price is ARMA (3, 2) with -2.5320739919 AIC value. There is ARCH effect for lags of 2, 4 and 8, and dependence in the Q square stats. BDS test indicates nonlinear structure in the series. Selected model for Wheat price is ARMA (2, 3) with -2.5466822711 AIC value. There is ARCH effect for lag of 8 and dependence in the Q square stats. BDS test does not indicate nonlinear structure in the series. Selected model for Salbe is ARMA (3, 3) with -0.351221563758 AIC value. There is ARCH effect for lags of 1, 2, 4, 8, 16 and dependence in the Q square stats. BDS test indicates nonlinear structure in the series. Selected model for Tubqinq is ARMA (4, 8) with -0.775227962635 AIC value. There is ARCH effect for lags of 1, 2, 4, 8, 16 and dependence in the Q square stats. BDS test indicates nonlinear structure in the series. Lastly, selected model for Tubrot is ARMA (4, 8) with -0.366388074531 AIC value. There is ARCH effect for lags of 1, 2, 4, 8, 16 and dependence in the Q square stats. BDS test indicates nonlinear structure in the series.

Table 6. Capesize Market BDS Results

Variable	Dimension	BDS Statistic	Std. Error	z-Statistic	Prob.
Ore	2	0.023108	0.006630	3.485285	0.0005***
	3	0.042562	0.010552	4.033315	0.0001***
	4	0.067683	0.012588	5.376666	0.0000***
	5	0.081453	0.013145	6.196244	0.0000***
	6	0.084742	0.012703	6.671221	0.0000***
Coal	2	0.013514	0.005765	2.343915	0.0191**
	3	0.035011	0.009175	3.816016	0.0001***
	4	0.051329	0.010940	4.691740	0.0000***
	5	0.058703	0.011419	5.140828	0.0000***
	6	0.059514	0.011028	5.396675	0.0000***
Wheat	2	0.004421	0.005275	0.838212	0.4019
	3	0.004385	0.008401	0.521960	0.6017
	4	0.008013	0.010025	0.799236	0.4242
	5	0.008270	0.010471	0.789766	0.4297
	6	0.007945	0.010119	0.785191	0.4323
Salbe	2	0.011402	0.005728	1.990684	0.0465**
	3	0.018962	0.009113	2.080832	0.0374**
	4	0.022468	0.010864	2.068067	0.0386**
	5	0.024362	0.011337	2.148893	0.0316**
	6	0.024370	0.010946	2.226297	0.0260**
Tubqinq	2	0.016307	0.004965	3.284409	0.0010***
	3	0.028903	0.007898	3.659649	0.0003***
	4	0.038440	0.009412	4.084107	0.0000***
	5	0.041876	0.009817	4.265534	0.0000***
	6	0.038244	0.009474	4.036632	0.0001***
Tubrot	2	0.009351	0.005226	1.789268	0.0736*
	3	0.014326	0.008328	1.720268	0.0854*
	4	0.021303	0.009943	2.142439	0.0322**
	5	0.025360	0.010391	2.440597	0.0147**
	6	0.026962	0.010046	2.683713	0.0073***

H_0 rejected ***99%, **95%, *90%.

According to the results of Capesize market, it can be concluded that both commodity price and route variables have nonlinear structures. In this case, causality in variance analysis can be applied and the results can be evaluated.

5.3. Causality in Variance

The results of causality in variance analysis applied for Capesize routes are presented in different tables according to cargo types. The included routes are SALBE (Saldanha - South Africa to Beilun - China), TUBQINQ (Tubarau - Brazil to Qingdao - China), TUBROT (Tubarau - Brazil to Rotterdam - Netherlands). First, the analysis between iron ore and Capesize routes are examined and the results are presented in Table 7. The results show that there are significant causal relationships from the iron ore price to the SALBE, TUBQINQ and TUBROT cargo routes. In other words, the null of non-causality hypothesis is rejected for all included routes. In this case, it can be said that there is a causal relationship in variance to all Capesize freights subject to research from the iron ore price.

Table 7. Results of Iron Ore and Capesize Routes

Causality-in-variance from	LM stat	p-value
ORE to SALBE	8.689	0.0130**
SALBE to ORE	1.761	0.4145
ORE to TUBQINQ	9.231	0.0099***
TUBQINQ to ORE	0.761	0.6834
ORE to TUBROT	8.064	0.0177**
TUBROT to ORE	2.105	0.3491

H_0 rejected ***99%, **95%, *90%.

Secondly, the causality relationships in the variance between coal price and Capesize routes are examined and the results are presented in Table 8. According to the results obtained, there are significant causal relationships from the coal price to all the routes mentioned. However, there is no significant causality from routes to coal prices in any case.

Table 8. Results of Coal and Capesize Routes

Causality-in-variance from	LM stat	p-value
COAL to SALBE	6.093	0.0475**
SALBE to COAL	0.397	0.8200
COAL to TUBQINQ	5.779	0.0556*
TUBQINQ to COAL	0.412	0.8138
COAL to TUBROT	5.885	0.0527*
TUBROT to COAL	0.428	0.8074

H_0 rejected ***99%, **95%, *90%.

Thirdly, the causal relationships between wheat price and Capesize freights are tested and the results are presented in Table 9. The results obtained for this commodity differ considerably from other results related to the Capesize market. The bidirectional null of non-causality hypothesis is rejected for all routes. In other words, for the aforementioned commodity, there are causality relations both from the commodity to freight rates and from freight rates to commodity.

Table 9. Results of Wheat and Capesize Routes

Causality-in-variance from	LM stat	p-value
WHEAT to SALBE	5.155	0.0760*
SALBE to WHEAT	6.682	0.0354**
WHEAT to TUBQINQ	5.851	0.0536*
TUBQINQ to WHEAT	5.906	0.0522*
WHEAT to TUBROT	8.896	0.0117**
TUBROT to WHEAT	7.356	0.0253**

H_0 rejected ***99%, **95%, *90%.

Conclusion

Capesize type ships are used extensively in iron ore transportation and are considered to specialize in this type of cargo. 70-80% of iron ore in the world, 30-40% of coal, and 0-5% of wheat are transported by such vessels (Meersman et al., 2014). Although they provide great benefits in terms of transportation cost per unit due to their large structures, they can only serve to certain major ports with high level of draft and big handling equipment. For this reason, they mostly carry out transportation activities in far intercontinental destinations. In this study, we examined the relationship between the price of 3 major dry bulk cargoes carried around the world, which are ore, coal and grain, and the three freight routes of the Capesize ship type. Since there is no general price data for the grain, we applied our analysis on the wheat price instead of it.

Our results reveal that the relationship of iron ore and coal prices with the Capesize market is similar, while the wheat price's is partially different. While the significant relationship from commodity price to freight is observed in all commodities, a significant relation is also determined from freight rates to wheat price. The causality in the variance findings from commodity prices to freights indicate that the volatility in commodity prices is the reason for the volatility in the freight markets. In other words, there is a volatility spillover and risk transmission from commodity prices to freights. Since the change in variance is related to how the information comes and how much it is evaluated (Cheung and Ng, 1996), it can be said that the shipowners have shaped their freight pricing according to the information from the commodity price. Since commodity prices usually carry information about the demand for them, this information is inquired and evaluated in the maritime market, which has a derived demand structure (Marcus, 1987:1).

Although the rate of transport with Capesize-type ships is very low, the relationship between wheat price and Capesize freight may be related to the neighboring market factor that we dealt with in one study (Açık and Başer, 2018a). Accordingly, even if the transportation cost of each type of ship is different, they can enter each other's markets under different market conditions. In this respect, even if the wheat price affects the markets of smaller ships, this effect may also indirectly be reflected on the Capesize market.

The different direction of causal relationships depending on the types of commodities may be due to differences in the structure of the markets. Iron ore market is defined as an oligopolistic industry since it is concentrated on a few producers (Johnson et al, 2014:46) and these producers have ability to influence the prices (Bullock and Mernitz, 2017:220). Also coal market is generally defined as an oligopolistic market since the coal product is relatively homogenous (Schernikau, 2016:448) and small number of firms carry out production activities (Mosk, 2008:14). On the other hand, wheat market is defined as a perfectly competitive market since the producers in the world are price takers (Fisher and Waschik, 2002:23), the products are generally homogenous and there are no entry barriers to the industry (Ragan, 2014:203).

Since wheat is an agricultural product, it can be quickly affected by climatic factors. This situation, unlike industrial products, causes wheat production outputs to be more uncontrollable. That situation is reflected in its price and causes it to have an unpredictable price mechanism. The BDS test we used was also used in many studies for the Effective Market Hypothesis testing in the weak form (Blasco et al., 1997; Afonso and Teixeira, 1998; Dorina and Simina, 2007; Lim and Brooks, 2011; Bhattarai and Margariti, 2018). According to the results we obtained, it was concluded that only the wheat price in the related commodities is not efficient in the weak form. This indicates that future prices cannot be estimated using past prices and extraordinary profit opportunities do not occur in the market by following commercial strategies (Adland and Koekebakker, 2004). Due to this structure, there may be fluctuations in its price according to the information coming from transportation costs.

Another factor may be the relationship of wheat with oil. The relevance of this relationship with freight is that the largest item affecting the costs of ships is the fuel prices (Stopford, 2009:225), which is directly related to the oil prices. The relationship between wheat and oil prices may be formed from two aspects, oil being an important cost factor in agricultural machines and the use of grains in bio fuel production. The studies examining this relationship empirically confirmed these possibilities by detecting significant relationships from oil prices to wheat prices (Alghalith, 2010; Alom et al., 2011; Nazlıoğlu et al., 2013). The vast majority of large agricultural vehicles used in agricultural production depend on the use of fossil energy sources, and therefore modern agriculture requires a huge energy input (Fess et al., 2015:263). In this respect, volatility in energy prices can affect production costs and cause volatility in the prices of agricultural products. On the other hand, depending on the level of oil prices, bio fuel production from agricultural products is becoming economical and producers with different cost structures can be included in the market. In this respect, demand for agricultural products for bio-fuel fluctuates according to fluctuations in oil prices and prices of the products are affected. No matter which of the two situations arises, it is likely that there will be a volatility spillover and risk transfer from oil prices to wheat prices.

In general, our study differs from the literature as a method and data set and it is hoped that it provides an original contribution. As the basic limitation of the study, the lack of route information can be mentioned. We were able to reach the 3 Capesize routes for our study, but more route information could be included to make the analysis more comprehensive. Further studies can examine whether there is a variation in the interaction between commodity prices and freight rates, including other ship types, by the rate of transportation of the major commodities. In addition, the relationship can be tested using different methods to see if this interaction occurs over the entire sample, as at sometimes non-price factors may be more effective.

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