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**AGENT BASED INTERACTION OF COMMODITY PRICE AND
FREIGHT MARKET**

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APPROVAL PAGE



DECLARATION

I hereby declare that this doctoral thesis titled as “**Agent Based Interaction of Commodity Price and Freight Market**” has been written by myself in accordance with the academic rules and ethical conduct. I also declare that all materials benefited in this thesis consist of the mentioned resources in the reference list. I verify all these with my honour.

27/05/2020

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ABSTRACT
Doctoral Thesis
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The aim of this study is to investigate the relationship between iron ore, coal and wheat prices, which are 3 major dry bulk cargoes, and Capesize, Panamax and Handymax freights, which are the intensively used ships in the transportation of these three basic cargoes. The main research questions are whether there is a volatility spillover and risk transmission between commodity prices and freight routes and whether there is a differentiation in relations according to the type of cargo and the rate of intensive carriage. To test these research questions, causality in variance analysis is used, which determines the flow of information between variables and the volatility spillover.

The obtained results reveal that the interaction can differ according to both ship types and commodity types. The relations of Capesize and Panamax ship types with commodities are partially similar. Even though the results are not common for all routes included, there is a causal relationship from the price of iron ore and coal to the freight of these ships. In their relations with the wheat price, there are bidirectional causality relationships between freight routes and commodity prices. For Handymax type ship, while no relation from commodity prices to freights can be determined, causalities were determined from freights to coal and wheat prices. The volatility in the prices of industrial products spread to the freight markets, and the carriage rates do not differentiate between these two markets due to the neighboring of Capesize and Panamax type vessels. In addition, the volatility spillover from wheat price to freight is likely due to the

market type or the close relationship of wheat price with oil price, which constitutes the biggest part of the voyage costs of the ships. Based on these results, it has been determined that volatility spillovers and risk transfers are from commodity prices to freight prices, and some relationships differ depending on the ship type. In this way, in addition to making an original contribution to the literature, the relationship between commodity prices and freight rates on the basis of the agent was determined, and a contribution is thought to be made in order to reduce the risks due to uncertainty for agents.

Keywords: Commodity price, freight market, dry bulk, volatility spillover.



ÖZET

Doktora Tezi

Emtia Fiyatı ve Navlun Piyasasının Ajan Bazlı Etkileşimi

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Bu çalışmanın amacı 3 temel kuru yük olan demir cevheri, kömür ve buğday fiyatları ile bu üç temel yükün taşımacılığında yoğun olarak kullanılan gemi tipleri olan Capesize, Panamax ve Handymax navlunları arasındaki ilişkiyi incelemektir. Temel araştırma soruları emtia fiyatları ve navlunlar arasında oynaklık yayılımının ve risk transferinin olup olmadığı ve yük türüne göre ve yoğun taşınma oranına göre ilişkilerde bir farklılaşma olup olmadığıdır. Bu doğrultuda varyansta nedensellik testi kullanılarak değişkenler arasındaki bilgi akışı ve oynaklık yayılımı test edilmektedir.

Elde edilen sonuçlar hem gemi türlerine göre hem de emtia türüne göre etkileşimin farklılaşabildiğini ortaya koymaktadır. Capesize ve Panamax gemi türünün emtialarla olan ilişkileri ise kısmen benzerlik göstermektedir. İçerilen tüm rotalar için sonuçlar ortak olmasa bile, Demir cevheri ve kömür fiyatından bu gemilerin navlunlarına doğru nedensellik ilişkisi mevcuttur. Buğday fiyatıyla olan ilişkilerinde ise çift yönlü bir nedensellik ilişkisi mevcuttur. Handymax türü gemi için ise emtia fiyatlarından navlunlara doğru herhangi bir ilişki tespit edilemezken, navlunlardan kömür ve buğday fiyatlarına bir nedensellik tespit edilmiştir. Sonuçlar endüstriyel ürünlerin fiyatlarındaki oynaklığın navlun piyasalarına yayıldığını, taşınma oranlarının Capesize ve Panamax tipi gemilerin komşu olması nedeniyle bu iki piyasada bir farklılaştırma oluşturmadığını göstermektedir. Ayrıca buğday fiyatından navlunlara olan oynaklık yayılımının muhtemelen piyasa türünden veya buğday fiyatının gemilerin sefer

maliyetlerinin en büyük kısmını oluşturan petrol fiyatıyla olan yakın ilişkisinden kaynaklandığı düşünülmektedir. Bu sonuçlara istinaden, oynaklık yayılımlarının ve risk transferlerinin emtia fiyatlarından navlun fiyatlarına doğru olduğu, gemi türüne göre bazı ilişkilerin farklılaştığı tespit edilmiştir. Bu sayede, literatüre özgün bir katkı sunmanın yanı sıra, ajan bazında emtia fiyatlarıyla navlunlar arasındaki ilişki tespit edilmiş ve ajanlar için belirsizlikten kaynaklı risklerin azaltılmasına katkıda bulunulmuştur.

Anahtar Kelimeler: Emtia fiyatı, navlun piyasası, kuru dökme yük, oynaklık yayılımı.



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ABBREVIATIONS

ASI	Asian Steel Index
ATC	Average Total Cost
AVC	Average Variable Cost
BCI	Baltic Capesize Index
BDI	Baltic Dry Index
BHI	Baltic Handysize Index
BPI	Baltic Panamax Index
CPI	Consumer Price Index
DEA	Data Envelopment Analysis
DWT	Dead Weight Tonnage
EMH	Efficient Market Hypothesis
GDP	Gross Domestic Product
GSADF	Generalized Sub Augmented Dickey Fuller
HAMROT	Hampthorn Road to Rotterdam
ISTFIX	Istanbul Freight Index
MC	Marginal Cost
PANSA	Pacific Northwest to South America
PPI	Producer Price Index
PSD	Parcel Size Distribution
RICROT	Richard Bay to Rotterdam
ROBROT	Roberts Bank to Rotterdam
SALBE	Saldanha to Beilun
TUBQINQ	Tubarau to Qingdao
TUBROT	Tubarau to Rotterdam
UNCTAD	United Nations Conference on Trade and Development
USJAP	US Gulf to Japan
WAROT	South Wales to Rotterdam

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INTRODUCTION

Research Background

Maritime markets and especially freight markets are defined as risky markets due to high volatility. Since they have a derived demand structure, they can be immediately affected by shocks in the world economy. Non-trend expansion or contraction in production activities cause high volatility in the maritime market. The main reason for this is that the supply curve is inelastic in the short run in the maritime market. The time-to-build effect lies behind this structure. The ship order placed in line with the future expectations arising according to the current market conditions can contribute to its carrying capacity by entering the market only between 1-3 years. Therefore, when the order is placed today, it remains uncertain how the market will be when the ship is completed. Although order quantities can be tracked through shipyards, demand for shipping services are difficult to predict. In the world economy, political balances, crises and wars between countries are felt immediately in the maritime markets. Also, natural events of different sizes affect the maritime market by rendering the ports dysfunctional and causing the change of commercial routes.

Due to its market structure, dry bulk market is defined as a perfect competition market by several researchers (Harlaftis and Theotokas, 2002), and this leads to high competition in the market. Although some vessels are specialized to carry some special cargoes, cargo pass-through between vessels is relatively easy under favorable market conditions. For instance, considering the economics of scale reality, although the transportation cost of iron ore cargoes on long routes is high with Panamax type vessel, iron ore cargoes transfer from Capesize type ships to Panamax type ships during the periods when the freights exceed a certain high bar. When such a level is reached, it becomes economical to carry the iron ore cargo for Panamax type ship owners and to prefer this ship type for shippers. Of course, in such a case, the situation in the markets where Panamax type ships are mostly preferred is effective and determines the available tonnage.

The commodities, which consist of three main bulks discussed in the study, differ in terms of production structures, supply structures and demand structures.

While iron ore and coal are mostly defined as industrial products and their production processes depend on underground activities, wheat plays a major role in household consumption and the production process is mostly dependent on climatic factors. Also, since the parcel size distribution functions of these cargoes are different, various types of ships are specialized in the transportation of these cargoes. However, depending on the market conditions, there may also be cargo pass-through between ship types. Demand for these commodities also affects maritime demand and causes fluctuations in the maritime markets, especially in freight market. Considering that prices of commodities also carry information about their supply and demand, there may be an interaction between commodity prices and freight markets. This possible interaction has also been studied in the maritime economics literature and significant results have been achieved (Kavussanos et al., 2010; Kavussanos et al., 2014; Chou et al., 2015; Tsioumas and Papadimitriou, 2018; Aık and Bařer, 2018a; Aık and Bařer, 2018b; Aık and İnce, 2019; Aık and Bařer, 2019a; Bařer and Aık, 2019a; Aık and Bařer, 2020; Angelopoulos et al., 2020). In these studies, interactions in derivative markets and over past prices were examined. This thesis aims to test the relationships over the prices that have already taken place rather than the analysis made on the future prices shaped by the expectations. It differs from studies conducted in this direction by using a more up-to-date method and approaching the subject from a non-linear perspective. Also, considering that the processes of reacting to new information are faster, spot freights were used in this study.

Research Questions and Aim of the Study

Basically, this study is based on three research questions; (i) Is there any volatility spillover and risk transfer from commodity prices to the freight market?; (ii) Is the flow of information from the prices of commodities to freights of the mostly used ships unidirectional?; (iii) Is there a difference in terms of information flow between commodity price and freight by type of commodity?

Why are these questions important? As Kavussanos et al. (2010) expresses, any information that enables early discovery of the change in freight rates increases the accuracy of investment decisions. Given the very volatile nature of the maritime

market and the market cycles of different sizes and lengths, this is vital for both ship and cargo owners. For instance, carrying the 200,000 tons of iron ore cargo to \$2 less or more per ton can result in a \$400,000 change in revenue for the ship owner at once. Or, in terms of cargo owner, there is a huge transportation cost. At this point, considering that each type of ship usually specializes in transportation of different types of cargoes, each ship can be identified as an “*agent*” in the market. In this respect, the effects of each cargo type on the type of ship may differ, and each ship owner (agent) may have to follow a different strategy according to the cargo type. In addition, a single agent may be affected by different commodity prices, as there is a pass-through between different types of cargoes among the ships. In this respect, this thesis aims to determine whether there is a spillover and risk transmission between commodity prices and freight rates, if any between which types of ships and cargoes, and whether specialization in a cargo type composes a differentiation in the relationship. Thus, it aims to better understand the market for each shipowner and reduce the risks arising from uncertainty by revealing agent-based findings.

Organization of The Dissertation

Chapter one examines the commodity trade in the world, the role of maritime transport in this trade activities, the specialization of ship types by commodity type and the factors affecting this specialization.

Chapter two examines the formation of the costs of ships, how freight is determined over these costs, the formation of demand for maritime transportation in the world, the formation of maritime transport supply, how the freight is determined in the market with the supply-demand balance, commodity price formation and the relationship between commodity prices and freight markets both in theoretical and practical area.

Chapter three examines the general framework of the study, the data set used in the study, the pretests required by the preferred method and the features of the method used.

Chapter four includes the results of the pretests performed before the analysis and the results of the basic method applied in the context of these tests.

Finally, the findings obtained from the study are evaluated, academic and practical implications are presented, and study limitations and suggestions for future studies are presented.



CHAPTER ONE

COMMODITY MARKET IN THE WORLD

This section begins with reference to the fields of use of commodities that are the subject of this research in general and the countries that are prominent in the international trade of these commodities, as maritime transportation is an international transportation network and the centers where trade is intensive are of great importance in terms of freight routes. Then, we discuss the role of maritime transport in international trade and show its importance. In this important function, we have studied how the commodity type and its destinations determine ship type choices and what are the reasons for this.

1.1.WORLD COMMODITY MARKETS

Maritime transport has a derived demand structure and is directly affected by situation in the world trade. The route of maritime transport is formed according to the locations where the goods subject to trade are produced and consumed. In container and general cargo transportation, mostly final products are transported, whereas in dry bulk transportation, industrial products are transported. The countries that are prominent in the trade of iron ore, coal and wheat commodities, which are the subject of the study, are mentioned in this section in order to draw a general formation of their trade.

1.1.1. Iron Ore Market

The iron ore is the main raw material of the iron and steel industry. By melting iron ore in furnaces under certain conditions, iron and steel products are obtained. The usage areas of these products are very common. Iron and steel industry, as one of the most important of the heavy industry, provides raw materials to the indispensable sectors in daily life such as construction, infrastructure, automotive, white goods and machinery industries (Çelikdemir et al., 2018:82). Table 1 presents the rankings of countries according to the trade volume in 2017 in iron ore commodity. The top 15

countries that both export iron ore and import iron ore are listed. Australia is the most remarkable country in the export of this commodity. 52% of world exports in dollars of iron ore is made by Australia. Although the share of Brazil that came after it remained small next to Australia, it constitutes 22% of the world iron ore exports. The export volumes of the countries following these two countries decrease to about 4% and decrease gradually from this rate. In terms of iron ore imports, China alone accounts for 63% of the world's iron ore imports and constitutes a huge share. The main reason for this may be that China is dependent on foreign sources due to its rapid development (Li, 2018:4). Even its closest follower, Japan, constitutes only 8.30%. This situation played a leading role in the Capesize market reaching the highest freight levels in the history after 2003. After Japan, South Korea constitutes a 5,10% share, while the rest of the countries have realized very small shares alongside these economic giants.

Table 1: Iron Ore Exporters and Importers in the World in 2017

	Country	Export Value \$	Share	Country	Import Value \$	Share
1	Australia	48.185.963.394	52%	China	58.976.461.066	63%
2	Brazil	20.146.562.457	22%	Japan	7.693.865.963	8.30%
3	South Africa	4.018.805.284	4.30%	South Korea	4.747.725.756	5.10%
4	Canada	3.888.379.346	4.20%	Germany	2.197.120.590	2.40%
5	Ukraine	2.610.932.967	2.80%	Netherlands	1.858.061.461	2.00%
6	Sweden	2.315.750.120	2.50%	Other Asia	1.465.262.670	1.60%
7	India	1.817.270.096	2.00%	Malaysia	1.200.740.860	1.30%
8	Russia	1.536.016.752	1.70%	France	1.081.715.664	1.20%
9	Iran	1.187.549.670	1.30%	Saudi Arabia	876.119.660	0.94%
10	Oman	1.002.476.147	1.10%	United Kingdom	725.480.511	0.78%
11	Chile	994.617.453	1.10%	Italy	701.699.484	0.75%
12	USA	824.763.963	0.89%	Belgium	685.152.515	0.74%
13	Mauritania	813.423.842	0.87%	Oman	667.181.634	0.72%
14	Malaysia	530.896.183	0.57%	Egypt	650.752.729	0.70%
15	Kazakhstan	508.045.249	0.55%	Turkey	649.821.040	0.70%
	OTHERS	2.591.515.808	2.78%	OTHERS	8.795.807.126	9.45%

Source: OEC (2020).

Iron ore trade routes are mostly formed between export countries and import countries, which is necessary to understand global seaborne iron ore transport routes. A very large density of routes starts from Australia and ends in China.

1.1.2. Coal Market

Usage areas of coal commodities are generally power generation, steel and cement production, coal liquefaction, household consumption, chemical industry, paper manufacturers, etc. (Schernikau, 2010:73). It has an indispensable function for the world especially considering its role in electricity production and steel production. One of the most important advantages of the coal mine is that it can be obtained not only from developing or underdeveloped countries, but also from the developed and stable countries of the world (Schernikau, 2010:37). This makes coal commodity more advantageous than other fossil fuels for energy supply security.

When the trade statistics in the world are analyzed, Australia has a very important share in exports with a share of 39%. The fact that the country has such a large share allows it to have a market driver power, and also causes the maritime transport traffic to be concentrated around the country. The countries that follow are Indonesia and Russia with shares of 16% and 13% respectively in the export rates. In coal imports, developed and developing countries come to the fore and import the energy resources they need for their industries. The countries that come to the fore are India and Japan, with shares of 16%. China and South Korea follow these countries.

Table 2: Coal Exporters and Importers in the World in 2017

	Country	Export Value \$	Share	Country	Import Value \$	Share
1	Australia	46.964.772.652	39%	India	19.448.811.506	16%
2	Indonesia	18.949.009.823	16%	Japan	19.535.712.160	16%
3	Russia	16.149.553.887	13%	China	17.843.888.433	15%
4	USA	10.550.069.646	8.70%	South Korea	13.332.913.630	11%
5	Colombia	7.628.520.403	6.30%	Other Asia	5.681.894.570	4.70%
6	South Africa	6.232.811.757	5.10%	Germany	4.281.119.065	3.50%
7	Canada	5.663.652.163	4.60%	Netherlands	3.415.101.607	2.80%
8	Mongolia	2.274.254.445	1.90%	Turkey	3.235.904.338	2.70%
9	Mozambique	1.443.591.645	1.20%	Brazil	2.979.317.895	2.40%
10	China	1.187.838.843	0.97%	Malaysia	2.610.515.558	2.10%
11	Poland	915.551.141	0.75%	Ukraine	2.176.221.824	1.80%
12	Kazakhstan	536.610.974	0.44%	France	1.852.543.427	1.50%
13	North Korea	367.996.092	0.30%	Spain	1.704.964.650	1.40%
14	Philippines	332.777.486	0.27%	Philippines	1.557.039.699	1.30%
15	Czech	332.982.696	0.27%	Italy	1.620.496.703	1.30%
	OTHERS	2.326.873.564	1.91%	OTHERS	20.580.422.156	16.82%

Source: OEC (2020).

Contrary to the iron ore trade, there are no concentrations in a few countries in the coal trade. For this reason, sea trade routes form a wider network in transport activities.

1.1.3. Wheat Market

Wheat is one of the most important nutrients for global food supply and meets about 1 in 5 of the world calories needs (Mitchell and Mielke, 2005:195). In addition, wheat plays an important role in the nutrition of animals that provide milk and meat to humans and therefore has an indirect effect on human nutrition (Lawlor and Mitchell, 2000:57). Also agriculture trade is an important income source for developing countries (Dehn et al., 2005).

Commercial statistics of countries related to wheat trade are presented in Table 2. Although there are some serious differences between the shares of the exporting countries, the shares of the importing countries are very close to each other. Russia is the most prominent country in wheat export rates and has a 19% share. USA and Canada follow it with little difference. The country which has the highest share in wheat import is Egypt with a share of 9,80% and it is followed by Indonesia with a rate of 6,10%. The import rates of most of the remaining countries are very close to each other. This is probably due to the fact that wheat is one of the most important foodstuffs in the world and is the main input of production activities in many food sectors.

Table 3: Wheat Exporters and Importers in the World in 2017

	Country	Export Value \$	Share	Country	Import Value \$	Share
1	Russia	7.933.019.494	19%	Egypt	4.170.289.809	9.80%
2	USA	5.819.623.638	14%	Indonesia	2.595.151.019	6.10%
3	Canada	5.430.131.406	13%	Algeria	1.699.849.042	4.00%
4	Australia	4.878.112.580	11%	Italy	1.549.546.011	3.60%
5	France	3.043.082.338	7.10%	Japan	1.399.907.936	3.30%
6	Ukraine	2.928.148.723	6.90%	Nigeria	1.346.953.526	3.20%
7	Argentina	2.531.560.696	5.90%	Bangladesh	1.233.016.077	2.90%
8	Germany	1.680.710.196	3.90%	Philippines	1.184.434.556	2.80%
9	Romania	1.467.125.853	3.40%	Spain	1.167.570.992	2.70%
10	Bulgaria	871.166.912	2.00%	China	1.076.802.781	2.50%
11	Kazakhstan	655.520.797	1.50%	Mexico	1.057.635.522	2.50%

12	Poland	620.802.376	1.50%	Brazil	1.059.680.250	2.50%
13	Hungary	598.291.514	1.40%	Sudan	977.930.635	2.30%
14	Czech Republic	543.208.805	1.30%	Vietnam	962.296.240	2.30%
15	Lithuania	473.882.081	1.10%	Netherland	966.283.474	2.30%
	OTHERS	3.150.181.395	7.40%	OTHERS	20.177.220.933	47.27%

Source: OEC (2020).

In the wheat market, as the export and import rates are very small, it can be said that the seaborne transport activities with low density are carried out in a much wider network than as in iron ore and coal commodities.

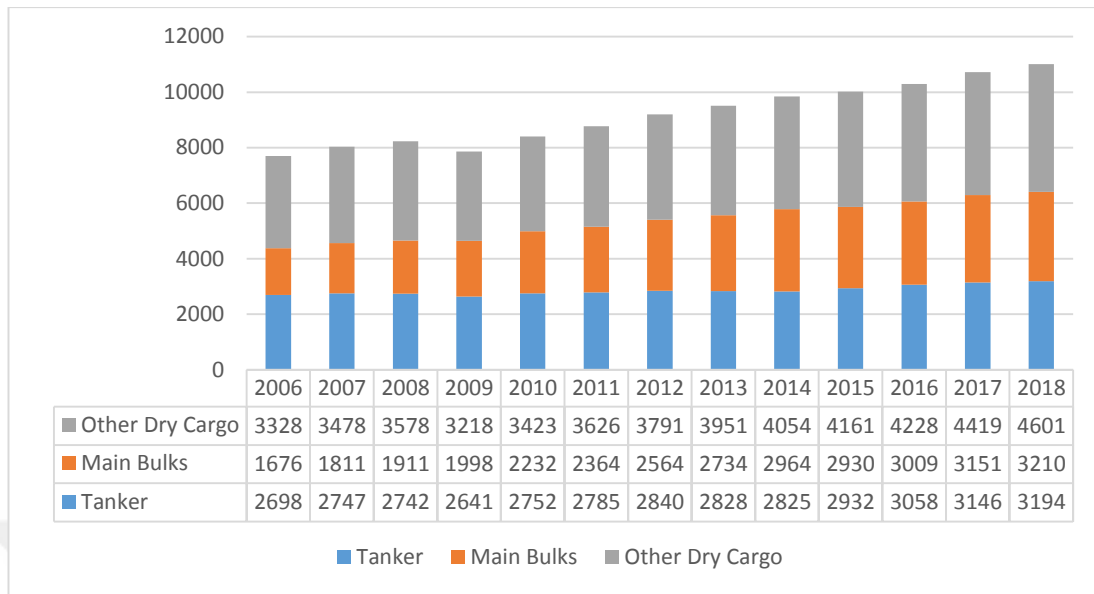
1.2.ROLE OF MARITIME TRANSPORTATION IN COMMODITY TRADE IN THE WORLD

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 transported cargoes are generally divided into containerized, general, bulk, hazardous and petroleum cargo types (Rowbotham, 2014:9). As this research focuses on dry bulk cargoes, our discussion will concentrate on this type.

Bulk cargoes can be defined as homogeneous goods that do not have a specific form and take the shape of the hold in which they are located (Hinkelman, 2008:678). Also, they are directly loaded to ships without protective packaging (Gubbins, 1996:58). There are basically 3 types of bulk cargoes which are liquid bulk cargoes, five major bulk cargoes and minor bulk cargoes (Stopford, 2009:63). Dry bulk cargo basically consists of homogeneous commodities that fill the whole ship, and the whole ship is consigned to related cargo contrary to general cargoes (Buxton et al., 1978:213)

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



Source: UNCTAD (2019a).

1.3.VESSEL SPECIALIZATION IN COMMODITY TRANSPORT

Ships have great advantages for sustainable run of world trade. In addition, having a cost-free infrastructure for transport activities, which is the sea, provides an important advantage to ships (ECMT, 2001:44). This transport service is provided by ship investors who have positive prospects for the future using large capital investments. Which type of ship will be preferred for these ship owners requires a critical and systematic strategy since the ships are expensive investments that have been in service for many years. A wrong strategy may have a high cost to the investor. These investments should be made considering some important factors in order to be able to survive in the competitive world (Bendall and Stent, 2005:13).

Stopford (2009:567) defines these factors as cargo type, type of shipping operation and commercial philosophy. The owner of the ship must decide what type of cargo it targets. Because some cargoes can only be transported with a single ship type, while some cargoes can be transported with different ships as well. In some cases, the physical properties of the ship may restrict the choice of cargo, for example the hatch type and size of the dry bulk ship may cause problems for the transportation of some wide general cargoes. The owner must decide how he wants to use his ship

commercially. It may charter long term or run on the spot market. Accordingly, a ship type should be selected to meet the expectations of the targeted market. For purely commercial reasons/ purposes, the owner may choose a flexible ship that can carry different types of cargo, or a specialized ship for a particular cargo. In this case, the transportation costs of flexible ships per unit will be high, while the ships that are special will be low. However, although this generates a cost advantage for the specialized ship, it reduces the chance of finding cargo for it. Therefore, ship selection is a crucial decision for the owner to continue his commercial activities.

Considering the mentioned factors, dry bulk cargo fleet has been formed as a result of cumulative investments made by ship owners to be used in commodity transportation. Dry bulk cargo fleet accounts for 42.6% of transport capacity of total world fleet in 2019, making the dry bulk market an important position in the world maritime trade (UNCTAD, 2019b). Vessel types in the dry bulk shipping market are classified based on their sizes as Handysize (20,000-35,000 DWT), Handymax (35,000-45,000 DWT), Supramax (45,000-55,000), Panamax (60,000-75,000 DWT) and Capesize (80,000-300,000 DWT) respectively (Alizadeh and Nomikos, 2009: 30).

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 4 shows the approximate transport shares of the three 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 4: 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)

At this point, the question of what are the criteria for selecting vessel type may come to mind. Important factors such as scale economy and parcel size distribution are effective in determining which cargo will be carried by which type of ship.

1.3.1. Economies of Scale

There are many factors affecting ship selection in dry bulk transportation by sea. One of the most important of these is economies of scale. In general, the economics of scale in maritime are examined under two headings; internal economies of scale and external economies of scale. While the external scale economy refers to the unit cost shaping according to the size of the maritime company, the internal scale economy refers to the unit cost shaping according to the size of the individual transport unit (Wilmsmeier, 2014:17). If the long-term average production cost decreases due to the output increase, the economies of scale appears (Sanchez and Wilmsmeier, 2011:164). In the maritime economy, it is generally referred to economics of scale for ship size rather than firm size (Cowie, 2010:302). The economies of scale is vital for keeping transport costs low, making it possible to trade from long distances (Stopford, 2009:75). Moreover, economies of scale not only provides an advantage in the transportation cost of the cargo per unit but also causes a decrease in some other cost items, which are effective in transport costs as well. For instance, man-ton ratio is low in bigger ships, so as the size of the ship increases, the need for personnel will not increase at the same rate, it will be lower. In addition, larger ships have lower construction costs per ton, and they offer a capital advantage when they first enter the market (Kaukiainen, 2012:76).

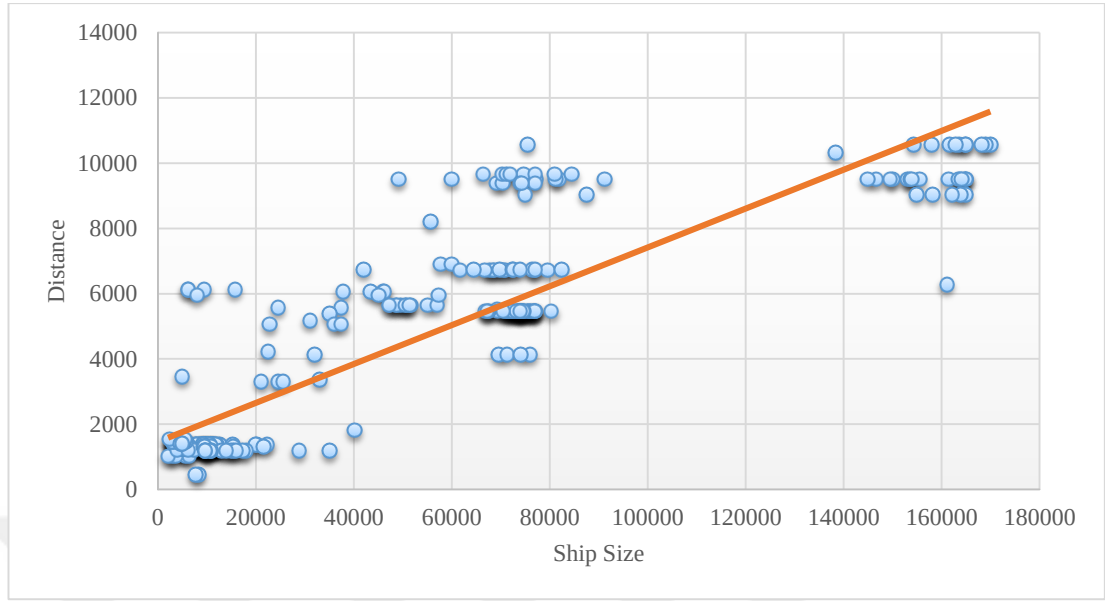
The scale economy can be easily understood with the help of equation (1). LC refers to capital cost, OPEX refers to operational costs, CH refers to handling of the cargo cost, and PS refers to parcel size. Parcel size in the bulk shipping indicates its tonnage.

$$Unit\ Cost = \frac{LC + OPEX + CH}{PS} \quad (1)$$

Transportation cost per unit generally tends to decrease as ship size increases. This decline is especially prominent in dry bulk freight transportation, and this has caused the economy of scale to become one of the main features of dry bulk vessels. Also, as the size grows among dry bulk ship types, significant differences can occur in transportation costs per unit. For example, switching from Handy type ship to Handymax type ship reduces the transportation cost per unit by 22%. Another 20% saving is achieved when switching from Handymax ship type to Panamax ship type. A 36% saving is achieved when switching from Panamax ship type to Capesize ship type. The difference between Handy and Capesize ship types is a huge difference of 67%, which makes the selection of vessels size vital for shippers and ship investors (Stopford, 2009:78).

A simple empirical study that tests the validity of economies of scale can provide a better understanding of the subject. We used ship size and distance in our study in order to determine whether economies of scale in ISDEMIR Port in Turkey is valid or not (Açık and Başer, 2017). Due to data constraint, we used these two variables, ignoring the impact of freight and coal prices. Our basic assumption is that larger vessels come from further distances, as larger vessels are employed to reduce the cost of transport per unit as the distance increases. The ship data consisted of 313 bulk cargo vessels and covered the periods between 2008 and 2011. In these years totally 14.032.392 tons of coal imported by the port in order to provide fuel to its power plant placed close to the port. The graph of dataset is presented in Figure 2 and the positive relationship between the variables can be seen clearly.

Figure 2: Ship Size and Distance Data of İSDEMİR Port



Source: Marine Traffic (2017); UDHB (2012).

The following regression model was estimated using mentioned data set as distance is dependent variable and volume of coal (ship size) is independent variable:

$$Volume_i = \beta_0 + \beta_1 Distance_i + \varepsilon_i$$

As a result of the regression estimation, it was found that Distance variable explained the Volume variable by 78% and one unit (nautical miles) change in distance caused 13 units (tons of coal) change in volume. Based on these results, the validity of economies of scale in coal transport was verified according to the analyzes made on the basis of İSDEMİR Port.

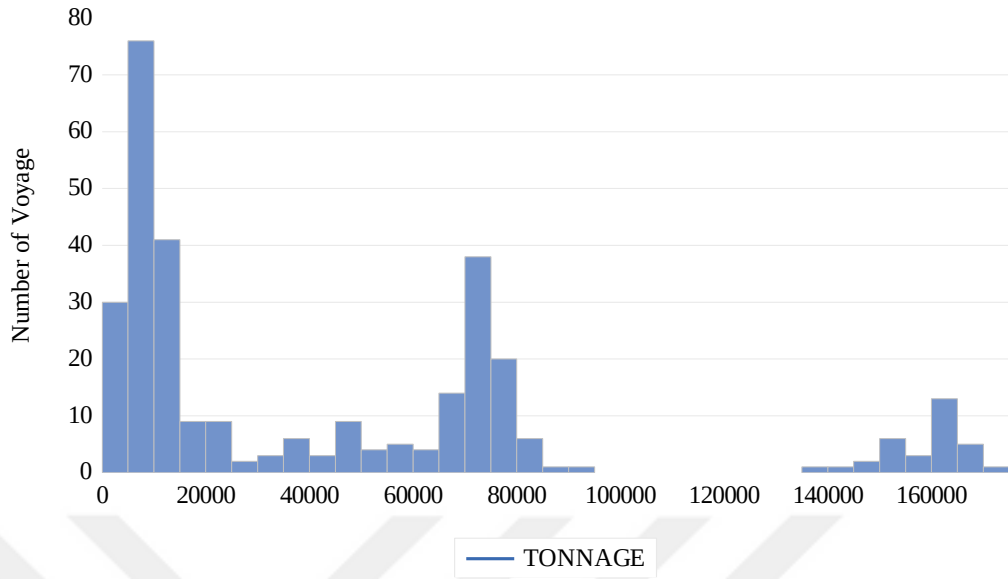
1.3.2. Parcel Size Distribution (PDS)

The Parcel Size mentioned in the economics of scale section is the consignment of the cargo to be shipped individually. For example, 150,000 tons of iron ore for a steel plant, 80,000 tons of coal for a thermal power plant, 25,000 tons of wheat for a bread factory, 2 thousand rolls of steel for a construction company. Parcel sizes are determined based on three factors; (i) stock levels of end users, (ii) draft levels at the

loading and unloading ports, (iii) cost savings using larger ships (Stopford, 2009:75). The PSD briefly deals with which type of cargo will go with which type of ship, and cargoes of similar characteristics are usually carried by the same type ships (Lun et al., 2010:8). Recently, the importance of storage and inventory costs has been increasing with industrial principles such as just-in-time case. For this reason, many buyers prefer small quantities of continuous purchases rather than purchasing large quantities with a few big ship loads (Kaukiainen, 2012:79).

Figure 3 shows the distribution of coal imports of İSDEMİR according to the parcel sizes. According to the graph, a large part of the port's imports was made in small parcel sizes. The countries from which small imports come from are mostly Russia, Poland, Ukraine and Romania destinations, which are very close to the İskenderun region where the port is located. Probably intensive transportation activities were carried out at close range in order to quickly respond to changes in inventory levels, which are crucial for thermal power plant businesses. On the other hand, large parcels were imported from countries such as USA, Australia, Canada and Indonesia, which come to the fore with their long distances to the port. Even though the frequency of these large parcel sizes is low, it can be said that much more coal is transported than small parcels considering the amount of cargo they include. In this case, it can be said that economies of scale and inventory levels come to the fore in the selection of parcel sizes in coal import activities. Moreover, the fact that the İSDEMİR port has high draft for cargo handling made it possible to import coal in large parcel sizes from long distances.

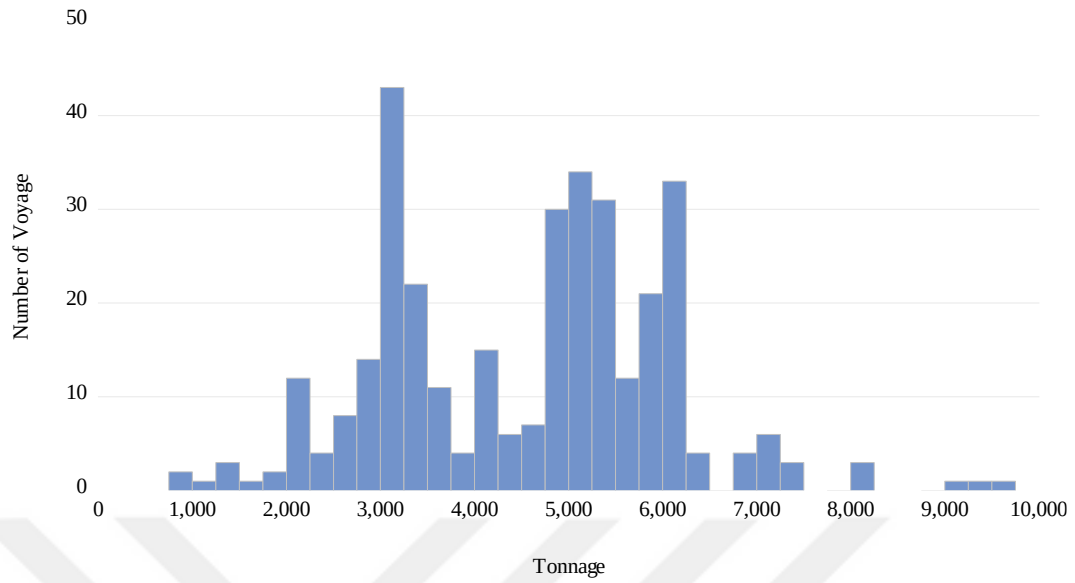
Figure 3: Ship Size Data of İSDEMİR Port



Source: UDHB (2012).

On the other hand, Figure 4 presents the distribution graph of the ships carrying imported coal to Zonguldak TTK Port. Unlike İSDEMİR port, the size of the largest coal load coming for this port is approximately 10,000 tons. The reason for this situation is that all the cargoes come from close range countries such as Egypt, Ukraine and Russia, and the transported loads are mostly realized in small size parcels. The ownership structure of the importing organization may also have contributed to this situation since it is a government organization and concerns for efficiency and profit maximization are generally low in these ones. Moreover, as the inventory and storage costs of purchasing large quantities are high, the organization's possibilities may not allow to order large quantities.

Figure 4: Ship Size Data of Zonguldak TTK Port



Source: UDHB (2012).

So far, we have summarized the trade of the 3 basic commodity in the world and examined the factors affecting the choice of ships used in the transportation of these commodities. From this point on, it is examined how the commodity prices and the freight that represent the transportation cost of the commodity occurred, and then the possible relationship between them is compiled from the literature.

CHAPTER TWO

MARITIME FREIGHT MARKET AND COMMODITY PRICES

In this section, we examine the structure of transportation costs that preceded the supply-demand balance, in the theory of freight formation. Then, we explained the factors affecting these costs and how the market is heterogeneous in terms of costs for each ship. After addressing the factors that constitute the supply and demand sides of maritime transportation, we examined how the equilibrium freight price was formed by the interactions of these factors. After briefly examining other maritime markets that have been influenced mainly by the freight market, we have touched on the issue of price formation in commodity markets, which is the second main focus of the study, on three main bulk cargoes. Then we examined how commodity prices are evaluated in the sector in terms of their relationship with freight rates. Finally, we tried to determine the position of our own study by evaluating the studies examining the commodity-freight relationship in the maritime literature.

2.1. COST OF TRANSPORTATION

Increasing competition among countries in the globalizing world caused a decrease in commercial tariffs in order to the international trade easier. This situation has increased the importance of the share of the cost of transportation in the final prices of the products subject to trade (Wilmsmeier, 2014:2). For this reason, the importance of the costs of maritime transportation, in which a very large proportion of the world trade is realized, comes to the fore. For instance, Korinek and Sourdin (2009) found in their research that a 10% increase in maritime transportation costs reduced global trade by 6-8%.

In the formation mechanism of freight rates, which are the main focus of the research, they are based on the interaction of supply and demand parties. However, before this economic theory, every ship can be thought of as a business and every ship has its own cost function. The ship owner should make transportation at a price above this cost factor while transporting so that he can continue his commercial activities with a sustainable profit margins.

Stopford (2009: 225) classifies costs of a ship into four categories as operating costs, periodic maintenance costs, voyage costs and capital costs. He exemplifies the shares of these costs through a 10 years old bulk carrier and indicates rates 14% for operating costs, 4% for maintenance costs, 40% for voyage costs and 42% for capital costs. The operation costs include manning cost, store cost, routine maintenance cost, insurance cost and administrative cost, and these costs vary depend on the type, size and age of the vessel (Alizadeh and Nomikos, 2009:43). The voyage costs include fuel cost, port and light cost, tugs and pilotage cost and canal cost. Capital cost varies according to the method of obtaining the ship and can be measured with interest rates.

The cost base consisting of these factors varies for almost every ship, and ship owners have to carry more than this rate in order to make a profit. In cases where freights are flying due to demand shocks, they may also carry out a transport operation higher than this cost base. In their study, Aık and Ayaz (2018) analyzed this situation with causality analysis that varies over time through bunker prices and found that the relationship between bunker cost and freight is not always present. This interaction is partially eliminated, especially when the market is alive.

The costs of running a ship are also directly related to the age and operating speed of the ship, and as these changes, the quantities and rates of the costs change.

2.1.1. Impact of Speed of the Ship

One of the most important factors affecting a ship's cost is the speed of the vessel as fuel consumption increases exponentially when the speed increases (Homayouni and Fontes, 2018:52). The main reason that makes this important is that fuel costs constitute the vast majority of voyage costs. Therefore, although fuel prices are very volatile, efforts are made to be as fuel-efficient as possible when designing ships (Kat and Mouawad, 2019:56). The equation (2) presented below regarding the fuel consumption proposed by Stopford (2009:234) can provide a better understanding of this fact:

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

In the equation (1), F refers to actual fuel consumption, F^* refers to design fuel consumption, S refers to actual speed, S^* refers to design speed. The coefficient a depends on the engine type and is taken 3 for diesel engine and 2 for steam turbines. As it is understood from this equation, as the speed increases, fuel consumption increases at a higher rate, the main reason for this is water resistance. To exemplify, a Panamax bulk carrier consumes 44 tons of bunker per day when it sails at 16 knots per hour. It consumes 24 tons at 13 knots, and 14 tons at 11 knots.

The relationship between ship speed and fuel consumption is very strong. However, this does not mean that ship owners always follow the sailing speed that will consume the least amount of fuel. There are other several factors that affect ship speed, and ship owners decide the speed of the vessel considering these factors. Considering these factors, equation (3) has been proposed by Evans and Marlow (1990) as follows regarding how the ships should adjust their optimum speeds:

$$S = \sqrt{\frac{R}{3 \cdot p \cdot k \cdot d}} \quad (3)$$

In this equation, R refers to total freight revenue, p refers to bunker price, k refers to constant number regarding to engine type and d refers to distance. Based on this, when freight revenue (R) increases, the recommended optimum speed increases since freight is numerator of the fraction. It is thought that it is more rational to deliver the cargo faster and to find a new cargo due to the increased freight levels in the market. Secondly, the recommended optimum speed is lower when the price of fuel (p) increases. The reason for this is that the increase in efficiency likely to be achieved with the increase in speed cannot meet the increase in cost caused by fuel consumption in higher sailing speed. As obtained from the previous equation, the increase in fuel consumption is proportionally larger compared to the increase in speed. In short, when the price of fuel increases too much, it may be necessary to decrease the speed in order to reduce the operational expenses (Christiansen et al., 2007:267). Finally, the recommended optimum speed is lower when the distance (d) increases. The probable reason for this is that the increase in fuel costs due to distance can reach very significant levels at high speeds.

In this regard, we examined the relationship between bunker price and ship speed in one study and tested theoretical validity through bulk market (Açık and Başer, 2018d). The relationship between fuel prices and the average speed of the dry bulk fleet was investigated by asymmetric causality analysis. The main reason for using asymmetric causality analysis is that there are many different variables that affect the relationship between the variables, as can be understood from the equations mentioned above. Therefore, it is possible to have a nonlinear and asymmetrical relationship between the variables. After verification of the nonlinear structures in the series, analysis was applied to the dataset covering the period between May 2008 to June 2018. The results obtained revealed that positive shocks in bunker prices were the reason for negative shocks in average ship speeds in the bulk fleet. However, the opposite relationship (from negative shocks in the bunker prices to positive shocks in the average ship speeds) could not be identified and it was stated that this may be due to commercial concerns and strategies. Probably the situation in other factors in the equation mentioned above was effective in these conclusions. As a result of all this drawn frame, it is clearly demonstrated that ship speed is a very important factor in costs of the ships.

2.1.2. Impact of Age of the Ship

One of the most important factors affecting the transportation costs of ships and therefore the freight base is their age. As the age of the ship increases, the share of the capital costs of the ships decrease, but the operating and voyage costs increase (Stopford, 2009: 222). One of the main reasons for this is that relatively new ships have newer engine technologies (Harwood, 2008:70). Considering that one of the biggest items of voyage costs is fuel costs, this gives new ships a very high cost advantage compared to older ones. In addition, maintenance and repair costs are very low on new ships. More provision for repairs and maintenance and more crew members are also needed in the older vessels (Alizadeh and Nomikos, 2009:43). The ratio of operating costs to all costs is 18% for a 5 years old ship and 31% for a 20 years old ship, also the ratio of voyage costs to all costs is 33% for a 5 years old ship and 40% for a 20 years old ship. Considering all these examples and evaluations, it can be

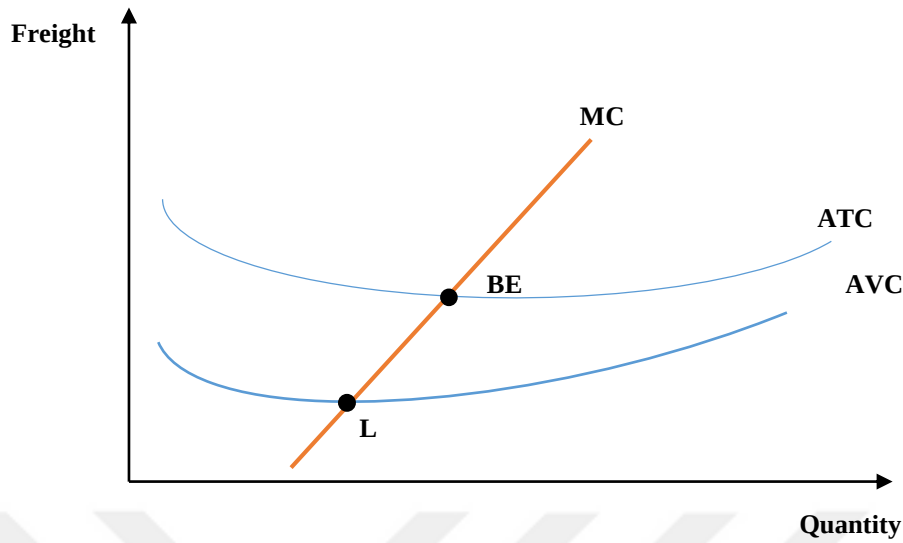
said that the age of the ship has an important role in transportation costs of the vessels, which are base line for shipowners to be able to offer freight to shippers.

2.1.3. Short Run Cost Function of a Vessel

In the short term, the cost situation for each ship can be evaluated as in Figure 5. Due to the factors mentioned in the previous sections, transportation costs of each ship occur and differs from the each other. According to these costs, the shipowner tries to achieve its profit targets by continuing its commercial activities in the freight market.

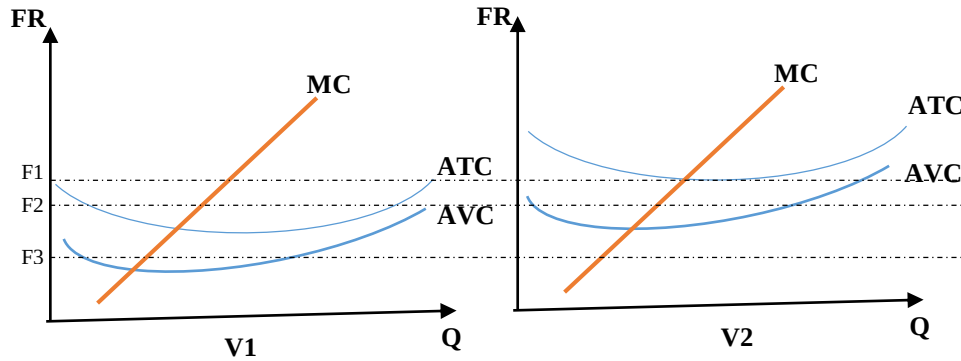
In the context of business enterprises, they stop their commercial activities when prices decrease to the average variable cost level. Because after this point, they become unable to meet even the variable costs used in production activities. This point is called the shut-down point (Mankiw, 2001:297). In the short run, the firm has to pay the fixed costs under any condition. For this reason, even if the prices fall down to the shut-down point, the company will be able to cover some of its fixed costs. However, when it falls down from this point, the company ends its production as there will be a greater loss than its fixed costs (Das, 2007:224). In the maritime economy, this shut-down point is expressed as a *Lay-Up* point and is represented by the letter *L* in the graph. At this point, the ship's revenues cannot even meet the variable costs that can be avoided when the ship is not operated (Sanklecha, 1982:78).

Figure 5: Short Run Cost Curves of the Vessels



The difference that this situation makes for the ships in the dry bulk market can be examined through Figure 6. This graph contains short-term cost curves for two different ships in the same market, that is to say dry bulk market. When the freight is at the F_1 level, the V_1 ship can make very high profits since a freight level is available on the market far above its average cost curve. This level also corresponds to the *Break-Even* point for the V_2 ship. In this case, both ships can continue their commercial activities in the market. When the freights drop to F_2 level, there is a less positive return for the V_1 ship as in the previous freight level. However, this level is below the *ATC* curve and above the *AVC* curve of the V_2 ship. In this case, the V_2 vessel will continue its commercial activities as it can meet some of its fixed costs by following the *Loss-Minimization* strategy. In the latter case, when the freight drops to F_3 , the freights for the V_1 ship fall below *ATC* and continue its commercial activities to reduce economic losses. For the V_2 ship, it ends its commercial activities as freight level falls below the *AVC* point, that is, the *Lay-Up* point.

Figure 6: Short Run Cost Curves of the Vessels



Changes in these cost structures of the ships form the basis for the offered transportation price for the shippers and thus affect the demand for sea transportation.

2.2. DEMAND OF SHIPPING SERVICES

The demand for physical products at certain points determines the demand for sea transportation. Because of the fact that some natural resources are randomly distributed all over the world and some countries are specialized in production, there is an excess supply in products in some regions while a shortage occurs in some regions (Lun et al., 2010:17). Thus, international trade develops with the exchange of excess products. Since one of the most economical ways of transporting goods is sea transportation, the demand for this mode of transportation also develops. Therefore, the demand for maritime transport is considered a derived demand. With this structure, every factor affecting international trade also affects the demand for maritime transportation, such as economic explosions and collapses, wars, droughts, channel closures and embargoes (Marcus, 1987:1). Therefore, control of transport service providers over shipping demand is very low (McConville, 1999).

Stopford (2009:136) states that there are 5 factors affecting the demand for maritime transportation in the world and lists these factors as follows; (i) world economy, (ii) commodity trade by sea, (iii) average haul, (iv) random shocks, and (v) transportation costs.

World Economy

It is surely beyond doubt that the main factor affecting the demand for maritime transport is the world economy (Stopford, 2009:140). Since the world economy leads the export and import of various commodities, it also affects the demand for shipping services. Due to this reason, fluctuations in the world economy cause fluctuations in the maritime transportation as well (Lun et al., 2010:19). In a study we conducted, we examined the demand effect naturally based on the effect of economic activities on freight levels in the dry bulk market (Başer and Açık, 2019b). We analyzed the change caused by changes in the total GDP in the world in the BDI variable and found a positive relationship between them, which indicates the important role of the global economy.

Commodity Trade by Sea

The commodity market contains many products, they are used extensively in the energy industry, heavy industry and food industry. Therefore, the situation in these sectors also affects the demand for specific commodity and consequently affects the demand for maritime transport (Burns ,2015:209). For example, since grain production is very dependent on climatic factors, trade of this commodity intensifies at certain periods throughout the year. In addition, consumption of some energy products such as coal varies according to the seasons, especially in winter it may increase. These situations cause the demand for sea transportation to change seasonally, causing fluctuations in the freight markets (Lun et al., 2010:19).

Average Haul

Although the sea areas are fixed around the world, the routes of ships do not always remain constant. Some natural, political or climatic events lead to changes in the routes of the ships and this situation has an effect on the demand for sea transportation. For example, the closure of the Suez Canal increased the distance from the Arabian Gulf to Europe from 6000 miles to 11000 miles (Stopford, 2009:146). This situation naturally caused the ships to complete their voyages in a longer time and the available tonnage in the market became scarce. So the freights jumped with unusual

rates (Marcus, 1987:169). This situation was also encountered in our study while analyzing the minor price bubbles in the BDI variable (Açık and Başer, 2018a). An embargo on imports of coal from Indonesia to China caused ships to bring coal from more distances, thereby causing a shortage of tonnage in the market by sailing of ships longer in the sea, which afterwards caused increase in the freight levels in the market.

Random Shocks

The random shocks can be large or small events for any reason. Jansson (2012:34) exemplified such events with strikes, discontinuities, weather changes, variations in production, and variations in tastes. The impact of these shocks can be shaped according to the condition of supply and demand balance in the market. While the shock is not felt when there is an oversupply, a random shock can have a big impact on freights when the market is tight (Alizadeh and Nomikos, 2009:80). In a study we conducted, we found similar factors while examining small price bubbles in Baltic Dry Index (Açık and Başer, 2018a). The climatic factors, cultural factors, political factors, voyage factors and operational factors can be defined as random shocks. For instance, when a storm occurs in a region, the ships change their routes, so there may be a jump in freight by suffering a carrying capacity. Or, the closure of the ports due to a cultural holiday may cause the ships to wait full and increase the freight rates thanks to the shortage in available capacity. A country's embargo on certain goods may increase the freight with the shortage of ships by changing routes and causing the ships to sail in more days on voyages. In addition, longer chartering of ship charterers in order to avoid risk may increase freights by causing ship shortage. Most of these are random events and affect the demand for maritime transport by affecting freight levels.

Transportation Costs

Transport costs mean different things for ship owners and cargo owners. It shows the expenses to be incurred in order to be able to carry out transportation operations for ship owners. For cargo owners, it shows the amount requested by the ship owner in return for the carriage of their cargo (freight rate). These two costs can

approach or move away each other in several periods. The periods when they are close indicate the times when the maritime market is depressed, while the times when it is distant are the times when the maritime markets are alive.

In particular, freight rate significantly affects the demand for maritime transport. In the established economic and theoretical models, it is stated that the demand for sea transportation is positively affected by the situation in world trade, while it is negatively affected by transportation costs (Beenstock and Vergottis, 1993:76). In addition, the distribution cost of the commodity generally costs between 8% and 15% of the commodity's market price. Based on this rate logic, products from different suppliers can be provided according to the movements of the commodity price (Branch, 1998:197).

2.3. SUPPLY OF SHIPPING SERVICES

Ship owners provide transportation services considering the level of demand. Karakitsos and Varnavides (2014: 43) defines the supply of shipping services in terms of a production function as follows:

$$Q_t = F(K_t, S_t)$$

In this model, Q refers to the supply of shipping services (tonne-miles), K refers to the size of the fleet (DWT) and S refers to the average speed of the fleet (miles per hour). K and S can be considered as inputs that are used to produce output Q .

Transport services can be offered with a large number of different combinations of these K and S variables. Thereby, it is possible to respond to changes caused by demand. However, K is fixed in the short run since the response of maritime transport capacity supply to demand is delayed due to the construction process of new ships. Therefore, the supply of shipping services in maritime transport is inelastic in the short run (Koopmans, 1939), and the possible increase in the supply can only be achieved by increasing average vessel speed S (Karakitsos and Varnavides, 2014).

Supply of shipping services in the short run is formed by the number of voyages performed by shipowners (Kalouptisidi, 2014) and average speed of the vessels (Karakitsos and Varnavides, 2016:14).

Stopford (2009: 136) indicates that five factors affect the supply of maritime transport services, which are (i) fleet size in the world, (ii) fleet productivity, (iii) shipbuilding outputs, (iv) demolition and losses and (v) freight levels.

Fleet Size

Fleet size refers to the overall available carrying capacity in the market offered to the services of cargo owners, and therefore it can be regarded as the supply side of shipping services (Duru, 2019:7). Its effective use makes it possible for ship owners to make sustainable profits. Profitability tends to decrease as the idle capacity increases when efficiency decreases. In the study conducted by Aık and Baran (2018), the efficiency of dry bulk freight transportation was modeled so that the amount of cargo carried was output, GDP and fleet amount were inputs. As a result of the input-oriented DEA analysis, it found that the freight rates high when the efficiency of transportation is high, and when the efficiency is low, freight rates are also low since the amount of transport capacity requested by cargo owners reduces in these periods.

Fleet Productivity

Fleet productivity can generally increase in two situations, the first one is realized when demand for maritime transport increase, the second one is realized when the fleet speed increase as the only way to increase the supply side in the short run is speed increase (Karakitsos and Varnavides, 2014:43).

In this context, it is inevitable to have a possible relationship between fleet productivity and freight level. In the first case, when the demand for maritime transportation increases, the freight rates increase, and in the second case, the decision to increase the speed is made by the ship owners when the freight reaches a certain high level. Based on this research question, the relationship between productivity and freight was examined in the study conducted by Aık and Kayıran (2018) through dry bulk market. While determining the productivity, the following formula (4) was used;

$$Productivity_t = \frac{Transported\ Dry\ Bulk\ Cargo_t}{Dry\ Bulk\ Fleet_t} \quad (4)$$

Baltic Dry Index, one of the important indicators of the global dry bulk market, was used as the indicator of the freight level in the market. According to the results obtained, the increase in freight positively affects fleet productivity and there is a highly positive correlation between the variables.

Shipbuilding Outputs

The shipbuilding market is actively involved in building and launching new marine vehicles or in various maintenance activities (Açık et al., 2017). In the shipyards, shipbuilding activities are continuing at a certain level since some of the ships fill their economic lives and some are destroyed due to accidents or losses. However, as freight levels exceed a certain level, the prices of second-hand ships also increase, so the demand for shipyards increases and it may even take years for the ship to be delivered to the owner. In this respect, the shipbuilding market undertakes important functions regarding the supply of carrying capacity by introducing new ships to the market. Thus, the difference between the market entry rate of newly built vessels and the increase in demand for maritime transport affects the supply of maritime transport, causing bursts, collapses and balances in the freight markets (Beenstock and Vergottis, 1993:96).

Demolition and Loses

The ship is sent to the demolition if the ship cannot continue its profitable commercial activities in the current freight environment, or when the value of the demolition corresponds to the income the ship owner hopes to generate in the future by operating the ships. In this case, ship supply in the market decreases and therefore the demolition market plays a balancing role in the maritime market (Buxton, 1991). Also by this way, over-supply is reduced and fleet modernization is provided (Bomhauer-Beins and Strüver, 2018). Losses refer to ships that are out of use for any

reason. These ships may be sunk, lost or fixed for use in other activities. This is one of the factors that reduces the supply of ships.

Freight Levels

As we mentioned in the previous sections, each ship has its own operating costs and in order to make a profit, the freights must exceed a certain level. The ship is sent to the lay-up at the point where the income drops to the average variable cost level (Sanklecha, 1982:78). The decisive role of freights on the supply side is related to this cost function, as well as affecting shipbuilding and demolition amounts. Ships, which are very costly to be operated and laid-up, start operating when the freight exceeds a certain level and the supply in the market increases (Stopford, 2009:160). Or vice versa, supply amount decreases when the freight levels fall. In addition, expectations play an important role, if the owner hopes the market will recover, the ship may not be laid-up even if it makes a loss (Alizadeh and Nomikos, 2009: 462).

2.4. SUPPLY AND DEMAND INTERACTION IN FORMATION OF FREIGHT RATES

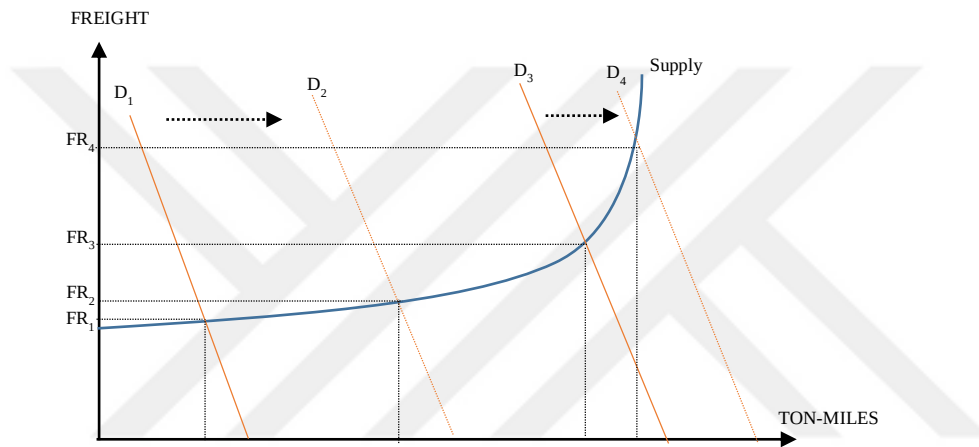
Freight can be defined as a reward given to the carrier in exchange for the carriage and delivery of the cargo under certain conditions (Knight, 1998:197). For this reason, it has an important function for both the shipper and the carrier, while it is a cost element for the shipper, it is a revenue element for the carrier. There are several approaches to its formation and some of them are briefly mentioned in this section.

2.4.1. Short Run Equilibrium

The graphical representation of this structure and its possible reflections on the market is shown in Figure 7. When the demand shifts from D_1 to D_2 , freight is less likely to be affected as there is extra transport capacity in the market although the increase in demand is quite large. However, although the demand shifts relatively

slightly from D_3 to D_4 , the change in freight rates is enormous. The biggest reason is the time-to-build effect (Kalouptsidi, 2014). Transport services are not available after a certain point, and when the new ships are ordered, it takes between 2-4 years to build and enter the market (Tsolakis, 2005). In one of our study, the relationship between freight and delivered tonnage was found to be 2 years, and when these 2 years were taken into account, the positive correlation between the variables was confirmed (Başer and Açık, 2018).

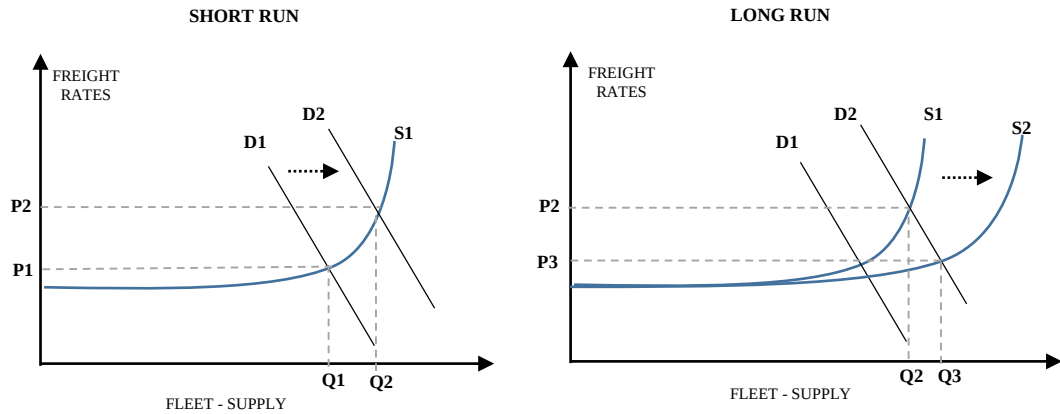
Figure 7: Inelastic Supply of Shipping Services in the Short-Run



2.4.2. Long Run Equilibrium

In the long run, with the introduction of new ships, the supply curve shifts to the right as in Figure 8 and the market returns to new equilibrium in response to the increase in demand. In this case, the new freight balance point is formed at a lower point than the previous level.

Figure 8: Short-Run and Long-Run Equilibrium of Freight rates



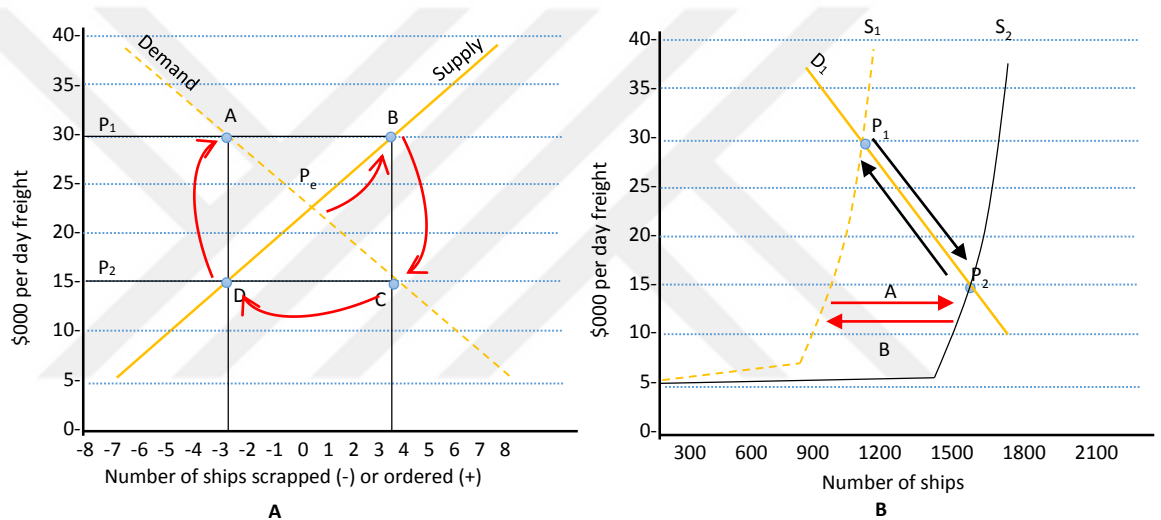
Efes et al. (2019) examined the freight formation mechanism through China, which is one of the biggest economies in the world, and calculated the coefficient equivalents of the balance between supply and demand. In the study examining the effect of China's trade volume as demand side and effect of dry bulk cargo fleet as supply side in dry bulk freight levels, it was found that 1% increase in supply caused 5.18% decrease in freight and 1% increase in demand increased 2.54% in freight. This was interpreted as supply side developments being more effective in the formation of freight rates in the dry bulk market.

2.4.3. Cobweb Approach

Stopford (2009:336) explains the changes in freights and supply in the short and long run through Cobweb theorem. The explanation mechanism of the market by this theorem is presented in Figure 9, where part A shows individual firm behaviors and part B shows market behaviors. Firstly, the analyzes start assuming that the freight rates are at equilibrium at P_e level at any time, since the supply and demand interacts there. When freight increases to P_1 due to any event occurring in the market, ship owners order new ships and try to get more shares from the high level of transport revenue, as an increase in earnings occurs (B). When the ordered new ships enter to the market, freight falls rapidly to P_2 , since there is an excess supply in the carrying capacity (C). In this case, shipowners are obliged to scrape their old and obsolescence ships and a decrease in the carrying capacity occurs (D). Then, as there is a decrease

in supply in the market, freight rates increase back to P_1 level (A). This cycle continues through history, generating cycles of different lengths and sizes. In addition, the movement in the aggregate market, which is formed by the decisions of the individual companies, is shown in the B section of the figure. Similarly, the supply curve shifts to the right and the freight drops from P_1 to P_2 , since an oversupply occurs when newly ordered ships enter the market. In this case, the old and obsolescence ships are sent to the demolition because of the high operational costs, and the supply curve shifts again to the left (S_1), causing an increase in the equilibrium freight rate (P_1).

Figure 9: Cobweb Theorem in Maritime Economics



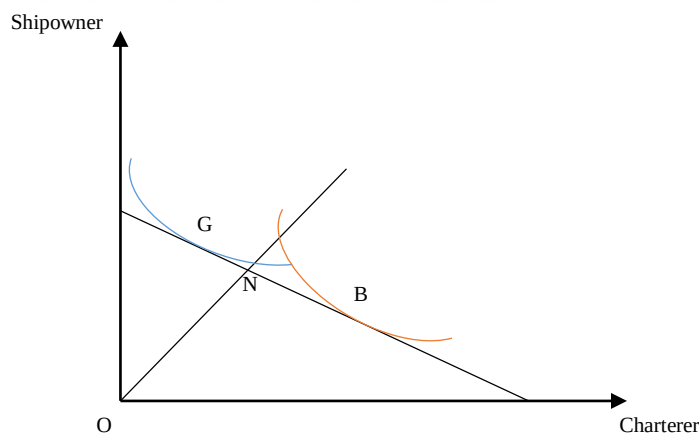
2.4.4. Modern Approach

The modern approach expressed by Karakitsos and Varnavides (2014) also includes the classical supply-demand balance model, but differs in a few points. In this approach, while the cargo owner and the ship owner negotiate for the freight price, the bargaining powers effectively decide whether the price will be above or below the current price. In this case, if the bargaining power of the cargo owner is high, the new price will be below the current price, and if the shipowner's bargaining power is high, the new price will be above the current price. The bargaining power of the cargo owner is mostly high in poor market conditions because there is an abundance of carrying capacity in the market and the ship owner has a hard time finding a cargo. The

bargaining power of the ship owner is often high in strong market conditions because there are many alternative cargoes to carry. In addition, market expectations also play an important role in the formation of bargaining power. For example, if there are signs of economic contraction due to political factors while freight rates are high, bargaining power of cargo owners may increase.

Three possible solutions to this bargaining power mechanism are presented in Figure 10. The letter *G* represents good times for the shipowner, and the letter *B* represents bad times. *N* is the situation in which the bargaining power of both parties is in balance. In this benefit mechanism, the total benefit is fixed and when the benefit of one of the parties increases, the benefit of the other party decreases. At this point, the balance occurs at point *G* when the shipowner's bargaining power is high, and at point *B* when the charterer's bargaining power is high. This mechanism is a static indicator, but it is important to understand the behavior of the negotiations in the overall market. Forcing one of the parties to a different point than these equilibrium points decreases the total benefit and worsens the situation for both parties.

Figure 10: Freight Rates in Different Conditions



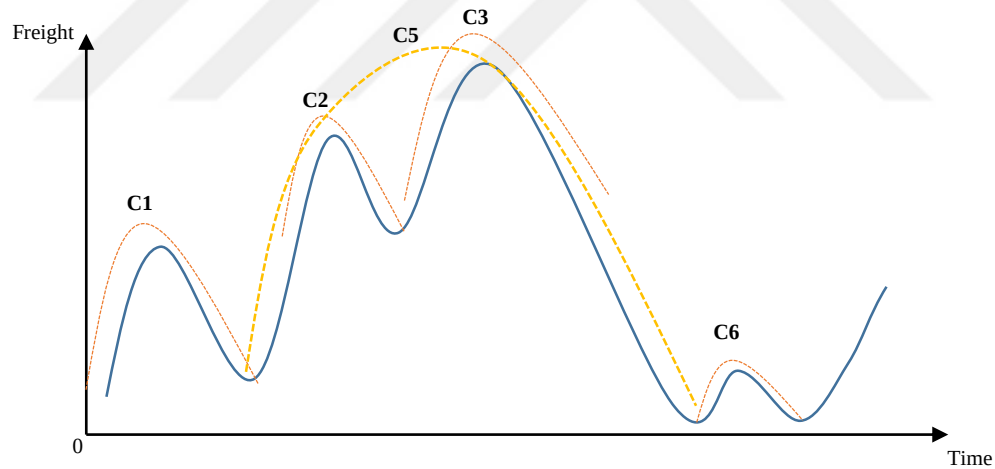
2.4.5. Shipping Cycles

Whether with a classic approach or a modern approach, freight is constantly on the move in the maritime market. These cycles in the maritime market basically derive from imbalances between supply and demand. In addition, as we mentioned before, the changes in the bargaining power of the parties significantly affect the formation of

these equilibrium points. In the maritime market, these cycles continue throughout the history. The cycles are usually random. However, they can also be affected by several deterministic events (Beenstock and Vergottis, 1993:64). Stopford (2007:105) stated that there were 22 cycles between 1741 and 2007, the average duration of these cycles was 10.4 years, the shortest cycle was 3 years and the longest was 15 years.

The cycles formed in the maritime market can be exemplified through Figure 11. Freight rates are affected by many deterministic and stochastic factors and therefore form cycles of different lengths and sizes. These fluctuations may be above a certain high freight level or near the bottom. For instance, C1 and C6 are cycles close to the bottom while C2 and C3 are cycles close to the peak. In addition, large cycles, consisting of a combination of small cycles, can be observed in the maritime markets, such as the large cycle, which is a combination of C2 and C3, denoted by C5 in the figure below.

Figure 11: Freight Cycles



It is vital for the ship owner to continue his commercial activities by foreseeing these fluctuations and developing proactive strategies and positioning himself in the market. However, although these cycles have occurred throughout history, ship owners can repeat their investment mistakes. In some periods, freight rates are incredibly high, and naturally new ship orders and sale and purchase activities increase since the capital income into the company increases (Chisté and Vuuren, 2014). Even ship owners may pay second-hand ships more than value of the new ships in order to increase their

transport capacity immediately. However, after the boom periods when the freight is at the ceiling, most shipowners will ignore the landing process. This situation is expressed by Zanettos (1996) as the *zero-memory* status of the ship owners. This is often caused by ship owners following their own feelings and competitors in the market (Scarsi, 2007). In this respect, while the volatilities and cycles in freights offer great profit opportunities, they can also cause great losses (Alizadeh and Nomikos, 2009:303).

2.5. OTHER MAIN SHIPPING MARKETS

Besides the freight market, there are three other main markets in the maritime markets, which are newbuilding market, sale and purchase market and demolition market (Stopford, 2009:177). While these markets are mainly affected by the freight market, developments in these markets can be reflected in the freight market as well. If we approach the economic life of the ship in a life cycle format, the birth and death of the ships have generated markets that have own characteristics. The new building market has been found by constructing new ships and the demolition market has been formed by dismantling the ships that have come to the end of their economic lives and bringing them back to the economy.

2.5.1. Newbuilding Market

The shipbuilding market is mainly affected by the freight market (Kim and Park, 2007). When the freight rates rise, ship owners order new ships to increase their carrying capacity and to get benefit from the high income opportunities due to the alive market conditions. While these decisions are sometimes made rationally by following the indicators (Beenstock and Vergottis, 1989), sometimes they can be made as a result of a general motivation generated by the market (Greenwood and Hanson, 2014).

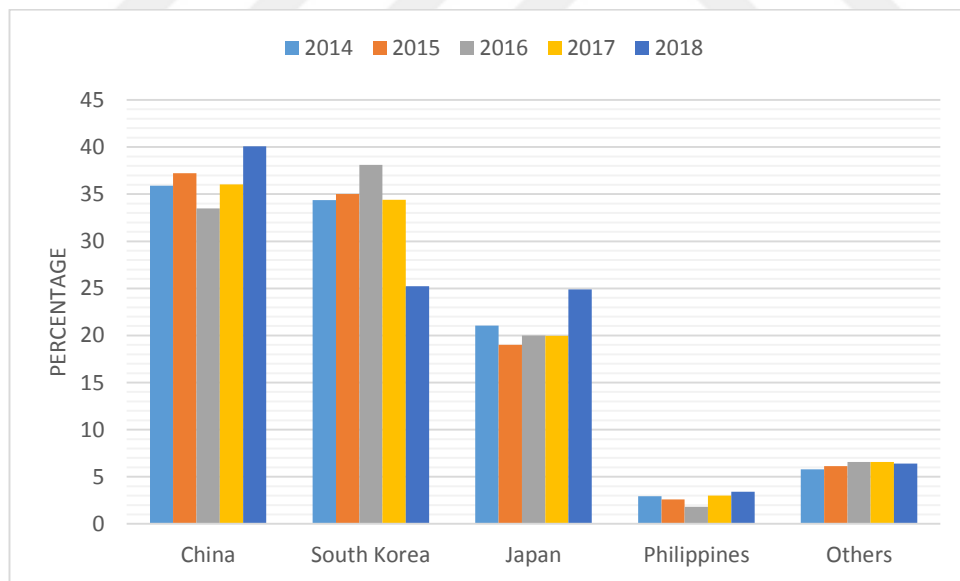
In the new building market, there is a time span between several years of placing and delivering orders. Therefore, uncertainties may arise as to how the market will be when the orders placed under the current conditions are completed (Tsolakis,

2005). This situation causes new building prices to be more stable than second-hand prices.

Based on this research question, we examined the relationship between freights and the tonnage completed and delivered (Başer and Açıık, 2018). In the study, which handled the Baltic Dry Index as an indicator of the general freight level in the maritime market, the delivered tonnage was also considered as data containing all types of ships. The results showed that there is a 2-year lag between the variables, and when this lag is taken into account, there is a positive relationship between them. In other words, increased freight causes an increase in orders and ships ordered according to today's freights enter the market on average 2 years later.

The distribution of the shipbuilding volumes in the world by percentage to major countries is presented in Figure 12. In particular, China and South Korea have huge shares in this market and maintain their shares. In 2018, it can be said that Korea's falling share was evaluated by Japan, and China became the market leader.

Figure 12: Ship Building Statistics in Major Countries



Source: UNCTAD (2020a).

2.5.2. Sale and Purchase Market

The ship sale and purchase market is a more liquid market than the new building market. Since the shipbuilding process takes a certain period of time, it is uncertain what the market will be like when that period ends. Therefore, prices are not very volatile (Adland and Jia, 2015). However, prices can change in a short time as transactions can be carried out instantaneously in the second-hand market. In fact, this situation led to such periods in history that the price of a 5-year-old ship has exceeded the price of the new building one.

Second-hand ship values are mainly affected by the freight market. According to the current freight levels, future freight expectations are shaped and investors decide whether to invest in ships accordingly (Lun and Quaddus, 2008).

Extraordinary gains can be achieved by increasing prices in the second-hand ship market. These increases can be defined as price bubbles as they are temporary, and profits that cannot be achieved with transportation activities can be obtained instantly in these bubble periods. We analyzed the situation through Panamax market in our study based on the research question, how much change in freight will have a bubble effect on the second hand ship price, since second hand ship values are mainly affected by the freight market (Açık and Başer, 2018e). In the study, firstly, price bubbles in ship value were determined by generalized sup augmented Dickey-Fuller (GSADF) method, and then probability calculation was made using Logit model. As a result of the analyzes made by 5-year-old Panamax type ship, it was determined that the increase of 1000 points in the Baltic Panamax Index increased the probability of being a price bubble in the value of second-hand ships by 11%.

Since maritime transport has a derived structure, the demand for the cargo transported may also indirectly affect the value of the ship. It is likely that there is an interaction between the commodity price and the value of the ship, as the demand for the transported cargo affects its price and is affected by this price. Based on this research question, in a study we conducted (Başer and Açık, 2019a), we examined the relationship between the value of 5-year-old Capesize vessel and the price of iron ore, the majority of which was carried by this type of vessel. Considering that approximately 70-80% of the iron ore load in the world is carried by this ship type, it

is likely to have a relationship. According to the results obtained, positive shocks in iron ore price are cause of the positive shocks in ship value, and negative shocks in iron ore price are cause of the negative shocks in ship value.

2.5.3. Demolition Market

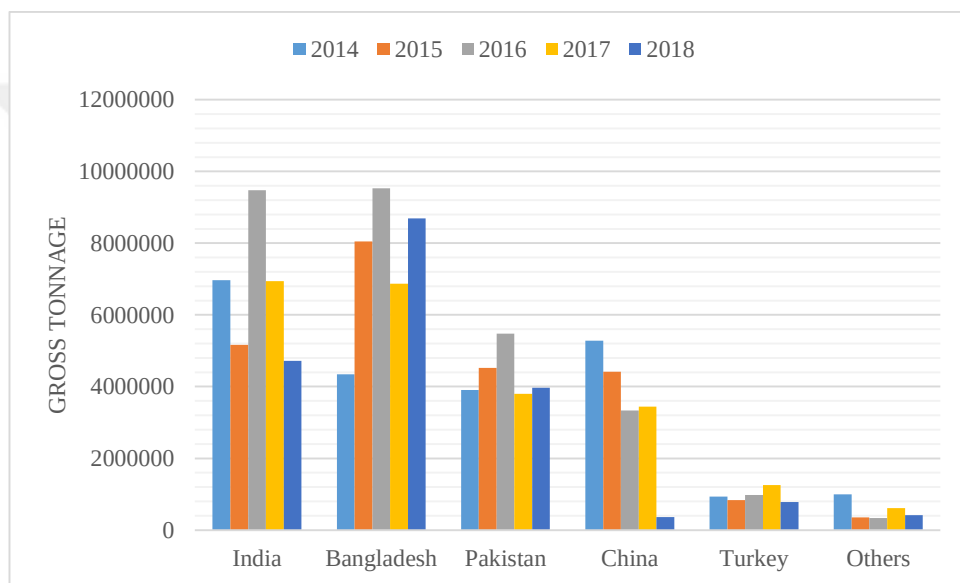
The demolition market is closely related to the freight market. Ship owners begin to order new ships when freight rates start to increase. This situation is based on the current freight conditions as mentioned in the previous sections and the future situation is uncertain. For this reason, an abundance of carrying capacity occurs in the market in the coming period and freights are reduced. As mentioned in the previous sections, each ship has its own cost structure and this structure is affected by some factors, causing different levels of transportation cost. While some ships require high freight to maintain their operational activities, even low freight may be sufficient for some ships. This enables new vessels with low operational costs to keep them on the market, while causing old vessels to become unemployed. Older ships have to be sent for demolition, and the drop in carrying capacity results in the upward movement of freights (Buxton, 1991). Therefore, the ship dismantling market plays an important role in balancing the market (Jugović et al., 2015). Based on this situation, we tested the relationship between freights and the amount of ships going to demolition (Açık and Başer, 2017). In the study where Baltic Dry Index was used as an indicator of freights, we found a negative relationship between freights and the amount of ships going to demolition. The 1% change in freight causes a 0.77% change in the amount and the relationship is negative as required by the theory.

Since the demolition market is very much related to the freight market, there is no specific age for ship to be sent to the demolition (Evans, 1989). This is related to the current freight level and the freight revenue expected to earn in the remainder of the technical life of the ship (Stranden, 2010), as in the new construction market. Another factor that affects the ship's demolition is the scrap price recommended by the demolition yards (Allum, 2013:131). These prices are directly related to steel prices (Tunç and Açık, 2019) and freight rates in the market (Açık and Başer, 2018c). Also,

since the number of countries trading in this market is very low, pricing strategies follow each other (Açık and Başer, 2019b).

Ship demolition market is mainly concentrated in a few countries and the common feature of these countries is that they are developing countries. Statistics on the years of these countries are presented in Figure 13. Until recently, the main countries in the demolition were Bangladesh, India, Pakistan, China and Turkey, however China has begun to withdraw from the market as seen from the figure.

Figure 13: Ship Demolition Statistics in Major Countries



Source: UNCTAD (2020b).

2.6. COMMODITY PRICE FORMATION

Although commodity prices are affected by the global economy, they also have an impressive function in the economy. Commodity prices affect input costs in industrial economies, while in countries focused on commodity export, they affect export revenues as well (Cashin et al., 1999:39). Since commodities are used as inputs in many production activities (Chevallier and Ielpo, 2013:320), they can affect the general levels of prices. This significance was examined by Ciner (2011) through the commodity futures price index. The components of the index are energy (39%), agriculture (41%), precious metals (7%) and base/industrial metals (13%). According

to the results obtained from the question of whether the change in commodity prices affects inflation, there is a long-run causality relationship from commodity prices to inflation.

Another impact of the commodity price is related to the income in the countries that export extensively the related commodity. A decrease in the real value of the commodity exported may cause a serious decline in the international purchasing power of the country's national production basket. It can also have serious effects on that country's balance of payments and the government budget. This volatility may even generate significant effects in producer surpluses, consumption trends and the government's financial position (Cashin et al., 1999:28). Such countries may experience a large degree of macroeconomic instability when exposed to a high degree of commodity price volatility (Cavalcanti et al., 2012:4).

Commodity prices may vary depending on the market to which they belong. However, they basically have similar mechanisms. In this regard, this section primarily introduces price mechanisms in the short and long term. Then, iron ore, coal and wheat markets used in the study are mentioned.

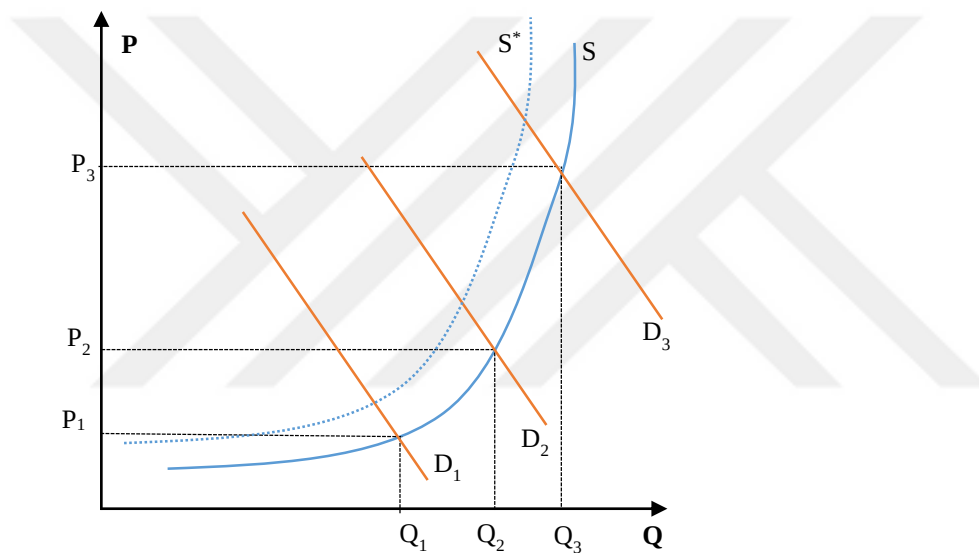
2.6.1. In the Short Run

The mechanism of commodity prices in the short run is similar to the behavior of the freight market in the short run, which we mentioned earlier, since capacity increase could not be achieved instantly.

Equilibrium is at P_1 in the short run. Since the production capacity is given in the short run, the supply curve on the graph can be thought to represent variable cost levels, which can change according to the production levels. The production costs may differ for each company, and the factors that determine this difference generally arise from advantages stem from natural location or resources, managerial efficiency, and differences in cost structures. When the equilibrium point is P_1 , for some reason, the demand can shift to the right and move from D_1 to D_2 . The reasons for this shift may be economic growth, a seasonal increase in business cycles, rational or irrational expectations, or increased demand for speculative purposes in order to increase the prices. For whatever the reason, prices increase to P_2 , as this increase in demand

requires more workforce and means of production in production units (Radetzki, 2008:57). The increase in prices may be caused not only by changes in the demand direction, but also by temporary shifts in supply to the left, which occur at times when the available supply capacity cannot be used effectively due to several reasons. For instance, a harmful insect for agricultural products or loss of production due to climatic factors; a strike or an accident in the field or mineral processing unit for industrial products may cause temporary shrinkage in production. These events cause the supply curve to move to S^* , which consequently results in increase in the equilibrium price.

Figure 14: Short-Run Price Mechanism



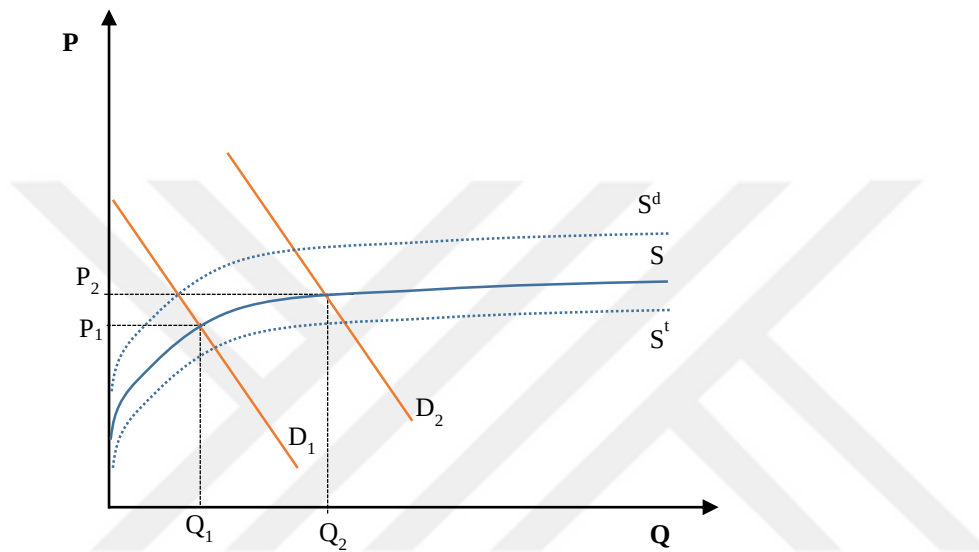
The supply curve is relatively flat at points where capacity utilization is low. The response of price to demand increases in these areas is relatively low. However, when the increase in demand reaches a certain point, that is where the capacity utilization is high, small changes in demand can cause huge fluctuations in prices. Because in this case, it is not possible to meet the demand by increasing the production output.

2.6.2. In the Long Run

Figure 15 includes the long-term price mechanism. The supply curve in this graph can also be interpreted as the average total cost of marginal units. As this is a long-run analysis, production capacities can vary here. The low price at the beginning

of the chart is due to the prices of the resources that can be obtained at a cheap cost. The curve then increases to a certain extent, as the costs of obtaining commodities increase. The reason why the curve continues straight is that the products are abundant as the high acquisition costs of commodities at a certain high price can be met, which means that they become economically exploitable (Radetzki, 2008:59).

Figure 15: Long-Run Price Mechanism



The supply curve may shift upwards due to the increasing demand in the long run, because marginal production costs may increase. In this case, the supply curve is in the S^d position. On the other hand, as technology improves, production costs can be reduced. In this case, the supply curve shifts down to the S^t position. However, in the long run, these two factors cancel each other out, and the supply curve tends to remain the same in the long run.

2.6.3. Commodity Price Fluctuations

The fluctuations in the supply and demand sides of the commodity price may be reflected in the prices and cause intense fluctuations. When it comes to commodity, its demands depend on the demands of the final products, as the raw materials used in the production of other finished goods are in question, and the increase in the demand for the final products is also reflected in the demand for the raw materials. Since the

production processes have different dimensions and each stage adjusts its own inventory levels, the demand for raw materials after the inventory planning from the finished product can go up to several times the demand for the finished product. A similar situation occurs when the demand for the finished product decreases and the demand for the commodity may decrease exponentially (Radetzki, 2008:65). Additionally, as we mentioned in the previous sections, short-term demand fluctuations due to relatively constant supply capacity can be very effective in commodity price fluctuations. These fluctuations may be attributed to global demand (Sevensson, 2008), interest rates (Frankel, 2008), oil prices (Vensteenkiste, 200) and industrial production (Lombardi, et al., 2010) in the related literature.

In addition, the effect of fluctuations in commodity prices may differ according to profiles of the countries. While these fluctuations cause volatility in the incomes of the countries that intensively export commodities, they may cause inflationary effects in developed countries, which are intensively commodity consumers (Labys, 2006:15). In this respect, preventing fluctuations is of great importance for the macroeconomic stability of the countries.

2.6.3. Iron Ore

There are different opinions about the structure of the iron ore market in several books. According to one source, iron ore market can be defined as a perfect competitive market since there are many sellers, products are homogenous and there are no barriers to entry (King, 2012:130). However, in another sources it 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). In addition, the contents and quality of the products are partially different, so it can be said to be close to homogeneity.

Since iron and steel industry, as one of the most important of the heavy industry, provides raw materials to the indispensable sectors in daily life such as construction, infrastructure, automotive, white goods and machinery industries (Çelikdemir et al., 2018:82), volatility in prices is also reflected in daily life and can significantly affect social welfare.

While iron ore prices have a significant impact on the income of the countries exporting them, it also has an important place in the profitability of the countries that process this raw material and produce steel. As we have mentioned in price mechanisms, when the demand increases in the iron ore market, prices can increase at a very high rate since production can be increased to a certain extent. The steel industry, on the other hand, may have more production activity in response to demand. The main source of this is that the price elasticities of iron ore and steel products are different. This leads to significant fluctuations in the profitability of steel exporting countries, as China has experienced (Hurst, 2016). Even, positive shocks in prices of iron ore may have negative effects on regional production output and employment levels in countries such as China, which have an industry intensive large economic structure (Wang et al., 2007).

2.6.4. Coal

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).

Although coal prices are commonly considered only as average contract and spot prices, cost mechanisms operate below these prices. Therefore, prices vary according to mining costs, coal quality and transportation cost (Murray, 2018). It can even be said that the most important factor is the quality of coal (National Research Council, 2007:61). For example, since some coal mines can be far from the ports, total costs may increase and profitability may decrease.

Coal, which is one of the main energy sources, can also have a huge impact on the economies of countries with high consumption. For instance, in the China, which is the leading coal consumer according to the Enerdata (2020), the inflationary effect of changes in coal prices in the economics of the country examined through GDP deflator, Consumer Price Index (CPI) and Producer Price Index (PPI) variables by Chen (2014). According to the results, it was determined that 5% of the GDP deflator and CPI, and 25% of PPI are due to changes in coal price., Asymmetric effect of coal price of inflation was investigated in a further study including the same researcher

(Guo et al., 2016). They examined the research question similar to the previous study from a different perspective and found that the PPI variable is more sensitive to shocks in coal price than the CPI variable. Considering that coal is mostly used in industrial production and energy production activities, this effect is inevitable. In fact, it is thought that this situation may cause problems in coal supply for countries such as China in the future considering the increasing consumption trend for their production activities (Wang et al., 2013).

2.6.5. Wheat

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).

The most important factor affecting the wheat market is seasonality since this commodity is most affected by climatic conditions. In this respect, it can be defined as the regular movement of seasonal price movements in wheat prices throughout the year. Considering the seasonality, it can be said that the prices are depressed due to the abundance of commodity at harvest time, and at other times the prices are inflated as the supply of wheat relatively narrows (Kherallah et al., 2000:69). In an additional study (Algieri, 2014), the factors affecting wheat price were expanded as speculation in futures markets, macroeconomic conditions, market-related indicators, and weather conditions. Also in this study, it is emphasized that oil price is one of the main determinants for wheat price, since it directly affects the production costs.

Studies stating that agricultural products are closely related to oil prices indicate that this relationship is due to two possible factors; (i) use of bio fuel, (ii) production cost. Especially, bio fuel production has started to increase recently in the world with increasing energy prices (Lichtfouse et al., 2011:453). In his study, Nazlıoğlu et al. (2013) examines the volatility spillover between global agricultural commodity prices, which are corn, soybeans, wheat and sugar, and oil prices. In their study, the authors analyzed the period between January 1986 and March 2011 and divided the sample from January 2006, when the global food price crisis was experienced, and examined the relations before and after the crisis. As a result of the

analysis carried out by using the causality in variance test, they could not detect any significant spillover in the pre-crisis period, while they found significant causal relationships from oil price to corn, soybean and wheat prices in the post-crisis period. This interaction was also verified by Alghalith (2010) and Alom et al. (2011).

In this context, the effect of oil prices on wheat prices can be expressed in two ways. Firstly, when the price of oil increases, the demand for wheat increases due to the production of bio fuel, which can be defined as an alternative energy source, and the prices of wheat may also move upwards. Secondly, since oil is an important cost input in agricultural activities, increases in its price may increase the cost of wheat production and cause an increase in the final price.

2.7. COMMODITY PRICE AND MARITIME FREIGHT MARKET

As the changes in commodity prices affect the demand for them and the sea transportation is used extensively in commodity transportation, it is inevitable to have a relationship between commodity prices and maritime markets. This idea formed the research question in the work of many academics. Although the data sets, methods, and time intervals differ, they are basically based on this idea. Studies examining these relationships in the maritime literature are summarized in Table 5 presented below. In the next sections, the mentioned studies are examined in details in order to placed our study in the related literature.

Table 5: Commodity Price Related Studies in the Maritime Literature

Authors	Title	Research Question	Method	Findings
Kavussanos et al., 2010	Information linkages between Panamax freight derivatives and commodity derivatives markets	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	Economic spillovers between related derivatives markets: The case of commodity and freight markets	Whether there are economic spillovers between the freight and commodity	Co-integration, GARCH Models	Commodity futures lead the FFAs in both in returns and volatilities.

		derivatives markets.		
Chou et al., 2015	An analysis of the relationship between Asian Steel Index and the Baltic Capsize Index	Whether there is a causal relationship between Baltic Capsize 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	The dynamic relationship between freight markets and commodity prices revealed	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	An analytical study on the likely causes of the minor bubbles in the Baltic dry index.	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	The Effects of Fast Decline in Crude Oil Prices on the Tanker Market in The Short Run	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	Do commodity price shocks matter for dry bulk freight markets?	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, 2019a	Impact of Commodity Price on Freight Market Considering The 2008 Crisis: An Investigation of Iron Ore Price and Capesize Shipping Rates	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, 2019a	Do Commodity Prices Matter for Second Hand Values? An Empirical Research on Capesize Market	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	Asymmetric causality from commodity prices to shipping markets: an empirical research on Istfix region	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	Commodity and transportation economic market interactions revisited: New evidence from a dynamic factor model	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.

These studies in the literature can be categorized as follows; reviewing the relationship between commodity and freight prices; reviewing the relationship between commodity and freight derivative markets; reviewing the relationship between commodity price and second-hand ship value; and other commodity-related studies. In general, when the studies between commodity prices and maritime markets are analyzed, it is seen that significant results were obtained even though there is not a rich literature on this subject.

2.7.1. Commodity and Freight Markets

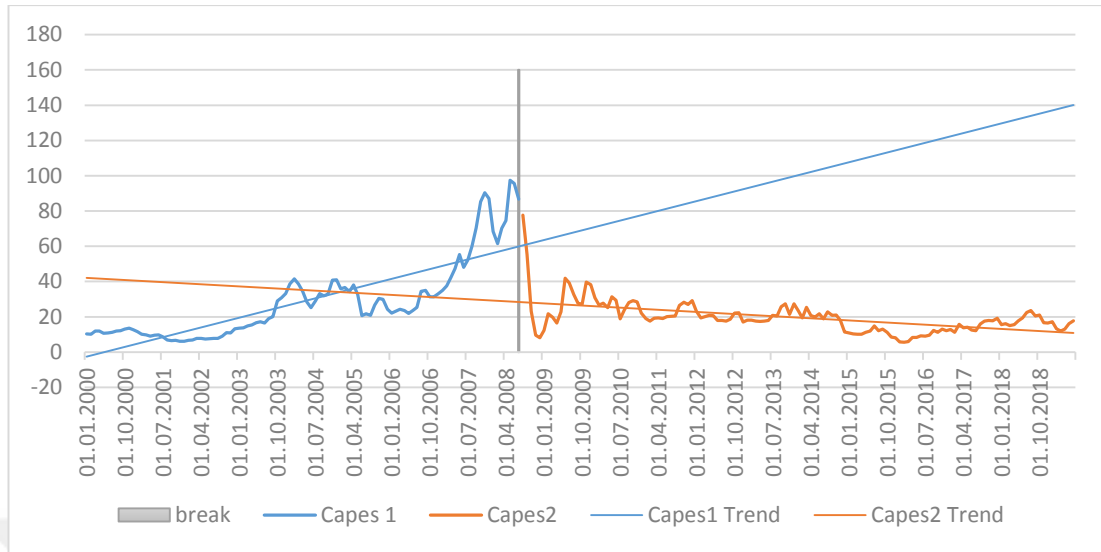
Almost all of the cargoes carried by dry bulk transportation are industrial products and they are used as raw materials in order to produce several materials. As mentioned earlier, some ships are specialized in the transportation of some cargoes. Capesize ships are among these types of ships, approximately 70-80% of the iron ore transported in the world is carried by Capesize ships. A large part of the iron ore transported is also used in steel manufacturing. It is therefore likely that there is an interaction between steel prices and Capesize freights. Based on this research question, the relationship between Baltic Capesize Index (BCI) and Asian Steel Index (ASI) was tested in a study conducted by Chou et al. (2015). The authors used weekly dataset covering the periods from July 2007 to December 2011, and employed VARMA method. As a result of the research, it was concluded that the ASI variable is 2 periods ahead of the BCI variable and thus the BCI variable is the leading indicator for the ASI variable. In this case, it can be said that shipping costs are an important factor in indirectly determining commodity demand by affecting the final steel prices.

Dry bulk transportation is used for the transportation of many cargoes, but the transportation rates of some cargoes are quite high compared to other cargoes. Therefore, this cargo group is defined by many researchers as major bulks. In this context, based on the idea that the changes in the prices of these main cargoes have an effect on the freight level of types of ships they are transported, Tsioumas and Papadimitriou (2018) examined the relationship between commodity and freight levels of the vessels that correspond to mostly used in the transport of this commodity. The

authors used Baltic Capesize Index (BCI) and the Baltic Panamax Index (BPI) as the representatives of the freight levels, and employed Granger causality and co-integration methods. The authors found a bidirectional causality relationship between the BCI index and iron ore and coal prices. It also identified a one-way causality relationship between wheat and BPI, from commodity to freight. The author states that sudden increases in commodity prices may throw freight for a short period of time, but high commodity prices may adversely affect trade in the long run.

In another study, Aık and Bařer (2019a) examined the relationship between commodity prices and freight rate by considering the possible impact of the 2008 crisis. In addition to the contraction in demand in these years, new ship orders, which had increased excessively, were also effective in the crisis of dry bulk shipping. Since the freight revenues had reached incredible levels, the lag in ship delivery due to the construction process (Bařer and Aık, 2018) has led to an uncontrollable supply side increase. In this respect, the study was conducted to examine whether the effect of commodity prices on the freight market differed before and after the 2008 crisis. 233 monthly observations covering the period between January 2000 and June 2019 were used and asymmetric causality analyses were applied. Freight rate is represented by price of transport per tonne from Tubarau (Brazil) to Qingdao (China) via Capesize vessel and Iron ore price is represented by the general price published by Worldbank. A significant break in level and trend was detected in July 2008 by unit root tests with single structural break (Zivot and Andrews, 1992; Lee and Strazicich, 2013), and the sample was divided into pre-crisis and post crisis periods. The difference in the trend of the divided sample was presented visually in Figure 16. There was an increasing trend before the crisis and a decreasing trend after the crisis.

Figure 16: Break Date and Trends of Different Periods



In the pre-crisis period, it was determined that positive shocks in the iron ore prices are the causes of positive shocks in the freight rates. In post-crisis period negative shocks in the ore prices were found to be the causes of the negative shocks in the freight rates, and negative shocks were found to be the causes of the positive shocks. The findings of the study revealed that the impact of commodity prices on the Capesize freight market may change before and after the crisis.

A study conducted by Aık and İnce (2019) examined the relationship between the freight rates of the three major ship types in the bulk market and the prices of the three major bulk cargoes. These three types of ships consist of Capesize, Panamax and Handymax vessels, while the three main cargo types are Iron ore, coal and wheat. The dataset used consisted of monthly observations and covered the period between July 1999 and May 2018 for Capesize and Panamax markets, and August 2005 and May 2018 for Handymax market. Baltic Capesize Index (BCI), Baltic Panamax Index (BPI) and Baltic Handymax Index (BHI) were used to represent the freight markets for each type of vessels. After determining nonlinear structures in variables, asymmetric causality tests developed by (Hatemi-J, 2012) were applied to all markets and some significant causal relationships were determined.

Firstly, when the results obtained for Capesize market were examined, significant causal relationships were determined from iron ore and wheat prices. Both positive and negative shocks in iron ore prices were identified as the cause of negative

shocks in Capesize freight levels. The authors revealed that negative to negative shocks may be explained by the decrease in the demand of iron ore, which consequently causes a decrease in its price as well. As the demand for maritime transport has a derived demand structure, the demand for Capesize ships reduce and hence the freight rates fall. The authors explained positive to negative shocks by non-demand driven movements in iron ore prices. Increase in the iron ore prices may be caused by trade policies of the producer countries since there are few suppliers in the world. This may have a negative impact on freight rates by negatively affecting the demand for ore. However, the authors stated that this situation needs empirical testing. On the other hand, a significant causality relation was determined from the wheat which is not generally preferred to be transported by Capesize vessel type. According to Meersman et al. (2014), only 0%-5% of the wheat cargo is transported by Capesize vessels in the world. Negative shocks in wheat prices were the causes of negative shocks in Capesize freight rates. The authors explained this as decrease in wheat price may be caused by the decrease for this commodity, and available tonnage for wheat transport consisted of other types of vessel may enter the Capesize market and cause an over-supply in the market. As the other types of vessels are common to Capesize cargoes, freight rates for Capes may be negatively affected.

For the Panamax market, the causal impact of iron ore price was similar to the Capesize case, and the mechanism can be interpreted in the same way. When the effect of wheat price is analyzed, unlike in Capes, positive shocks in wheat price have a positive effect on Panamax freight rates. The authors argued that demand-driven price increases in the wheat may positively affect the Panamax freight market since this increase may reflect the increase in demand for transportation activities. Lastly, according to the results of the Handymax market, there were significant causalities from iron ore and coal prices. The negative shock in iron ore price is the cause of negative shocks in the freight market. This may be attributed to demand-driven price decline in iron ore prices, as is the case in all other vessel types. While there was no causal impact from wheat price to the market, the only significant causality from coal price was included in the Handymax market. The positive shocks were causes of the negative shocks, and the negative shocks were the causes of positive shocks. The authors found this situation to be difficult to explain by demand-driven arguments. The

situation was explained by the economies of scale which was related to transport cost per unit. An increase in coal price may trigger to search for cheaper sources at the longer distances, therefore larger vessels may be used for obtaining these sources thanks to the lower transport costs per units. Demand for Handymax vessels may be negatively affected by this situation, which may consequently cause fall in freight rates in the market. In case of a decrease in the coal price, the opposite scenario may occur and demand for vessels may increase. In the general perspective, it was concluded that the effects of commodity prices vary according to the type of commodity and the ship market.

There are also indices used for the freight levels of the ships carrying out their commercial activities in relatively narrow regions as well as indices formed by large markets. One of them is ISTFIX index which is an important indicator of the freight levels around Turkey and is used to track freight flows in the Black Sea and Mediterranean regions (Ünal and Köseoğlu, 2014). Although the market is relatively small, it is likely that there will be an interaction between the prices of the cargo transported in the region and the freight levels. Based on this research question, we tested the effects of the prices of coal, steel and wheat, which are mostly transported in the region, on the freight rates through implementing unidirectional asymmetric causality test (Açık and Başer, 2020). 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. The results obtained are interpreted similarly for steel and coal; Increasing commodity prices in line with rising demand also increases the demand for sea transportation, causing an increase in freight and vice versa. For wheat, it can be considered as a negative reflection of increasing prices, possibly due to supply cuts, to the demand for wheat and therefore to sea transportation. It can be said that the decreasing prices were realized due to the excess supply and thus the increase in the freight rates by increasing the demand for sea transportation. Unlike other commodities, the fact that the wheat is open to such unplanned irregularities with its climate-affected structure may support such findings.

In terms of information flow between commodity prices and freights, a study similar to our thesis was done by Angelopoulos et al. (2020). In their study, researchers studied the information pass-through between commodity prices and corresponding dry bulk and tanker freights. They used Time-Charter Equivalent versions of Baltic Capesize Index, Baltic Panamax Index, Baltic Supramax Index, Baltic Handysize Index and the Baltic Dry Index (BDI) as representatives of the dry bulk freight rates. As a result of the research, they found that commodity prices significantly affect the freight rates, but the interaction varies according to the dry bulk and tanker market. 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. They also found that the price discovery mechanism is not only between the commodity and freight markets, but also among the sub components of the maritime markets. In terms of dry bulk cargo, in general, they found that commodity prices are informationally leading to freight rates.

When the studies examining the relationship between commodity prices and freights are examined, there are studies that determine significant relationships both from commodity price to freights and from freight to commodity prices. These relationships may differ according to the method, commodity type and ship type.

2.7.2. Commodity and Freight Derivative Markets

In maritime markets, some markets are derived from the main markets in order to meet the demand. These markets were developed by stakeholders to enable commercial activities to be maintained in an easier way. One of these is derivative markets, which are derived from freight markets. A derivative contract is the decision of a freight rate for the future with the agreement of the two parties. Thus, the risks caused by large fluctuations in the freights are reduced (Stopford, 2009:193). This is because it is very difficult to predict as freight markets can be affected by many factors. The future price may of course also deviate in favor of the shipowner or cargo owner. Of course, as in the freight markets, there are derivative markets in commodity prices and future prices are traded. In this context, it is likely that there is a flow of information between both the freight and commodity derivative markets. Based on this

research question, Kavussanos et al. (2010) examined the information flow between Panamax derivative markets and commodity derivatives markets. The commodity derivatives examined in the study consist of grain, iron ore, coal, bauxite, sulphur. In their analysis, researchers used GARCH, co-integration, VECM and Granger causality analysis. As a result of their research, the authors concluded that the grain futures markets are an important indicator for freight future markets. These findings are important to reduce investors' risks of uncertainty in a risky market such as maritime. In another study, Kavussanos et al. (2014) expanded the subject a little more and made it cover the Capesize, Panamax and Supramax markets, and the included commodity futures in the market were coal, corn, wheat and soybeans. As a result of the study, it was concluded that the commodity derivative markets in general are the pioneers in terms of return and volatility to the freight derivative markets. Considering the returns, the spillover from commodities to freights was determined for the Panamax and Supramax markets. However, no significant spillover was identified for the Capesize and coal derivative markets. These results indicate that there is a general flow of information from the commodity derivative markets to the freight derivative markets.

2.7.3. Commodity and Secondhand Markets

The effect of commodity prices on the freight market is crystal clear with the studies we have mentioned. This effect can be thought of as a direct effect. On the other hand, it is also likely that commodity prices will have an impact on other maritime markets as well. Based on this research question, the effect of commodity prices on the ship sale and purchase market, which is the most active market after the freight market, was examined in a study by Başer and Açıık (2019a). The study examined the effect of iron ore price, which is the type of cargo most commonly carried by Capesize type vessels, on the values of 5-year-old Capesize vessels. 227 monthly observations covering the dates between July 1999 and May 2018 were used and asymmetric causality analysis was applied in the study. The results revealed that positive shocks in iron ore price are the cause of positive shocks and the negative shocks in the iron ore price are the cause of negative shocks in the value of 5-year-old vessel. This situation has been evaluated in two ways; first, when demand for

commodities increases, freight rates increase as the demand for transport increases, and the value of their assets increases since this leads to an increase in future income levels for ship owners. Second, since iron ore is the raw material of steel, the increase in its price has led to an increase in shipbuilding costs, and the rise in second-hand ship prices has also occurred. The first one was described as a Demand-driven effect and the second one as a Cost-driven effect by the authors.

2.7.4. Other Commodity Related Studies

In a study carried out in order to determine the price bubbles in dry bulk freight market through Baltic Dry Index and possible factors causing these price bubbles, we determined several events causing small deviations from the actual price and categorized these events into the factors (Açık and Başer, 2018a). Firstly, price bubbles were determined by generalized sup augmented Dickey-Fuller (GSADF) test using 1550 daily data covering January 2012 and May 2018 period. The presence of 8 price bubbles in different specifications was revealed. Then, the maritime market reports which correspond to these bubble periods were examined and the events that occurred in those periods were investigated. As a conclusion of the study, the events were categorized to eight factors which are climatic factors, cultural factors, political factors, voyage factors, operational factors, production factors, adjacent market factors and sentiment factors. Contents of the factors can be exemplified as changes in sail routes due to storm, unavailability of service in ports due to cultural holiday holidays, trade embargoes among countries, long-distance charter contracts, miners' production increase decisions, cargo shift among different ship types and ship owners' positive atmospheres about the market.

We studied the effect of commodity prices on the maritime freight markets in the short run through oil price and tanker market as a thesis (Açık, 2016) and then as an article (Açık and Başer, 2018b). The main focus of the study was to examine the impact of the oil price, which was \$ 120 at the beginning of 2013 and decreased to \$ 27 in 2016, on the four-tanker market. The main hypothesis of the research is that falling oil prices increase the demand for oil, and this decrease positively affect the tanker transportation in short run due to the derived demand structure of the market.

In the short run, ship production lasts between 1-3 years, therefore a period of 3 years was taken for the analysis. Due to this time-demanding nature of ship building, its supply has an inelastic structure in the short run. This structure can cause huge fluctuations in the market, and sudden increases in demand can lead to sudden increases in freight and therefore in the remaining maritime markets. In the study, based on the correlation analysis, significant correlations were found between five maritime markets and crude oil prices. Accordingly, freight rates (Time Charter Rates), new building prices, second hand ship values and tanker companies' share values have a negative correlation with oil prices, while demolition prices have a positive correlation.

2.8. COMMODITY PRICE AND FREIGHT EVALUATIONS IN THE SECTOR REPORTS

After mentioning the studies showing the relationship between commodity price and freight market in the literature, weekly market reports are analyzed to examine how commodity prices are evaluated in the sector. The source referenced is free weekly market reports from Fearnleys (2019). It is one of the leading broker companies in the world and dates back to the 1860s. In that year, the company was founded by Thomas Fearnley (1841-1927) as a shipping and agency business in Oslo.

Market reports published by Fearnleys (2019) cover the period 23 February 2005 to 13 November 2019 and consist of a 752-week market summary report. The report provides summary information about the freight market, the new construction market, the sale and purchase market and the bunker market from the eyes of ship brokers. The freight market is handled as tanker, dry bulk, LPG and LNG markets.

The findings related commodity prices obtained from the investigation of the reports are presented in Table 6. These findings are obtained by scanning and deducing the commodity and its price related sections in all these 752 weekly reports. According to the findings, generally 4 types of situations occurred in the market; (i) the increase in commodity demand led to increase in both commodity prices and transport demand, which result in rise in the freight rates; (ii) The increase in commodity prices has driven

manufacturers to produce more, leading to an increase in demand for transport and freight rates; (iii) the decline in demand for commodity has caused a decline in both commodity prices and demand for transport negatively affecting the freight rates; (iv) The decline in commodity prices has negatively affected producers' production motivation, leading to a decline in both transport demand and freight rate.

Table 6: Commodity Related Events in the Reports

Time	Content	Inference
2009a	"Expectations of increased demand of i.ore and higher ore prices have increased the rates."	Commodity demand increase, high ore prices => Increase in rates
2009b	"Grain prices at the moment are not so price sensitive as i.ore and coal. Buyers are holding back and not yet prepared to pay or even give a price for minerals, demand from China is decreasing which might be a sign of a short-lived upturn."	Commodity demand decrease => Decrease in rates
2011a	"There is some speculation that the increase in the Pacific activity we have seen is on the back of an increase in the iron ore prices, which have fallen considerably in recent months."	Commodity price increase => Increase in rates
2011b	"However, iron ore prices are dropping and rates may be expected to drop further."	Commodity price decrease => Decrease in rates
2012a	"The levels that did fix are down w-o-w levels. C5 continued to slide, due to a very slow iron ore market, believe the lowest level iron ore cargo fixed at USD 6.75 pmt and coal prices are also dropping slowing the coal market with limited activity from Chinese importers."	Commodity price decrease => Decrease in rates
2013a	"At present it appears that Chinese seasonal re-stocking activities will continue to absorb the growing spot iron ore supply, at least in the short term. This, combined with a relatively stable iron ore price, are good short term indicators for the Cape market."	Commodity demand increase => Increase in rates
2013b	"The fronthaul market continues to be actively fixed, with the C3 index Tubarao/Qingdao now marked at USD 20 PMT. West Australia holds steady at USD 7.75 PMT - however in general, time charter rates in the Pacific have come off, due to a squeeze on the current coal prices."	Commodity price decrease => Decrease in rates
2013c	"However, with the iron ore price holding firm at \$132 PMT, many are of the opinion that market fundamentals remain positive and there is still more Chinese restocking activity to come."	Commodity demand increase, high iron ore prices => Increase in rates
2015a	"The sentiment is bearish with falling demand and prices on coal and i.ore."	Commodity demand decrease, commodity price decrease => Decrease in rates
2015b	"One the demand side there are a number of minor miners, who are struggling or have already halted operations, due to the low ore price, and the Majors will easily be able to pick up the slack if these volumes need to be moved at all."	Production decrease, low iron ore prices
2016a	"Increased iron ore prices created a positive sentiment across the market beginning of the week."	High iron ore prices => Increase in rates

2017a	“The Brazil market have gone very quiet, and fronthaul rates have dropped from around mid to low 20k level on tct. It has been some problems at some loading ports, combined with dropping iron ore prices.”	Commodity price decrease => Decrease in rates
2017b	“The long-anticipated boost in the Cape market did arrive this week. Increased Chinese steel prices have pushed iron ore prices and demand up.”	Commodity demand increase, high iron ore prices => Increase in rates
2019a	“The Capesizes are experiencing a rally this week, supported by a range of factors but increased iron ore prices being the main driver as iron ore prices have reached its highest value since 2013.”	High iron ore prices => Increase in rates
2019b	“Fundamentals for the big ships remain robust, with all major miners back on stage, enjoying historically high iron ore prices and pushing out as much volume as possible.”	Production increase, high iron ore price => Increase in rates
2019c	“Vale is back in the market, and a strong iron ore price combined with high Chinese demand is giving rates a solid push.”	Commodity demand increase, high iron ore price => Increase in rates
2019d	“whilst iron ore prices are up and all major miners needing/taking prompt units.”	High iron ore price => Increase in rates

As a result of the report reviews, the relations with the neighboring market have also been identified and are presented in Table 7 to address the above-mentioned adjacent market effect. The results of this review indicate that all of the interactions are between the Capesize and Panamax markets, and three cases are often observed; (i) Excessive demand in the Capesize market leads to an increase in Panamax freights as it increases demand by transferring Cape-splits to Panamax vessels; (ii) The abundance of Cape-splits has caused ship shortages in the Panamax market, which consequently causes freights increase in the market; (iii) When the amount of Cape-splits decreases, freight rates in the Panamax market also decrease since demand for Panamax-type vessels decreases. What is more often emphasized in the reports is the positive reflection of the neighborhood effect to Panamax market.

Table 7: Adjacent Market Events in the Reports

Time	Content	Inference
2007w	“Cape- split cargoes from Brazil made the rates for trip out increase strongly.”	Cape-split => Increase in Panamax rates
2007x	“Especially Atlantic has been strong, lack of tonnage and increased grain cargoes from Brazil, combined with iron ore Cape splits has made it difficult to find tonnage able to make loading within first half March within this area.”	Cape-split, Increase in Grain Shipments => Increase in Panamax rates

2007y	“Market heading north and chrs considering splitting cargoes into Panamax bottoms as tonnage is tight in all areas.”	Cape-split, Tonnage Scarce=> Increase in Panamax rates
2007z	“With an extremely strong Cape market it was worthwhile once again to split the Cape cargos, which gave the Panamax market a good push.”	Cape-split=> Increase in Panamax rates
2009w	“With the Cape market increasing rapidly, some charterers were willing to split the cargoes into Pmax stems, which were already in a tight squeeze for tonnage in N.Atlantic.”	Cape-split, Tonnage Scarce=> Increase in Panamax rates
2009x	“The Cape splits were also seen in the Pacific, which boosted the Pmax rates from usd 19,000 last week to usd 25,000.”	Cape-split=> Increase in Panamax rates
2009y	“The market primarily driven by the increased Cape rates resulting in Cape splits, mainly i.ore Bzl/China - and it’s starting to be tight supply of Pmax tonnage to cover the demand.”	Cape-split, Tonnage Scarce=> Increase in Panamax rates
2009z	“And with Cape-splits and fresh orders in the market, there were no reasons for a decline in the Atlantic.”	Cape-split=> Increase in Panamax rates
2010w	“We expect the market to continue its strengthening as the Cape rates continue to increase and we see more split cargoes being quoted.”	Cape-split=> Increase in Panamax rates
2013w	“Atlantic rounds are being paid from Usd 6,500 to 9,000 and a good Usd 15,250 + Usd 550,000 was done USG/Feast. In the Pacific the rounds are now paying abt Usd 300 more than last week (i.e Usd 6,800) and this is much caused from Aussie rounds which seems to be Cape splits being done due to the much stronger Cape market.”	Cape-split=> Increase in Panamax rates
2013x	“Pacific on the other hand continues to firm probably due to many Cape stems now being split into Pmax stems.”	Cape-split=> Increase in Panamax rates
2013y	“Also the recent Cape rally has had a positive impact on the Panamaxes as we see many Cape splits.”	Cape-split=> Increase in Panamax rates
2013z	“NOPAC rounds being fixed from 14k and close to 15k mid-week, but with healthy volumes and a steady flow of Cape splits there is room for elevated levels short term.”	Cape-split=> Increase in Panamax rates
2013t	“The Cape market has also had a direct impact on pmax rates with stems being split into pmax stems, but the recent dramatic rate decline for Capes influences the Pmax market with no benefit from these additional cargoes.”	Decrease in Cape Rates, Decrease in Cape-splits=> Decrease in Panamax rates
2017w	“A booming Cape market has led to Cape splits talk in the Atl which is a positive factor going forward.”	Cape-split=> Increase in Panamax rates
2018w	“The Atlantic market has been much influenced by the strong Capesize market, which again has led to Cape splits into Pmax cargos.”	Cape-split=> Increase in Panamax rates
2019w	“Fronthaul and transatlantic trades remain the brightest spots, where shortage of available early units have forced major Brazilian exporters to split Capesize stems destined for China into Panamax lots at high cost to secure tonnage.”	Cape-split, Tonnage Scarce=> Increase in Panamax rates

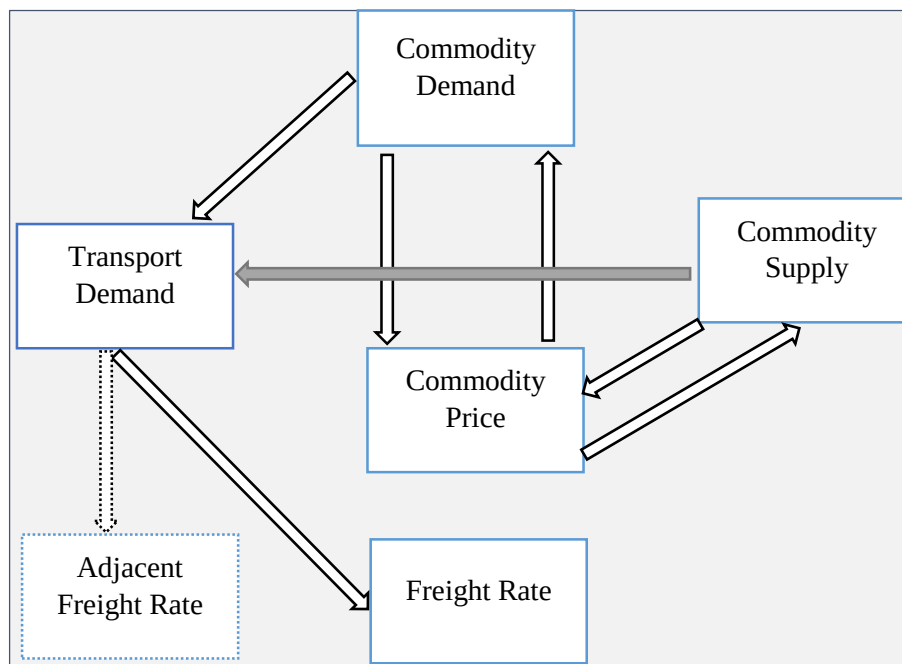
Within the framework of all these findings, it is possible to draw a model like below as in Figure 17. This mechanism is dynamic, so it may be useful to examine it as demand-based and supply-based to simplify expression. In terms of demand, the demand for commodities naturally affects the commodity price and is influenced by the commodity price. As demand for commodities increases, prices rise, and this increase affects demand for commodities. The increase in demand also increases the demand for transportation services, which consequently positively affects freight rates in the market. In case of a decrease in demand, the reverse of this plot takes place and the freight rates fall.

In terms of supply, rising commodity prices positively affect production as producers want to make more use of existing high-income conditions. This affects commodity prices and also positively affects the demand for transport services. The increase in transportation demand from this production activity positively affects the freight rates. On the other hand, there is a decrease in freight rate if the reverse scenario occurs.

Adjacent freight means the increase in freight in the adjacent shipping market due to the shift in major cargoes of other ships to this market since excessive demand in the major shipping market occurs some periods. As can be seen from the reports, it has been effective several times during the period covered, and Panamax vessels have taken advantage of shining Capesize freight rates. Therefore, this effect is indirect and can be observed between neighboring markets.

However, this mechanism may vary for some types of cargoes. The cargo types mentioned in these reports and used in our study are iron ore, coal and wheat. The first two are minerals and the production quantity can be adjusted in a short time according to the changes in demand. However, as wheat is a plant, it is difficult to plan production since it is affected by climatic conditions and it is very difficult to respond to changes in demand by increasing production in a short time.

Figure 17: Commodity and Shipping Market Relationship in Practice



CHAPTER THREE

RESEARCH METHODOLOGY AND DESIGN

This section is the part where the empirical side of the thesis is designed and the contents of the analyzes are introduced. Firstly, the research questions are emphasized based on the basic background and theoretical framework mentioned in the previous sections. Then, data sets used in empirical analysis are introduced and examined through graphs and descriptive statistics. Finally, information about the methods used in the research is presented and the section is completed.

3.1. RESEARCH QUESTIONS AND FLOW

This study seeks answers to some research questions, considering the studies examining the commodity price freight market relationship in the literature and assuming a complementary role to them. When the studies in the literature are examined, it is seen that the research topics are generally concentrated in the following groups; the studies reviewing the relationship between commodity and freight rates (Chou et al., 2015; Tsioumas and Papadimitriou, 2018; Açık and Başer, 2019; Açık and İnce, 2019; Açık and Başer, 2020; Angelopoulos et al., 2020); the studies reviewing the relationship between commodity and freight derivative markets (Kavussanos et al., 2010; Kavussanos et al., 2014); the studies reviewing the relationship between commodity price and second-hand ship value (Başer and Açık, 2019a); and other commodity-related studies (Açık and Başer, 2018a; Açık and Başer, 2018b). In this context, this study has three basic research questions.

Is there any volatility spillover and risk transfer from commodity prices to the freight market?

As freight rates are related to the situation of maritime transport with a derived demand structure, the condition of the cargo carried may affect fluctuations in freight prices. Since information about the demand of the commodity is first reflected on the commodity price, it is likely that there may be a flow of information from the price to the freight rates. This situation may cause the volatility and risk in the commodity

market to be reflected in the freight market. In this context, one of our research questions is designed to examine this topic.

Is there a difference in terms of information flow between commodity price and freight by type of commodity?

The characteristics of the commodities carried in dry bulk transportation are different from each other. For example, iron ore and coal used in this study are industrial mineral products, while wheat is a natural plant product. Therefore, production structures, supply structures, demand structures differ from each other. Therefore, there may be differences in their relationship with freight rates and this forms one of our research questions. Although there are studies investigating this in the literature, our study examines the subject with a different method in terms of information flow and volatility transmission.

Is there a flow of information from the prices of commodities only to freights of the mostly used ships?

As presented by Meersman et al. (2014), the transport rates of the 3 main bulk cargoes by ships differ. Some ships specialize in some cargoes, and the use of such vessels makes it possible to transport those cargoes in a sustainable manner. For instance, 70%-80% of iron ore is transported by Capesize vessels while only 10% is transported by Handymax vessels. Another specialization seems in the Handymax ships, 45%-55% of grain cargo is transported by this kind of vessels. To summarize in general, Capesize-type ships are extensively involved in the transportation of iron ore goods; Panamax and Capesize type ships are extensively used to transport coal; Handymax and Panamax type ships are extensively used in the transportation of grain. In this respect, it is one of our research questions whether commodity prices affect only the freight of the ship type in which they are used extensively in terms of information flow.

3.2. DATA

Commodity prices are obtained from World Bank (2019). The freight information of the vessels is obtained from Bloomberg Data Platform (2019) and their monthly averages are obtained from weekly observations. Capesize dataset covers the

dates between January 2000 and June 2019. 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 unit of these three routes are \$ per metric tons.

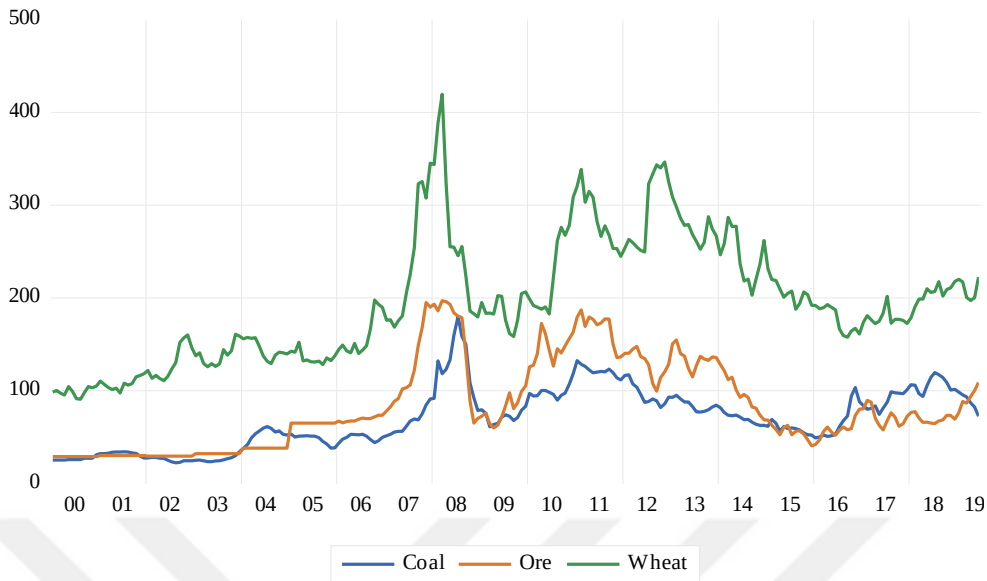
Table 8: Descriptive Statistics for the Capesize Dataset

	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
Observations	234	234	234	234	234	234

Source: The World Bank (2019); Bloomberg (2019).

Figure 18 shows the movements of the commodity prices used in the study according to the period covered in the size of the Capesize sample. The same data was used in the analyzes for Panamax and Handymax, which are other ship types, but their freight data can be accessed at different lengths, so their commodity prices cover shorter periods.

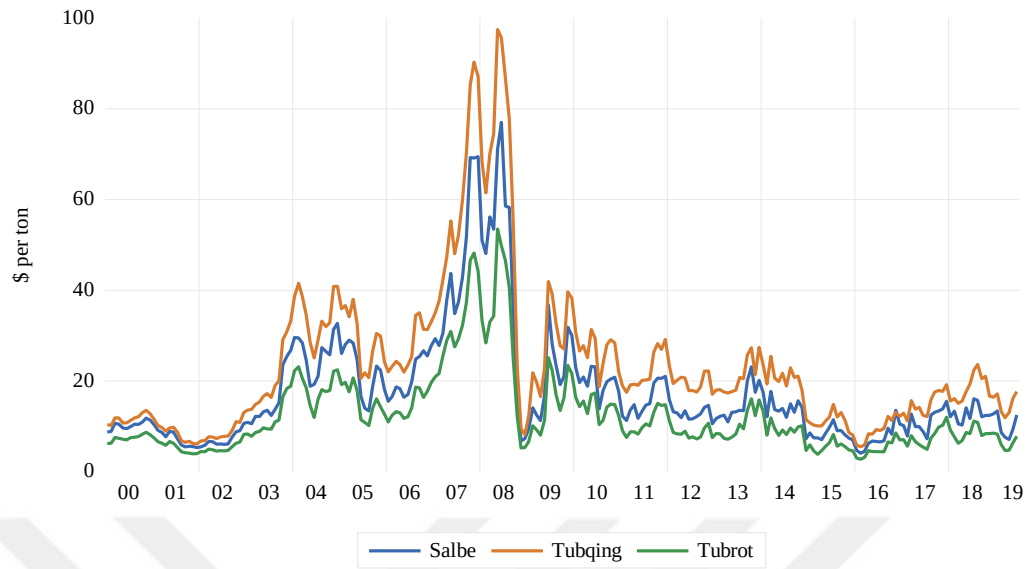
Figure 18: Commodity Prices Included in the Study



Source: Bloomberg (2019).

The movements of the freights of the routes included in the study according to the Capesize ship type are presented in Figure 19. As can be seen from the figure, although the freights in the routes generally move in parallel, there have been relatively minor differences. Therefore, this may cause minor variations in their relationship with commodity prices. In addition, the reflections of the 2008 global economic crisis on the Capesize freight markets are clearly visible. Freights, which rose to the highest levels in history, suddenly crashed to the bottom.

Figure 19: Capesize Prices for various Routes



Source: Bloomberg (2019).

Panamax dataset covers the dates between February 2001 and June 2019. HAMROT refers to Panamax route from Hamphthor Road (USA) to Rotterdam (Netherlands), RICROT refers to Panamax route from Richard Bay (South Africa) to Rotterdam (Netherlands), ROBROT refers to Panamax route from Roberts Bank (Canada) to Rotterdam (Netherlands), WAROT refers to Panamax route from South Wales to Rotterdam (Netherlands). The unit of these three routes are \$ per metric tons.

Table 9: Descriptive Statistics for the Panamax Dataset

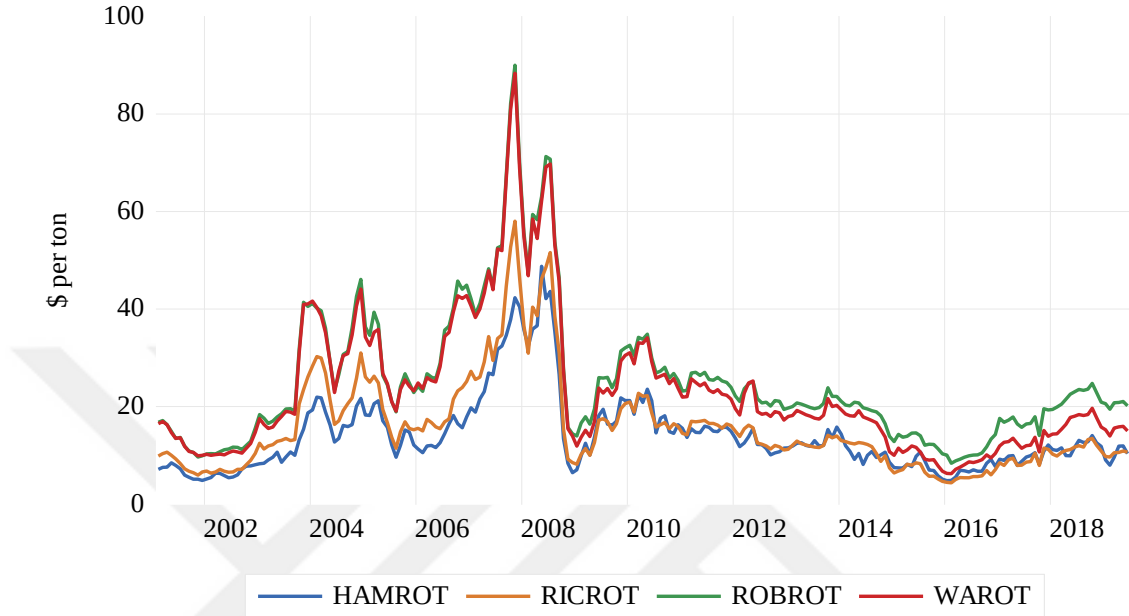
	COAL	ORE	WHEAT	HAMROT	RICROT	ROBROT	WAROT
Mean	72.29	86.67	201.16	13.94	15.55	25.05	23.16
Median	71.07	71.53	190.3	12.00	12.62	21.07	18.46
Maximum	180.0	197.12	419.6	48.75	58.00	90.0	88.34
Minimum	22.25	29.31	97.42	4.82	4.36	8.36	6.26
Std.Dev.	31.37	47.19	64.44	7.87	9.59	13.77	14.13
Skewness	0.41	0.69	0.70	1.93	1.86	1.83	1.78
Kurtosis	2.86	2.43	2.97	7.23	6.95	7.14	6.76
Jarque-Bera	6.63	20.90	18.05	302.7	272.0	282.4	247.9
Probability	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Observations	221	221	221	221	221	221	221

Source: The World Bank (2019); Bloomberg (2019).

Visual of the routes of Panamax type ships included in the study is presented in Figure 20. Although there are minor differences in general, it is seen that the routes

generally move in parallel. In addition, the impact of the 2008 crisis can be clearly seen on the routes of Panamax ships.

Figure 20: Panamax Prices for Various Routes



Source: Bloomberg (2019).

Handymax dataset covers the dates between January 2009 and June 2019, and consists of 126 monthly observations. USJAP refers to Handymax route from US Gulf to Japan, PANSA refers to Handymax route from Pacific Northwest (US) to South America.

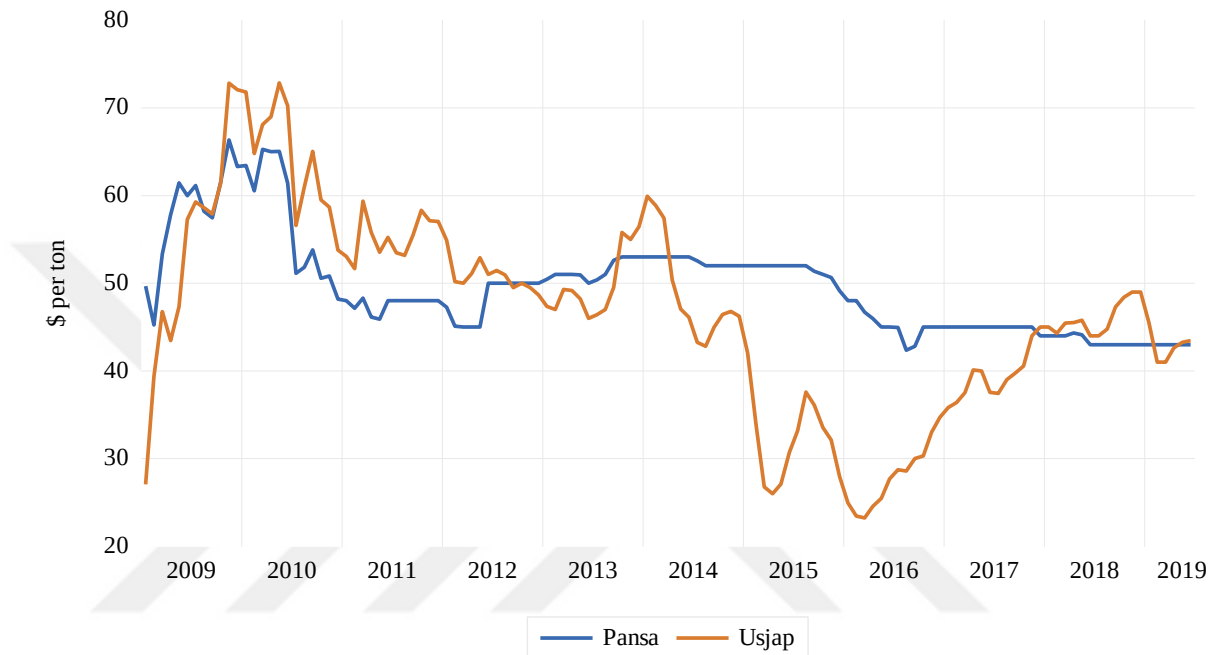
Table 10: Descriptive Statistics for the Handymax Dataset

	COAL	ORE	WHEAT	PANSA	USJAP
Mean	86.47380	100.6030	227.4696	49.68036	46.66348
Median	86.98000	88.83000	209.8247	49.84375	46.90000
Maximum	132.4800	187.1800	346.4928	66.33333	72.85714
Minimum	49.02000	40.50000	157.5605	42.34783	23.21739
Std.Dev.	20.60809	39.48412	48.84567	5.671771	11.54198
Skewness	0.127367	0.461457	0.674789	1.043974	0.005553
Kurtosis	2.202819	1.963352	2.468203	3.746093	2.726485
Jarque-Bera	3.677032	10.11365	11.04690	25.80996	0.393403
Probability	0.159053	0.006366	0.003992	0.000002	0.821436
Observations	126	126	126	126	126

Source: The World Bank (2019); Bloomberg (2019).

The visual that shows the movements of the routes of the ships of Handymax type is presented in Figure 21. Although the first bright part of the crisis effect can not be seen since the data period covered is short, the increase after 2009 indirectly reflects the crisis effect.

Figure 21: Handymax Prices for Various Routes



Source: Bloomberg (2019).

3.3. PRELIMINARY TESTS FOR ECONOMETRIC ANALYSIS

For the analyzes applied in the study, it is necessary to check the stationarity of the data since the data must be stationary in all causality tests. In addition, nonlinear structures of the series should be determined in order to apply nonlinear causality analyzes in a healthy way. Therefore, unit root and nonlinearity tests are applied to the all variables.

3.3.1. Unit Root Tests

In order to determine possible unit roots in time series, some tests should be applied. While some methods require stationarity (Linear Granger causality, causality

in variance, DP causality, etc.), some methods need to know the degree of integration (Asymmetric causality, time varying causality, etc.). Therefore, unit root tests are an important step in any situation before the econometric analysis. In the series, structural breaks in level and trend caused by various reasons such as policy change, war and crisis can lead to results as if the series has a unit root. Therefore, the use of unit root tests, which also take into account breaks in the series, is of great importance in order to avoid misleading results.

Accordingly, one break ADF test developed by Zivot and Andrews (1992), one break LM test developed Lee and Strazicich (2013), two break ADF test developed by Narayan and Popp (2010), two break LM test developed by Lee and 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.

3.3.2. Nonlinearity Tests

In today's world, which is globalized and where news is spreading rapidly, financial data is subject to much shocks and structural changes. This interaction causes the series to have high volatility and to be exposed to several crises, thus disrupting the linear structure of the series (Bildirici and Turkmen, 2015). In addition, macro-scale factors such as reform policies, changes in economic structure, investor heterogeneity and fluctuations in industrial production cause deterioration in the linear structure of the series (Ajmi et al., 2013). These events cause the variances to be dependent on time and distort the constant variance assumption (Månsson and Shukur, 2009). Conducting linear analyzes in this kind of series may cause to obtain misleading results and may lead to unrealistic findings. Therefore, it is more appropriate to use the methods suitable to their structure by checking the linearity of the series in question.

When the issue is investigated through causality analysis, Brock (1991) used nonlinear data and model in order to demonstrate that standard linear causality analysis fails to detect non-linear relationships. This is a natural result considering the structures of linear models (Bal & Rath 2015; Adıgüzel et al., 2013). In order to test

nonlinearity in the series, BDS Independence (Brock et al., 1987), ARCH LM (Engle, 1982), and Ljung-Box (1978) tests are applied to the series.

BDS Independence test was designed by Brock, Dechert and Scheinkman (1987). Before the implementation, a model is estimated (e.g., ARMA model) and the test is implemented to the residuals of the model in order to check whether the residuals are independent and identically distributed (i.i.d. assumption). The null hypothesis for this test indicates iid assumption (Brock et al., 1996), and rejection of the hypothesis implies possibly non-linear structure in the series. LB portmanteau test was developed by Ljung-Box (1978) and it is generally implemented to the squared residuals of the estimated model (McLeod et al, 2012:683). The null hypothesis of the test can be evaluated as linearity and therefore rejection of the null hypothesis indicates nonlinearity. In addition, ARCH LM test developed by Engle (1982) is used for detection of nonlinearities and its null hypothesis indicates linearity (Heij et al., 2004:628).

In this respect, when the null hypothesis is rejected in any of the mentioned nonlinearity tests, the application of nonlinear methods rather than linear ones may provide more reliable results (Lim and Ho, 2013).

3.4. CAUSALITY TESTS

The standard causality test was developed by Granger (1969) to test the causality relationship between two time series. The intuition of the test is as follows: if the historical data of one series helps to improve predicting the current and future values of the other series (Yu et al., 2015), the first series is expressed as the Granger cause of the second series (Dura et al., 2017). In the circumstances, the test detects a significant correlation between the historical values of the first series and the present value of the second series in the case of causality (Chiou-Wei, 2008). However, as mentioned in the previous sections, time series may not always be linear. This situation makes it difficult to analyze with linear methods and brings nonlinear methods to the fore. Causality in variance test is one of these nonlinear methods, which is developed in order to investigate nonlinear time series.

The causality in variance test, which is a kind of current causality analysis and examines the causality relationship between the variances of the variables, can provide important findings especially for the financial markets. The transmissions between financial markets can be tested and identified by this method (Koseoglu and Çevik, 2013) since it spots the volatility spillover between the two variables (Bayat et al., 2015). In addition, the variance changes when the new information arrives and it reflects how this information is interpreted in the market (Cheung and Ng, 1996).

The fundamentals of the method were formed by Cheung and Ng (1996) for the first time and the method was developed over time by overcoming the missing aspects. Squared univariate GARCH residuals estimates and their cross-correlation function (CCF) lie at the bottom of the method. However, when the volatility processes are leptokurtic, the corresponding CCF-based Portmanteau test statistics may be problematic in relatively small samples (Nouira et al., 2019). This situation reduced the applicability of the method, and one of the methods developed to overcome this deficiency is the volatility spillover test based on the Lagrange Multiplier (LM) principle. The method was developed by Hafner and Herwartz (2006), and they proved robustness of the LM approach towards spotted deficiencies by using Monte Carlo simulations (Nazlioglu et al., 2013).

The null of non-causality in the variance hypothesis between the two variables can be defined as follows;

$$H_0: Var(\varepsilon_{it} | F_{t-1}^{(j)}) = Var(\varepsilon_{it} | F_{t-1}) \quad j = 1, \dots, N, i \neq j$$

$F_t^{(j)} = F_t \setminus \sigma(\varepsilon_{j\tau}, \tau \leq t)$ and ε_{it} indicates the residuals from the estimated GARCH models. The model below is used to test the null hypothesis:

$$\varepsilon_{it} = \xi_{it} \sqrt{\sigma_{it}^2 g_t}, \quad g_t = 1 + z_{jt}' \pi, \quad z_{jt} = (\varepsilon_{jt-1}^2, \sigma_{jt-1}^2)$$

To test the volatility spillover between variables, the following LM test is recommended by Hafner and Herwartz (2006):

$$\lambda_{LM} = \frac{1}{4T} \left(\sum_{t=1}^T (\xi_{it}^2 - 1) z_{jt}' \right) V(\theta_i)^{-1} \left(\sum_{t=1}^T (\xi_{it}^2 - 1) z_{jt} \right)$$

where

$$V(\theta_i) = \frac{\kappa}{4T} \left(\sum_{t=1}^T z_{jt} z'_{jt} - \sum_{t=1}^T z_{jt} x'_{it} \left(\sum_{t=1}^T x_{it} x'_{it} \right)^{-1} \sum_{t=1}^T x_{it} z'_{jt} \right), \kappa = \frac{1}{T} \sum_{t=1}^T (\xi_{it}^2 - 1)^2$$

In this way, causality in the variance is tested between the series and possible volatility spillovers are determined. The method used has some advantages and disadvantages in our research. First of all, this method tests mutual causality in variance between two variables and a third or more variable cannot be included in the analysis, which can be seen as a disadvantage. Therefore, the freight rate and commodity prices are assumed to contain all the information available in their markets. As a result, all factors such as supply-demand imbalances, seasonal events, political balances and cultural events are reflected in prices. The study of volatility spillover between the prices carrying this information makes the method reasonable and sufficient. It can be said that the method examines the relationship between the two variables through changes in the variance and eliminates the inadequacy caused by other external variables that are not considered. Because, for whatever reason, the change in variance can cause a change in the variance of the other variable. For example, whatever affects the commodity prices may be reflected in the prices, and this may affect the behavior of those interested in the related commodity. As a result, this impact may spillover to the commodity-related industries. Another advantage of the method is that it can be easily used by researchers whose theoretical background and coding skills are not very high. Since the maritime economics is an application area rather than theoretical development, the convenience in the applicability of the method provides a great advantage. In addition, the method is considered to be an adequate one for research questions in our study. By testing the risk and volatility spillover between commodity prices and freight rates for each route, appropriate results were obtained for the research questions.

CHAPTER FOUR

TESTING THE INFORMATION FLOW

In this section, the implementation of the analyzes and the determination of the information flow between the commodity prices and the freights are carried out. Firstly, since the causality in variance method is not linear one, the linearity of the data is tested. Then, since the method requires the series to be stationary, unit root analyzes are applied to each commodity price and freight variables. After determining the non-linearity and unit root status, causality in variance analyses are applied and the findings are evaluated.

4.1. PRELIMINARY TEST RESULTS

In this section, nonlinearity and stationarity states, which are the requirements of causality test in variance, are tested and their results are presented.

4.1.1. Nonlinearity Test Results

In order to determine the nonlinear structures in the series, the most appropriate ARMA model was determined for each variable according to the lowest Akaike information criterion value. After checking AR and MA roots of the model, the linearity was tested by applying BDS Independence Test, ARCH LM test and Ljung-Box test. The results of BDS Independence Test, which is one of the most common and reliable tests for nonlinearity check, are tabulated separately for commodity price index and freight values of each ship type. The results obtained for the Capesize market are presented in Table 11.

Selected model for Ore price is ARMA (0, 1) with -2.05265315386 AIC value. There is ARCH effect for lags of 2 and dependency in the squared residuals. 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 dependency in the squared residuals. BDS test indicates nonlinear structure in the series. Selected model for Wheat price is ARMA (2, 3) with -2.546 AIC value. There

is ARCH effect for lag of 8 and dependency in the squared residuals. BDS test does not indicate nonlinear structure in the series. Selected model for Salbe is ARMA (3, 3) with -0.351 AIC value. There is ARCH effect for lags of 1, 2, 4, 8, 16 and dependency in the squared residuals. BDS test indicates nonlinear structure in the series. Selected model for Tubqinq is ARMA (4, 8) with -0.775 AIC value. There is ARCH effect for lags of 1, 2, 4, 8, 16 and dependency in the squared residuals. BDS test indicates nonlinear structure in the series. Lastly, selected model for Tubrot is ARMA (4, 8) with -0.366 AIC value. There is ARCH effect for lags of 1, 2, 4, 8, 16 and dependency in the squared residuals. BDS test indicates nonlinear structure in the series. According to the results of Capesize market, it can be concluded that both commodity price and route variables have nonlinear structures.

Table 11: Capesize Market BDS Results

	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

The process applied to the Capesize market was also applied to the Panamax market, and the results of the BDS Independence Test for market are presented in Table 12. Selected model for Ore price is ARMA (0, 1) with -1.994 AIC value. There is ARCH effect for lag of 2 and dependency in the squared residuals. BDS test indicates nonlinear structure in the series. Selected model for Coal price is ARMA (5, 4) with -2.494 AIC value. There is ARCH effect for lags of 2, 4, 8, 16 and dependency in the squared residuals. BDS test indicates nonlinear structure in the series. Selected model for Wheat price is ARMA (2, 3) with -2.523 AIC value. There is ARCH effect for lag of 8 and dependency in the squared residuals. BDS test does not indicate nonlinear structure in the series. Selected model for Hamrot is ARMA (6, 7) with -1.064 AIC value. There is ARCH effect for lags of 1, 2, 4, 8, 16 and dependency in the squared residuals. BDS test indicates nonlinear structure in the series. Selected model for Ricrot is ARMA (6, 5) with -1.289 AIC value. There is ARCH effect for lags of 1, 2, 4, 8 and dependency in the squared residuals. BDS test indicates nonlinear structure in the series. Selected model for Robrot is ARMA (2, 3) with -1.524 AIC value. There is ARCH effect for lags of 1, 2, 4 and dependency in the squared residuals. BDS test indicates nonlinear structure in the series. Finally, selected model for Warot is ARMA (1, 0) with -1.407 AIC value. There is ARCH effect for lags of 1, 2, 4 and dependency in the squared residuals. BDS test indicates nonlinear structure in the series. According to the results, it can be concluded that nonlinear structures are determined in all data covering Panamax market. Although the BDS test cannot confirm the nonlinearity for the wheat price, the results of the ARCH test and dependency in the squared residuals contain information that wheat price has also nonlinear structure.

Table 12: Panamax Market BDS Results

	Dimension	BDS Statistic	Std. Error	z-Statistic	Prob.
Ore	2	0.019964	0.006555	3.045503	0.0023
	3	0.035996	0.010459	3.441741	0.0006
	4	0.057538	0.012506	4.600958	0.0000
	5	0.067578	0.013090	5.162734	0.0000
	6	0.068209	0.012678	5.380323	0.0000
Coal	2	0.013734	0.005929	2.316318	0.0205

	3	0.037538	0.009436	3.978338	0.0001
	4	0.054038	0.011252	4.802707	0.0000
	5	0.060946	0.011744	5.189501	0.0000
	6	0.059357	0.011342	5.233342	0.0000
Wheat	2	0.005418	0.005550	0.976217	0.3290
	3	0.005324	0.008843	0.602066	0.5471
	4	0.009108	0.010559	0.862576	0.3884
	5	0.008107	0.011034	0.734679	0.4625
	6	0.006940	0.010669	0.650467	0.5154
Hamrot	2	0.012065	0.004584	2.631698	0.0085
	3	0.032180	0.007291	4.413475	0.0000
	4	0.040666	0.008687	4.681394	0.0000
	5	0.043617	0.009057	4.815627	0.0000
	6	0.045012	0.008737	5.151695	0.0000
Ricrot	2	0.019469	0.005514	3.530918	0.0004
	3	0.034971	0.008771	3.986964	0.0001
	4	0.042304	0.010455	4.046442	0.0001
	5	0.043563	0.010906	3.994234	0.0001
	6	0.042772	0.010527	4.063011	0.0000
Robrot	2	0.013773	0.006278	2.193832	0.0282
	3	0.034809	0.009988	3.484983	0.0005
	4	0.047993	0.011909	4.030100	0.0001
	5	0.051241	0.012429	4.122813	0.0000
	6	0.048064	0.012002	4.004560	0.0001
Warot	2	0.016550	0.006729	2.459682	0.0139
	3	0.031889	0.010730	2.971927	0.0030
	4	0.046514	0.012824	3.627031	0.0003
	5	0.054149	0.013417	4.035754	0.0001
	6	0.055377	0.012990	4.263160	0.0000

The results of the BDS Independence Test applied Handymax market are presented in Table 13. Selected model for Ore price is ARMA (2, 3) with -1.983 AIC value. BDS test and the other tests do not indicate nonlinear structure in the series. Selected model for Coal price is ARMA (0, 1) with -2.638 AIC value. There is ARCH effect for lags of 2, 4 and 8, and dependency in the squared residuals. BDS test indicates nonlinear structure in the series. Selected model for Wheat price is ARMA (3, 0) with --2.616 AIC value. BDS test and the other tests do not indicate nonlinear structure in the series. Selected model for Pansa is ARMA (9, 3) with -3.988 AIC value. There is ARCH effect for lags of 1, 16 and dependency in the squared residuals. BDS test indicates nonlinear structure in the series. Selected model for Usjap is ARMA (2, 12) with 2.502 AIC value. BDS test indicates nonlinear structure in the series. According to the results, nonlinear structures were determined in two freight route and one commodity price variables. Nonlinearity in ore and wheat prices could not be

determined, however, since the route variables that are subjected to analysis have nonlinear structures, the use of nonlinear methods is thought not to constitute a major problem.

Table 13: Handymax Market BDS Results

	Dimension	BDS Statistic	Std. Error	z-Statistic	Prob.
Ore	2	-0.001534	0.006087	-0.252080	0.8010
	3	0.004676	0.009708	0.481696	0.6300
	4	0.011842	0.011599	1.020930	0.3073
	5	0.018376	0.012129	1.515034	0.1298
	6	0.018196	0.011734	1.550647	0.1210
Coal	2	0.006216	0.007877	0.789144	0.4300
	3	0.044638	0.012562	3.553489	0.0004
	4	0.065051	0.015011	4.333631	0.0000
	5	0.073243	0.015701	4.664903	0.0000
	6	0.076408	0.015196	5.028255	0.0000
Wheat	2	0.003044	0.007417	0.410412	0.6815
	3	-0.001567	0.011833	-0.132465	0.8946
	4	0.005236	0.014144	0.370210	0.7112
	5	0.006588	0.014798	0.445220	0.6562
	6	0.005172	0.014325	0.361073	0.7180
PANSA	2	0.034267	0.009867	3.472799	0.0005
	3	0.067772	0.015817	4.284788	0.0000
	4	0.091458	0.019006	4.812084	0.0000
	5	0.105040	0.019994	5.253589	0.0000
	6	0.113450	0.019464	5.828645	0.0000
USJAP	2	0.017798	0.007378	2.412311	0.0159
	3	0.031746	0.011749	2.702130	0.0069
	4	0.037738	0.014018	2.692180	0.0071
	5	0.046726	0.014639	3.191883	0.0014
	6	0.042136	0.014146	2.978755	0.0029

4.1.2. Unit Root Test Results

Since the stationarity of the data is required for causality analysis, unit root tests are applied. In addition, nonlinear structures of the series are tested in order to be able to apply nonlinear causality analysis. Unit root tests with structural breaks were applied to each variable to determine the possible unit root conditions in the variables. Tests were applied to both freight rates and commodity price index for each ship market and the results were presented in tables.

Capesize Market Results

The ore price in the Capesize sample variable is stationary when the structural breaks in level and level and trend were considered according to two breaks ADF test (Narayan and Popp, 2010).

Table 14: Unit Root Tests with Structural Breaks for Ore Price

Test Items	Break in Level (Mod A) Ore	Break in Level and Trend (Mod C) Ore
One break ADF test (Zivot and Andrews, 1992)		
ADF Stat	-3.78	-3.56
Break Date	2001M4	2006M11
Fraction	0.71	0.35
Lag	2	2
One break LM test (Lee and Strazicich, 2013)		
LM Stat	-1.97	-3.22
Break Date	2012M7	2011M8
Fraction	0.64	0.59
Lag	2	2
Two break ADF test (Narayan and Popp, 2010)		
ADF Stat	-4.89**	-4.60*
Break Date	2004M11, 2014M3	2007M6, 2009M8
Fraction	0.25, 0.73	0.38, 0.49
Lag	2	2
Two break LM test (Lee and Strazicich, 2003)		
LM Stat	-2.16	-4.29
Break Date	2012M7, 2015M6	2007M3, 2014M7
Fraction	0.64, 0.79	0.37, 0.74
Lag	2	1

Mod A refers to Break in Level and Mod C refers to Break in Both Level and Trend. ZA (1992) One Break in Level CVs: -5.34 for ***1%, -4.80 for **5%, -4.58 for *10%. ZA (1992) One Break in Level and Trend CVs: -5.57 for ***1%, -5.08 for **5%, -4.82 for *10%. LS (2013) One Break in Level CVs: -4.23 for ***1%, -3.56 for **5%, -3.21 for *10%. LS (2013) One Break in Level and Trend CVs: -5.11 for ***1%, -4.51 for **5%, -4.17 for *10% when λ is 0.5. NP (2010) Two Break in Level CVs: -4.95 for ***1%, -4.31 for **5%, -3.89 for *10%. NP (2010) Two Break in Level and Trend CVs: -5.57 for ***1%, -4.93 for **5%, -4.59 for *10%. LS (2003) Two Break in Level CVs: -4.54 for ***1%, -3.84 for **5%, -3.50 for *10%. LS (2003) Two Break in Level and Trend CVs: -6.42 for ***1%, -5.65 for **5%, -5.32 for *10% when λ_1 is 0.4 and λ_2 is 0.8.

The coal price in the Capesize sample variable is stationary when the structural breaks in level and level and trend were considered according to two breaks ADF test (Narayan and Popp, 2010).

Table 15: Unit Root Tests with Structural Breaks for Coal Price

Test Items	Break in Level (Mod A) Coal	Break in Level and Trend (Mod C) Coal
One break ADF test (Zivot and Andrews, 1992)		
ADF Stat	-3.41	-3.88
Break Date	2012M11	2007M4
Fraction	0.66	0.37
Lag	1	1
One break LM test (Lee and Strazicich, 2013)		
LM Stat	-2.51	-3.57
Break Date	2008M1	2007M10
Fraction	0.41	0.40
Lag	1	1
Two break ADF test (Narayan and Popp, 2010)		
ADF Stat	-4.69**	-5.33***
Break Date	2012M11, 2015M1	2007M8, 2013M11
Fraction	0.66, 0.77	0.39, 0.71
Lag	1	1
Two break LM test (Lee and Strazicich, 2003)		
LM Stat	-2.69	-5.23
Break Date	2003M11, 2008M1	2011M1, 2016M5
Fraction	0.20, 0.41	0.56, 0.84
Lag	1	1

Mod A refers to Break in Level and Mod C refers to Break in Both Level and Trend. ZA (1992) One Break in Level CVs: -5.34 for ***1%, -4.80 for **5%, -4.58 for *10%. ZA (1992) One Break in Level and Trend CVs: -5.57 for ***1%, -5.08 for **5%, -4.82 for *10%. LS (2013) One Break in Level CVs: -4.23 for ***1%, -3.56 for **5%, -3.21 for *10%. LS (2013) One Break in Level and Trend CVs: -5.05 for ***1%, -4.50 for **5%, -4.18 for *10% when λ is 0.4. NP (2010) Two Break in Level CVs: -4.95 for ***1%, -4.31 for **5%, -3.89 for *10%. NP (2010) Two Break in Level and Trend CVs: -5.57 for ***1%, -4.93 for **5%, -4.59 for *10%. LS (2003) Two Break in Level CVs: -4.54 for ***1%, -3.84 for **5%, -3.50 for *10%. LS (2003) Two Break in Level and Trend CVs: -6.32 for ***1%, -5.73 for **5%, -5.32 for *10% when λ_1 is 0.6 and λ_2 is 0.8.

The wheat price in the Capesize sample variable is stationary when the structural breaks in level and level and trend were considered according to two breaks ADF test (Narayan and Popp, 2010).

Table 16: Unit Root Tests with Structural Breaks for Wheat Price

Test Items	Break in Level (Mod A) Wheat	Break in Level and Trend (Mod C) Wheat
One break ADF test (Zivot and Andrews, 1992)		
ADF Stat	-4.42	-4.20
Break Date	2014M11	2007M2
Fraction	0.76	0.36
Lag	1	1
One break LM test (Lee and Strazicich, 2013)		
LM Stat	-2.73	-3.91
Break Date	2014M5	2013M1
Fraction	0.73	0.67
Lag	1	1

Two break ADF test (Narayan and Popp, 2010)		
ADF Stat	-5.31***	-6.66***
Break Date	2007M2, 2014M11	2007M4, 2010M5
Fraction	0.36, 0.76	0.37, 0.53
Lag	1	1
Two break LM test (Lee and Strazicich, 2003)		
LM Stat	-3.03	-4.97
Break Date	2014M5, 2014M12	2007M2, 2014M11
Fraction	0.73, 0.76	0.36, 0.76
Lag	1	1

Mod A refers to Break in Level and Mod C refers to Break in Both Level and Trend. ZA (1992) One Break in Level CVs: -5.34 for ***1%, -4.80 for **5%, -4.58 for *10%. ZA (1992) One Break in Level and Trend CVs: -5.57 for ***1%, -5.08 for **5%, -4.82 for *10%. LS (2013) One Break in Level CVs: -4.23 for ***1%, -3.56 for **5%, -3.21 for *10%. LS (2013) One Break in Level and Trend CVs: -5.11 for ***1%, -4.51 for **5%, -4.17 for *10% when λ is 0.5. NP (2010) Two Break in Level CVs: -4.95 for ***1%, -4.31 for **5%, -3.89 for *10%. NP (2010) Two Break in Level and Trend CVs: -5.57 for ***1%, -4.93 for **5%, -4.59 for *10%. LS (2003) Two Break in Level CVs: -4.54 for ***1%, -3.84 for **5%, -3.50 for *10%. LS (2003) Two Break in Level and Trend CVs: -6.42 for ***1%, -5.65 for **5%, -5.32 for *10% when λ_1 is 0.4 and λ_2 is 0.8.

The Capesize freight from Saldanha to Beilun (SALBE) variable is stationary according to one break ADF test (Zivot and Andrews, 1992), one break LM test (Lee and Strazicich, 2013) and two break ADF test (Narayan and Popp, 2010).

Table 17: Unit Root Tests with Structural Breaks for SALBE Route

Test Items	Break in Level (Mod A) Salbe	Break in Level and Trend (Mod C) Salbe
One break ADF test (Zivot and Andrews, 1992)		
ADF Stat	-4.608*	-5.740***
Break Date	2003M6	2008M7
Fraction	0.17	0.44
Lag	1	1
One break LM test (Lee and Strazicich, 2013)		
LM Stat	-3.312	-4.832**
Break Date	2003M6	2008M8
Fraction	0.19	0.44
Lag	1	1
Two break ADF test (Narayan and Popp, 2010)		
ADF Stat	-5.411***	-6.537***
Break Date	2008M7, 2014M9	2008M7, 2014M10
Fraction	0.44, 0.75	0.44, 0.76
Lag	1	1
Two break LM test (Lee and Strazicich, 2003)		
LM Stat	-3.779	-5.316
Break Date	2003M6, 2010M6	2008M7, 2016M11
Fraction	0.19, 0.53	0.44, 0.86
Lag	1	1

Mod A refers to Break in Level and Mod C refers to Break in Both Level and Trend. ZA (1992) One Break in Level CVs: -5.34 for ***1%, -4.80 for **5%, -4.58 for *10%. ZA (1992) One Break in Level and Trend CVs: -5.57 for ***1%, -5.08 for **5%, -4.82 for *10%. LS (2013) One Break in Level CVs: -4.23 for ***1%, -3.56 for **5%, -3.21 for *10%. LS (2013) One Break in Level and Trend CVs: -5.05 for ***1%, -4.50 for **5%, -4.18 for *10% when λ is 0.4. NP (2010) Two Break in Level CVs: -4.95

for ***1%, -4.31 for **5%, -3.89 for *10%. NP (2010) Two Break in Level and Trend CVs: -5.57 for ***1%, -4.93 for **5%, -4.59 for *10%. LS (2003) Two Break in Level CVs: -4.54 for ***1%, -3.84 for **5%, -3.50 for *10%. LS (2003) Two Break in Level and Trend CVs: -6.42 for ***1%, -5.65 for **5%, -5.32 for *10% when λ_1 is 0.4 and λ_2 is 0.8.

The Capesize freight from Tubarau to Rotterdam (TUBROT) variable is stationary according to one break ADF test (Zivot and Andrews, 1992), one break LM test (Lee and Strazicich, 2013), two break ADF test (Narayan and Popp, 2010) and two break LM test (Lee and Strazicich, 2003).

Table 18: Unit Root Tests with Structural Breaks for TUBROT Route

Test Items	Break in Level (Mod A) Tubrot	Break in Level and Trend (Mod C) Tubrot
One break ADF test (Zivot and Andrews, 1992)		
ADF Stat	-4.723**	-5.811***
Break Date	2003M6	2008M7
Fraction	0.17	0.44
Lag	1	1
One break LM test (Lee and Strazicich, 2013)		
LM Stat	-3.405	-4.979**
Break Date	2014M11	2008M8
Fraction	0.76	0.44
Lag	1	1
Two break ADF test (Narayan and Popp, 2010)		
ADF Stat	-5.45***	-6.668***
Break Date	2008M7, 2013M11	2008M7, 2014M10
Fraction	0.44, 0.71	0.44, 0.76
Lag	1	1
Two break LM test (Lee and Strazicich, 2003)		
LM Stat	-4.016**	-5.493*
Break Date	2010M6, 2014M11	2008M7, 2016M11
Fraction	0.53, 0.76	0.44, 0.86
Lag	1	1

Mod A refers to Break in Level and Mod C refers to Break in Both Level and Trend. ZA (1992) One Break in Level CVs: -5.34 for ***1%, -4.80 for **5%, -4.58 for *10%. ZA (1992) One Break in Level and Trend CVs: -5.57 for ***1%, -5.08 for **5%, -4.82 for *10%. LS (2013) One Break in Level CVs: -4.23 for ***1%, -3.56 for **5%, -3.21 for *10%. LS (2013) One Break in Level and Trend CVs: -5.05 for ***1%, -4.50 for **5%, -4.18 for *10% when λ is 0.4. NP (2010) Two Break in Level CVs: -4.95 for ***1%, -4.31 for **5%, -3.89 for *10%. NP (2010) Two Break in Level and Trend CVs: -5.57 for ***1%, -4.93 for **5%, -4.59 for *10%. LS (2003) Two Break in Level CVs: -4.54 for ***1%, -3.84 for **5%, -3.50 for *10%. LS (2003) Two Break in Level and Trend CVs: -6.42 for ***1%, -5.65 for **5%, -5.32 for *10% when λ_1 is 0.4 and λ_2 is 0.8.

The Capesize freight from Tubarau to Qingdao (TUBQINQ) variable is stationary according to one break LM test (Lee and Strazicich, 2013) and two break ADF test (Narayan and Popp, 2010).

Table 19: Unit Root Tests with Structural Breaks for TUBQINQ Route

Test Items	Break in Level (Mod A) Tubqing	Break in Level and Trend (Mod C) Tubqing
One break ADF test (Zivot and Andrews, 1992)		
ADF Stat	-3.795	-4.751
Break Date	2002M7	2008M7
Fraction	0.13	0.44
Lag	9	9
One break LM test (Lee and Strazicich, 2013)		
LM Stat	-2.54	-4.403**
Break Date	2008M9	2008M8
Fraction	0.44	0.44
Lag	9	9
Two break ADF test (Narayan and Popp, 2010)		
ADF Stat	-4.503**	-6.212***
Break Date	2009M10, 2014M9	2008M6, 2015M8
Fraction	0.50, 0.75	0.43, 0.80
Lag	9	9
Two break LM test (Lee and Strazicich, 2003)		
LM Stat	-2.875	-5.116
Break Date	2008M9, 2014M11	2003M8, 2009M11
Fraction	0.44, 0.76	0.18, 0.50
Lag	9	9

Mod A refers to Break in Level and Mod C refers to Break in Both Level and Trend. ZA (1992) One Break in Level CVs: -5.34 for ***1%, -4.80 for **5%, -4.58 for *10%. ZA (1992) One Break in Level and Trend CVs: -5.57 for ***1%, -5.08 for **5%, -4.82 for *10%. LS (2013) One Break in Level CVs: -4.23 for ***1%, -3.56 for **5%, -3.21 for *10%. LS (2013) One Break in Level and Trend CVs: -5.05 for ***1%, -4.50 for **5%, -4.18 for *10% when λ is 0.4. NP (2010) Two Break in Level CVs: -4.95 for ***1%, -4.31 for **5%, -3.89 for *10%. NP (2010) Two Break in Level and Trend CVs: -5.57 for ***1%, -4.93 for **5%, -4.59 for *10%. LS (2003) Two Break in Level CVs: -4.54 for ***1%, -3.84 for **5%, -3.50 for *10%. LS (2003) Two Break in Level and Trend CVs: -6.16 for ***1%, -5.59 for **5%, -5.27 for *10% when λ_1 is 0.2 and λ_2 is 0.4.

As a result of the analyzes made for Capesize market, when the breaks in the series are taken into consideration, it is determined that the series are stationary and do not contain unit root.

Panamax Market Results

The ore price in the Panamax sample variable is stationary when the structural breaks in level and level and trend were considered according to two breaks ADF test (Narayan and Popp, 2010).

Table 20: Unit Root Tests with Structural Breaks for Ore Price

Test Items	Break in Level (Mod A) Ore	Break in Level and Trend (Mod C) Ore
One break ADF test (Zivot and Andrews, 1992)		
ADF Stat	-3.67	-3.53
Break Date	2013M11	2006M11
Fraction	0.69	0.31
Lag	2	2
One break LM test (Lee and Strazicich, 2013)		
LM Stat	-1.92	-3.21
Break Date	2012M7	2011M8
Fraction	0.62	0.57
Lag	1	1
Two break ADF test (Narayan and Popp, 2010)		
ADF Stat	-4.75**	-4.67*
Break Date	2004M11, 2014M3	2007M6, 2009M8
Fraction	0.20, 0.71	0.34, 0.46
Lag	2	2
Two break LM test (Lee and Strazicich, 2003)		
LM Stat	-2.09	-4.31
Break Date	2012M7, 2015M6	2007M6, 2014M8
Fraction	0.62, 0.78	0.34, 0.73
Lag	1	1

Mod A refers to Break in Level and Mod C refers to Break in Both Level and Trend. ZA (1992) One Break in Level CVs: -5.34 for ***1%, -4.80 for **5%, -4.58 for *10%. ZA (1992) One Break in Level and Trend CVs: -5.57 for ***1%, -5.08 for **5%, -4.82 for *10%. LS (2013) One Break in Level CVs: -4.23 for ***1%, -3.56 for **5%, -3.21 for *10%. LS (2013) One Break in Level and Trend CVs: -5.11 for ***1%, -4.51 for **5%, -4.17 for *10% when λ is 0.5. NP (2010) Two Break in Level CVs: -4.95 for ***1%, -4.31 for **5%, -3.89 for *10%. NP (2010) Two Break in Level and Trend CVs: -5.57 for ***1%, -4.93 for **5%, -4.59 for *10%. LS (2003) Two Break in Level CVs: -4.54 for ***1%, -3.84 for **5%, -3.50 for *10%. LS (2003) Two Break in Level and Trend CVs: -6.45 for ***1%, -5.67 for **5%, -5.31 for *10% when λ_1 is 0.4 and λ_2 is 0.6.

The coal price in the Panamax sample variable is stationary when the structural breaks in level and level and trend were considered according to two breaks ADF test (Narayan and Popp, 2010).

Table 21: Unit Root Tests with Structural Breaks for Coal Price

Test Items	Break in Level (Mod A) Coal	Break in Level and Trend (Mod C) Coal
One break ADF test (Zivot and Andrews, 1992)		
ADF Stat	-3.36	-3.92
Break Date	2012M11	2007M4
Fraction	0.64	0.33
Lag	1	1
One break LM test (Lee and Strazicich, 2013)		
LM Stat	-2.47	-3.56
Break Date	2008M1	2007M12
Fraction	0.38	0.37
Lag	1	1
Two break ADF test (Narayan and Popp, 2010)		

ADF Stat	-4.53**	-5.38**
Break Date	2003M9, 2007M4	2010M7, 2015M1
Fraction	0.14, 0.33	0.51, 0.76
Lag	1	1
Two break LM test (Lee and Strazicich, 2003)		
LM Stat	-2.63	-4.88
Break Date	2003M11, 2007M9	2008M5, 2017M4
Fraction	0.15, 0.38	0.39, 0.88
Lag	1	1

Mod A refers to Break in Level and Mod C refers to Break in Both Level and Trend. ZA (1992) One Break in Level CVs: -5.34 for ***1%, -4.80 for **5%, -4.58 for *10%. ZA (1992) One Break in Level and Trend CVs: -5.57 for ***1%, -5.08 for **5%, -4.82 for *10%. LS (2013) One Break in Level CVs: -4.23 for ***1%, -3.56 for **5%, -3.21 for *10%. LS (2013) One Break in Level and Trend CVs: -5.05 for ***1%, -4.50 for **5%, -4.18 for *10% when λ is 0.4. NP (2010) Two Break in Level CVs: -4.95 for ***1%, -4.31 for **5%, -3.89 for *10%. NP (2010) Two Break in Level and Trend CVs: -5.57 for ***1%, -4.93 for **5%, -4.59 for *10%. LS (2003) Two Break in Level CVs: -4.54 for ***1%, -3.84 for **5%, -3.50 for *10%. LS (2003) Two Break in Level and Trend CVs: -6.42 for ***1%, -5.65 for **5%, -5.32 for *10% when λ_1 is 0.4 and λ_2 is 0.8.

The wheat price in the Panamax sample variable is stationary when the structural breaks in level and level and trend were considered according to two breaks ADF test (Narayan and Popp, 2010).

Table 22: Unit Root Tests with Structural Breaks for Wheat Price

Test Items	Break in Level (Mod A) Wheat	Break in Level and Trend (Mod C) Wheat
One break ADF test (Zivot and Andrews, 1992)		
ADF Stat	-4.11	-4.09
Break Date	2014M2	2007M2
Fraction	0.71	0.33
Lag	1	1
One break LM test (Lee and Strazicich, 2013)		
LM Stat	-2.74	-3.97
Break Date	2014M5	2014M12
Fraction	0.72	0.75
Lag	1	1
Two break ADF test (Narayan and Popp, 2010)		
ADF Stat	-5.44***	-6.58***
Break Date	2007M2, 2014M11	2007M4, 2010M5
Fraction	0.33, 0.75	0.33, 0.50
Lag	1	1
Two break LM test (Lee and Strazicich, 2003)		
LM Stat	-3.02	-4.71
Break Date	2014M5, 2014M12	2007M2, 2014M11
Fraction	0.72, 0.75	0.33, 0.75
Lag	1	1

Mod A refers to Break in Level and Mod C refers to Break in Both Level and Trend. ZA (1992) One Break in Level CVs: -5.34 for ***1%, -4.80 for **5%, -4.58 for *10%. ZA (1992) One Break in Level and Trend CVs: -5.57 for ***1%, -5.08 for **5%, -4.82 for *10%. LS (2013) One Break in Level CVs: -4.23 for ***1%, -3.56 for **5%, -3.21 for *10%. LS (2013) One Break in Level and Trend CVs: -5.11 for ***1%, -4.51 for **5%, -4.17 for *10% when λ is 0.5. NP (2010) Two Break in Level CVs: -4.95 for ***1%, -4.31 for **5%, -3.89 for *10%. NP (2010) Two Break in Level and Trend CVs: -5.57 for ***1%, -4.93 for **5%, -

4.59 for *10%. LS (2003) Two Break in Level CVs: -4.54 for ***1%, -3.84 for **5%, -3.50 for *10%. LS (2003) Two Break in Level and Trend CVs: -6.42 for ***1%, -5.65 for **5%, -5.32 for *10% when λ_1 is 0.4 and λ_2 is 0.8.

The Panamax freight from Hampton Road to Rotterdam (HAMROT) variable is stationary according to one break ADF test (Zivot and Andrews, 1992), one break LM test (Lee and Strazicich, 2013), two break ADF test (Narayan and Popp, 2010) and two break LM test (Lee and Strazicich, 2003).

Table 23: Unit Root Tests with Structural Breaks for HAMROT Route

Test Items	Break in Level (Mod A) Hamrot	Break in Level and Trend (Mod C) Hamrot
One break ADF test (Zivot and Andrews, 1992)		
ADF Stat	-4.260*	-5.229**
Break Date	2003M5	2008M6
Fraction	0.127	0.40
Lag	1	1
One break LM test (Lee and Strazicich, 2013)		
LM Stat	-2.903	-4.390*
Break Date	2003M9	2008M8
Fraction	0.145	0.41
Lag	1	1
Two break ADF test (Narayan and Popp, 2010)		
ADF Stat	-4.939**	-6.572***
Break Date	2008M6, 2013M11	2008M6, 2015M6
Fraction	0.40, 0.69	0.40, 0.78
Lag	1	1
Two break LM test (Lee and Strazicich, 2003)		
LM Stat	-3.208	-5.736**
Break Date	2003M9, 2014M5	2008M6, 2017M4
Fraction	0.14, 0.72	0.40, 0.88
Lag	1	1

Mod A refers to Break in Level and Mod C refers to Break in Both Level and Trend. ZA (1992) One Break in Level CVs: -5.34 for ***1%, -4.80 for **5%, -4.58 for *10%. ZA (1992) One Break in Level and Trend CVs: -5.57 for ***1%, -5.08 for **5%, -4.82 for *10%. LS (2013) One Break in Level CVs: -4.23 for ***1%, -3.56 for **5%, -3.21 for *10%. LS (2013) One Break in Level and Trend CVs: -5.05 for ***1%, -4.50 for **5%, -4.18 for *10% when λ is 0.4. NP (2010) Two Break in Level CVs: -4.95 for ***1%, -4.31 for **5%, -3.89 for *10%. NP (2010) Two Break in Level and Trend CVs: -5.57 for ***1%, -4.93 for **5%, -4.59 for *10%. LS (2003) Two Break in Level CVs: -4.54 for ***1%, -3.84 for **5%, -3.50 for *10%. LS (2003) Two Break in Level and Trend CVs: -6.42 for ***1%, -5.65 for **5%, -5.32 for *10% when λ_1 is 0.4 and λ_2 is 0.8.

The Panamax freight from Richard Bay to Rotterdam (RICROT) variable is stationary according to one break LM test (Lee and Strazicich, 2013), two break ADF test (Narayan and Popp, 2010) and two break LM test (Lee and Strazicich, 2003).

Table 24: Unit Root Tests with Structural Breaks for RICROT Route

Test Items	Break in Level (Mod A) Ricrot	Break in Level and Trend (Mod C) Ricrot
One break ADF test (Zivot and Andrews, 1992)		
ADF Stat	-3.762	-4.760
Break Date	2003M1	2008M6
Fraction	0.10	0.40
Lag	1	1
One break LM test (Lee and Strazicich, 2013)		
LM Stat	-2.729	-4.027*
Break Date	2003M9	2007M12
Fraction	0.14	0.37
Lag	1	1
Two break ADF test (Narayan and Popp, 2010)		
ADF Stat	-4.807**	-6.665***
Break Date	2009M10, 2014M4	2008M6, 2015M6
Fraction	0.47, 0.71	0.40, 0.78
Lag	1	1
Two break LM test (Lee and Strazicich, 2003)		
LM Stat	-2.946	-5.722**
Break Date	2003M9, 2014M11	2008M4, 2017M4
Fraction	0.14, 0.75	0.39, 0.88
Lag	1	1

Mod A refers to Break in Level and Mod C refers to Break in Both Level and Trend. ZA (1992) One Break in Level CVs: -5.34 for ***1%, -4.80 for **5%, -4.58 for *10%. ZA (1992) One Break in Level and Trend CVs: -5.57 for ***1%, -5.08 for **5%, -4.82 for *10%. LS (2013) One Break in Level CVs: -4.23 for ***1%, -3.56 for **5%, -3.21 for *10%. LS (2013) One Break in Level and Trend CVs: -5.05 for ***1%, -4.50 for **5%, -4.18 for *10% when λ is 0.4. NP (2010) Two Break in Level CVs: -4.95 for ***1%, -4.31 for **5%, -3.89 for *10%. NP (2010) Two Break in Level and Trend CVs: -5.57 for ***1%, -4.93 for **5%, -4.59 for *10%. LS (2003) Two Break in Level CVs: -4.54 for ***1%, -3.84 for **5%, -3.50 for *10%. LS (2003) Two Break in Level and Trend CVs: -6.42 for ***1%, -5.65 for **5%, -5.32 for *10% when λ_1 is 0.4 and λ_2 is 0.8.

The Panamax freight from Roberts Bank to Rotterdam (ROBROT) variable is stationary according to one break ADF test (Zivot and Andrews, 1992) and two break ADF test (Narayan and Popp, 2010).

Table 25: Unit Root Tests with Structural Breaks for ROBROT Route

Test Items	Break in Level (Mod A) Robrot	Break in Level and Trend (Mod C) Robrot
One break ADF test (Zivot and Andrews, 1992)		
ADF Stat	-3.865	-4.945*
Break Date	2003M8	2008M6
Fraction	0.14	0.40
Lag	1	1
One break LM test (Lee and Strazicich, 2013)		
LM Stat	-2.873	-3.953
Break Date	2003M9	2008M7
Fraction	0.14	0.40
Lag	1	1

Two break ADF test (Narayan and Popp, 2010)		
ADF Stat	-4.794**	-6.099***
Break Date	2008M6, 2013M9	2008M6, 2014M9
Fraction	0.40, 0.68	0.40, 0.74
Lag	1	1
Two break LM test (Lee and Strazicich, 2003)		
LM Stat	-3.047	-5.215
Break Date	2002M12, 2003M9	2008M5, 2017M4
Fraction	0.10, 0.14	0.39, 0.88
Lag	1	1

Mod A refers to Break in Level and Mod C refers to Break in Both Level and Trend. ZA (1992) One Break in Level CVs: -5.34 for ***1%, -4.80 for **5%, -4.58 for *10%. ZA (1992) One Break in Level and Trend CVs: -5.57 for ***1%, -5.08 for **5%, -4.82 for *10%. LS (2013) One Break in Level CVs: -4.23 for ***1%, -3.56 for **5%, -3.21 for *10%. LS (2013) One Break in Level and Trend CVs: -5.05 for ***1%, -4.50 for **5%, -4.18 for *10% when λ is 0.4. NP (2010) Two Break in Level CVs: -4.95 for ***1%, -4.31 for **5%, -3.89 for *10%. NP (2010) Two Break in Level and Trend CVs: -5.57 for ***1%, -4.93 for **5%, -4.59 for *10%. LS (2003) Two Break in Level CVs: -4.54 for ***1%, -3.84 for **5%, -3.50 for *10%. LS (2003) Two Break in Level and Trend CVs: -6.42 for ***1%, -5.65 for **5%, -5.32 for *10% when λ_1 is 0.4 and λ_2 is 0.8.

The Panamax freight from South Wales to Rotterdam (RICROT) variable is stationary according to two break ADF test (Narayan and Popp, 2010) and two break LM test (Lee and Strazicich, 2003).

Table 26: Unit Root Tests with Structural Breaks for WAROT Route

Test Items	Break in Level (Mod A)	Break in Level and Trend (Mod C)
	Ricrot	Ricrot
One break ADF test (Zivot and Andrews, 1992)		
ADF Stat	-3.744	-4.681
Break Date	2003M2	2008M6
Fraction	0.11	0.40
Lag	1	1
One break LM test (Lee and Strazicich, 2013)		
LM Stat	-2.683	-3.763
Break Date	2003M9	2008M7
Fraction	0.14	0.40
Lag	1	1
Two break ADF test (Narayan and Popp, 2010)		
ADF Stat	-4.762**	-6.869***
Break Date	2008M6, 2014M4	2008M6, 2015M5
Fraction	0.40, 0.71	0.40, 0.77
Lag	1	1
Two break LM test (Lee and Strazicich, 2003)		
LM Stat	-2.918	-5.583*
Break Date	2003M9, 2012M5	2008M4, 2017M5
Fraction	0.14, 0.61	0.39, 0.88
Lag	1	1

Mod A refers to Break in Level and Mod C refers to Break in Both Level and Trend. ZA (1992) One Break in Level CVs: -5.34 for ***1%, -4.80 for **5%, -4.58 for *10%. ZA (1992) One Break in Level and Trend CVs: -5.57 for ***1%, -5.08 for **5%, -4.82 for *10%. LS (2013) One Break in Level CVs: -4.23 for ***1%, -3.56 for **5%, -3.21 for *10%. LS (2013) One Break in Level and Trend CVs: -5.05 for ***1%, -4.50 for **5%, -4.18 for *10% when λ is 0.4. NP (2010) Two Break in Level CVs: -4.95 for ***1%, -4.31 for **5%, -3.89 for *10%. NP (2010) Two Break in Level and Trend CVs: -5.57 for ***1%, -4.93 for **5%, -4.59 for *10%. LS (2003) Two Break in Level CVs: -4.54 for ***1%, -3.84 for **5%, -3.50 for *10%. LS (2003) Two Break in Level and Trend CVs: -6.42 for ***1%, -5.65 for **5%, -5.32 for *10% when λ_1 is 0.4 and λ_2 is 0.8.

As a result of the analyzes made for Panamax market, it is determined that the series are stationary and do not contain unit root when the breaks in the series are taken into consideration.

Handymax Market Results

The Ore price in the Handymax sample variable is stationary when the structural breaks in level and level and trend were considered according to two breaks ADF test (Narayan and Popp, 2010).

Table 27: Unit Root Tests with Structural Breaks for Iron Ore Price

Test Items	Break in Level (Mod A) Ore	Break in Level and Trend (Mod C) Ore
One break ADF test (Zivot and Andrews, 1992)		
ADF Stat	-3.24	-3.99
Break Date	2014M3	2014M7
Fraction	0.50	0.53
Lag	11	11
One break LM test (Lee and Strazicich, 2013)		
LM Stat	-2.10	-3.08
Break Date	2017M3	2014M3
Fraction	0.78	0.50
Lag	12	12
Two break ADF test (Narayan and Popp, 2010)		
ADF Stat	-4.64**	-4.58**
Break Date	2014M3, 2016M9	2014M3, 2018M3
Fraction	0.50, 0.73	0.50, 0.88
Lag	11	11
Two break LM test (Lee and Strazicich, 2003)		
LM Stat	-2.27	-4.79
Break Date	2011M3, 2017M3	2012M1, 2015M5
Fraction	0.21, 0.78	0.29, 0.61
Lag	12	12

Mod A refers to Break in Level and Mod C refers to Break in Both Level and Trend. ZA (1992) One Break in Level CVs: -5.34 for ***1%, -4.80 for **5%, -4.58 for *10%. ZA (1992) One Break in Level and Trend CVs: -5.57 for ***1%, -5.08 for **5%, -4.82 for *10%. LS (2013) One Break in Level CVs: -4.23 for ***1%, -3.56 for **5%, -3.21 for *10%. LS (2013) One Break in Level and Trend CVs: -5.11 for ***1%, -4.51 for **5%, -4.17 for *10% when λ is 0.5. NP (2010) Two Break in Level CVs: -4.95 for ***1%, -4.31 for **5%, -3.89 for *10%. NP (2010) Two Break in Level and Trend CVs: -5.57 for ***1%, -4.93 for **5%, -4.59 for *10%. LS (2003) Two Break in Level CVs: -4.54 for ***1%, -3.84 for **5%, -3.50 for *10%. LS (2003) Two Break in Level and Trend CVs: -6.41 for ***1%, -5.74 for **5%, -5.32 for *10% when λ_1 is 0.2 and λ_2 is 0.6.

The coal price in the Handymax sample variable is stationary when the structural breaks in level and level and trend were considered according to one break ADF test (Zivot and Andrews, 1992) and two breaks ADF test (Narayan and Popp, 2010).

Table 28: Unit Root Tests with Structural Breaks for Coal Price

Test Items	Break in Level (Mod A) Coal	Break in Level and Trend (Mod C) Coal
One break ADF test (Zivot and Andrews, 1992)		
ADF Stat	-4.91**	-3.43
Break Date	2016M5	2016M5
Fraction	0.70	0.70
Lag	1	1
One break LM test (Lee and Strazicich, 2013)		
LM Stat	-2.60	-3.00
Break Date	2016M9	2016M2
Fraction	0.73	0.68
Lag	2	2
Two break ADF test (Narayan and Popp, 2010)		
ADF Stat	-5.33***	-5.08**
Break Date	2010M9, 2016M5	2010M9, 2016M5
Fraction	0.16, 0.70	0.16, 0.70
Lag	1	1
Two break LM test (Lee and Strazicich, 2003)		
LM Stat	-2.81	-4.72
Break Date	2016M9, 2018M4	2011M2, 2016M6
Fraction	0.73, 0.88	0.20, 0.71
Lag	2	2

Mod A refers to Break in Level and Mod C refers to Break in Both Level and Trend. ZA (1992) One Break in Level CVs: -5.34 for ***1%, -4.80 for **5%, -4.58 for *10%. ZA (1992) One Break in Level and Trend CVs: -5.57 for ***1%, -5.08 for **5%, -4.82 for *10%. LS (2013) One Break in Level CVs: -4.23 for ***1%, -3.56 for **5%, -3.21 for *10%. LS (2013) One Break in Level and Trend CVs: -5.11 for ***1%, -4.51 for **5%, -4.17 for *10% when λ is 0.5. NP (2010) Two Break in Level CVs: -4.95 for ***1%, -4.31 for **5%, -3.89 for *10%. NP (2010) Two Break in Level and Trend CVs: -5.57 for ***1%, -4.93 for **5%, -4.59 for *10%. LS (2003) Two Break in Level CVs: -4.54 for ***1%, -3.84 for **5%, -3.50 for *10%. LS (2003) Two Break in Level and Trend CVs: -6.33 for ***1%, -5.71 for **5%, -5.33 for *10% when λ_1 is 0.2 and λ_2 is 0.8.

The wheat price in the Handymax sample variable is stationary when the structural breaks in level and level and trend were considered according to two breaks ADF test (Narayan and Popp, 2010).

Table 29: Unit Root Tests with Structural Breaks for Wheat Price

Test Items	Break in Level (Mod A) Wheat	Break in Level and Trend (Mod C) Wheat
One break ADF test (Zivot and Andrews, 1992)		
ADF Stat	-4.29	-4.26
Break Date	2010M5	2010M5
Fraction	0.13	0.13
Lag	5	5
One break LM test (Lee and Strazicich, 2013)		
LM Stat	-2.20	-3.27
Break Date	2014M12	2014M3
Fraction	0.57	0.50
Lag	1	1

Two break ADF test (Narayan and Popp, 2010)		
ADF Stat	-5.78***	-6.11***
Break Date	2010M5, 2014M4	2010M5, 2016M5
Fraction	0.13, 0.50	0.13, 0.70
Lag	6	5
Two break LM test (Lee and Strazicich, 2003)		
LM Stat	-2.52	-4.67
Break Date	2010M6, 2014M12	2012M10, 2017M2
Fraction	0.14, 0.57	0.36, 0.77
Lag	1	1

Mod A refers to Break in Level and Mod C refers to Break in Both Level and Trend. ZA (1992) One Break in Level CVs: -5.34 for ***1%, -4.80 for **5%, -4.58 for *10%. ZA (1992) One Break in Level and Trend CVs: -5.57 for ***1%, -5.08 for **5%, -4.82 for *10%. LS (2013) One Break in Level CVs: -4.23 for ***1%, -3.56 for **5%, -3.21 for *10%. LS (2013) One Break in Level and Trend CVs: -5.11 for ***1%, -4.51 for **5%, -4.17 for *10% when λ is 0.5. NP (2010) Two Break in Level CVs: -4.95 for ***1%, -4.31 for **5%, -3.89 for *10%. NP (2010) Two Break in Level and Trend CVs: -5.57 for ***1%, -4.93 for **5%, -4.59 for *10%. LS (2003) Two Break in Level CVs: -4.54 for ***1%, -3.84 for **5%, -3.50 for *10%. LS (2003) Two Break in Level and Trend CVs: -6.42 for ***1%, -5.65 for **5%, -5.32 for *10% when λ_1 is 0.4 and λ_2 is 0.8.

The Handymax freight from US Gulf to Japan (USJAP) variable is stationary according to one break ADF test (Zivot and Andrews, 1992), one break LM test (Lee and Strazicich, 2013), two break ADF test (Narayan and Popp, 2010) and two break LM test (Lee and Strazicich, 2003).

Table 30: Unit Root Tests with Structural Breaks for USJAP

Test Items	Break in Level (Mod A) Usjap	Break in Level and Trend (Mod C) Usjap
One break ADF test (Zivot and Andrews, 1992)		
ADF Stat	-4.81**	-4.31
Break Date	53	82
Fraction	0.42	0.65
Lag	12	12
One break LM test (Lee and Strazicich, 2013)		
LM Stat	-3.89**	-4.71**
Break Date	41	82
Fraction	0.32	0.65
Lag	12	12
Two break ADF test (Narayan and Popp, 2010)		
ADF Stat	-6.48***	-7.29***
Break Date	16, 40	17, 82
Fraction	0.12, 0.31	0.13, 0.65
Lag	12	12
Two break LM test (Lee and Strazicich, 2003)		
LM Stat	-4.57***	-4.97
Break Date	28, 41	53, 82
Fraction	0.22, 0.32	0.42, 0.65
Lag	12	12

Mod A refers to Break in Level and Mod C refers to Break in Both Level and Trend. ZA (1992) One Break in Level CVs: -5.34 for ***1%, -4.80 for **5%, -4.58 for *10%. ZA (1992) One Break in Level and Trend CVs: -5.57 for ***1%, -5.08 for **5%, -4.82 for *10%. LS (2013) One Break in Level CVs: -4.23 for ***1%, -3.56 for **5%, -3.21 for *10%. LS (2013) One Break in

Level and Trend CVs: -5.11 for ***1%, -4.51 for **5%, -4.17 for *10% when λ is 0.5. NP (2010) Two Break in Level CVs: -4.95 for ***1%, -4.31 for **5%, -3.89 for *10%. NP (2010) Two Break in Level and Trend CVs: -5.57 for ***1%, -4.93 for **5%, -4.59 for *10%. LS (2003) Two Break in Level CVs: -4.54 for ***1%, -3.84 for **5%, -3.50 for *10%. LS (2003) Two Break in Level and Trend CVs: -6.45 for ***1%, -5.67 for **5%, -5.31 for *10% when λ_1 is 0.4 and λ_2 is 0.6.

The Handymax freight from Pacific Northwest to South America (PANSA) variable is stationary according to one break ADF test (Zivot and Andrews, 1992) and two break ADF test (Narayan and Popp, 2010).

Table 31: Unit Root Tests with Structural Breaks for PANSA

Test Items	Break in Level (Mod A)	Break in Level and Trend (Mod C)
	Pansa	Pansa
One break ADF test (Zivot and Andrews, 1992)		
ADF Stat	-3.58	-4.92*
Break Date	62	71
Fraction	0.49	0.56
Lag	10	10
One break LM test (Lee and Strazicich, 2013)		
LM Stat	-2.19	-2.97
Break Date	19	63
Fraction	0.15	0.50
Lag	11	11
Two break ADF test (Narayan and Popp, 2010)		
ADF Stat	-5.17***	-6.07***
Break Date	71, 93	55, 91
Fraction	0.56, 0.73	0.43, 0.72
Lag	10	10
Two break LM test (Lee and Strazicich, 2003)		
LM Stat	-2.54	-4.27
Break Date	19, 63	36, 77
Fraction	0.15, 0.50	0.28, 0.61
Lag	11	11

Mod A refers to Break in Level and Mod C refers to Break in Both Level and Trend. ZA (1992) One Break in Level CVs: -5.34 for ***1%, -4.80 for **5%, -4.58 for *10%. ZA (1992) One Break in Level and Trend CVs: -5.57 for ***1%, -5.08 for **5%, -4.82 for *10%. LS (2013) One Break in Level CVs: -4.23 for ***1%, -3.56 for **5%, -3.21 for *10%. LS (2013) One Break in Level and Trend CVs: -5.11 for ***1%, -4.51 for **5%, -4.17 for *10% when λ is 0.5. NP (2010) Two Break in Level CVs: -4.95 for ***1%, -4.31 for **5%, -3.89 for *10%. NP (2010) Two Break in Level and Trend CVs: -5.57 for ***1%, -4.93 for **5%, -4.59 for *10%. LS (2003) Two Break in Level CVs: -4.54 for ***1%, -3.84 for **5%, -3.50 for *10%. LS (2003) Two Break in Level and Trend CVs: -6.41 for ***1%, -5.74 for **5%, -5.32 for *10% when λ_1 is 0.2 and λ_2 is 0.6.

As a result of the analyzes made for Handymax market, when the breaks in the series are taken into consideration, it is determined that the series are stationary and do not contain unit root.

If it is necessary to make an overall assessment of the freight rates, all of them are stationary and in accordance with the feature stated by Tvedt (2003). Freight

shocks are temporary and prices tend to return to mean over time. Strong breaks due to market structure may be experienced only in some periods.

4.2. CAUSALITY IN VARIANCE TEST RESULTS

The series must be stationary in order to perform this test recommended by Hafner and Herwartz (2006). According to the tests carried out in the unit root test section, all series are stationary when structural breaks are taken into consideration. For this reason, the series are included in the analysis logarithmically without any difference taking operation.

Capesize Market Results

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 32. 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 32: 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

H₀ rejected ***1%, **5%, *10%.

Secondly, the causality relationships in the variance between coal price and Capesize routes are examined and the results are presented in Table 33. 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 33: 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

H₀ rejected ***1%, **5%, *10%.

Thirdly, the causal relationships between wheat price and Capesize freights are tested and the results are presented in Table 34. 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 34: 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**

H₀ rejected ***1%, **5%, *10%.

Panamax Market Results

Causality in variance between commodity prices and Panamax routes are investigated and presented separately. The freight routes included are HAMROT (Hampton Road - USA to Rotterdam - Netherlands), RICROT (Richard Bay - South Africa to Rotterdam - Netherlands), ROBROT (Roberts Bank - Canada to Rotterdam

- Netherlands), WAROT (South wales to Rotterdam - Netherlands). The results of the analysis carried out for the causality in variance relationship between Panamax routes and iron ore prices are presented in Table 35. According to the results obtained, the null of non-causality hypothesis can be rejected for only 2 route. There are significant causal relationships from the Iron ore price to the freights on the HAMROT and RICROT routes.

Table 35: Results of Iron Ore and Panamax Routes

Causality-in-variance from	LM stat	p-value
ORE to HAMROT	5.192	0.0746*
HAMROT to ORE	0.445	0.8004
ORE to RICROT	5.453	0.0655*
RICROT to ORE	0.900	0.6375
ORE to ROBROT	2.293	0.3177
ROBROT to ORE	0.283	0.8679
ORE to WAROT	3.384	0.1841
WAROT to ORE	0.477	0.7877

H₀ rejected ***1%, **5%, *10%.

The causality relationships of coal price with Panamax routes are examined and the results are presented in Table 36. The results obtained show that only 2 out of 4 routes included in the study have significant causality results. These relations are formed from coal price to Hamrot and Ricrot routes.

Table 36: Results of Coal and Panamax Routes

Causality-in-variance from	LM stat	p-value
COAL to HAMROT	9.739	0.0077***
HAMROT to COAL	0.363	0.8339
COAL to RICROT	6.632	0.0363**
RICROT to COAL	1.563	0.4578
COAL to ROBROT	2.717	0.2571
ROBROT to COAL	2.344	0.3097
COAL to WAROT	3.521	0.1719
WAROT to COAL	2.964	0.2272

H₀ rejected ***1%, **5%, *10%.

Thirdly, the relationship between wheat price and Panamax routes and the results are presented in Table 37. The results show that the relationship between commodity price and freight has been partially complicated in this type of ship and cargo. As a result of the analyzes, significant causal relationships are determined for

all routes. In Hamrot and Ricrot routes, the relationship is bidirectional, and in Robrot and Warot routes, the relationships are from freight routes to wheat price.

Table 37: Results of Wheat and Panamax Routes

Causality-in-variance from	LM stat	p-value
WHEAT to HAMROT	6.720	0.0347**
HAMROT to WHEAT	5.620	0.0602*
WHEAT to RICROT	5.829	0.0542*
RICROT to WHEAT	7.983	0.0185**
WHEAT to ROBROT	2.604	0.2720
ROBROT to WHEAT	6.826	0.0329**
WHEAT to WAROT	3.989	0.1361
WAROT to WHEAT	10.836	0.0044***

H₀ rejected ***1%, **5%, *10%.

Handymax Market Results

For Handymax type ship routes, causality in variance analyses are applied separately according to the cargo type and the results are presented. The included freight routes are USJAP (US Gulf to Japan), PANSA (Pacific Northwest - US to South America). Firstly, analyzes are applied for iron ore and two Handymax routes and the results are presented in Table 38. According to the results of the applied analyzes, the null of non-causality hypothesis could not be rejected on either route. In other words, there is no significant relationship between iron ore prices and Handymax freights rates.

Table 38: Results of Iron Ore and Handymax Routes

Causality-in-variance from	LM stat	p-value
ORE to PANSA	2.787	0.2481
PANSA to ORE	4.314	0.1157
ORE to USJAP	0.754	0.6861
USJAP to ORE	4.507	0.1050

H₀ rejected ***1%, **5%, *10%.

Causality tests between coal price and Handymax routes are applied and the results are presented in Table 39. According to the results obtained, the null of non-causality hypothesis can be rejected for one routes. There is significant causal relationship from Usjap route to coal price.

Table 39: Results of Coal and Handymax Routes

Causality-in-variance from	LM stat	p-value
COAL to PANSa	2.868	0.2384
PANSa to COAL	3.892	0.1429
COAL to USJAP	1.978	0.3719
USJAP to COAL	9.696	0.0078***

H₀ rejected ***1%, **5%, *10%.

Thirdly, causality relationships with wheat price are tested for Handymax routes and the results are presented in Table 40. The results show that there is one causal relationship from Pansa route to wheat price.

Table 40: Results of Wheat and Handymax Routes

Causality-in-variance from	LM stat	p-value
WHEAT to PANSa	2.113	0.3477
PANSa to WHEAT	7.683	0.0215**
WHEAT to USJAP	0.591	0.7441
USJAP to WHEAT	0.273	0.8723

H₀ rejected ***1%, **5%, *10%.

Bunker Price Results

Since causality in variance relationships were determined from the wheat commodity price to the routes for the several ship, we thought that the significant relationship may actually stem from the fuel costs of the ships, based on the studies examining the wheat-oil relationship in the literature and obtaining meaningful results. We used Singapore LQM Petroleum bunker prices for this, the descriptive statistics for this variable are presented in Table 41. Since the causality in the variance test requires stationarity, the unit root tests were applied to the series in the next stage. Since these tests were already applied for wheat price in the previous section, only the results for bunker price were presented in this section.

Table 41: Descriptive Statistics for the Bunker Price

	BUNKER
Mean	361.5
Median	336.9
Maximum	732.3
Minimum	108.4

Std. Dev.	176.7
Skewness	0.39
Kurtosis	1.94
Jarque-Bera	17.0
Probability	0.00
Observations	233

Source: Bloomberg, 2019.

According to the unit root test results, the bunker price variable is stationary according to one break ADF test (Zivot and Andrews, 1992), one break LM test (Lee and Strazicich, 2013), two break ADF test (Narayan and Popp, 2010) and two break LM test (Lee and Strazicich, 2003). After verifying the stationarity, other tests were applied to test whether the structure of the series is non-linear.

Table 42: Unit Root Tests with Structural Breaks for Bunker Price

Test Items	Break in Level (Mod A) Bunker	Break in Level and Trend (Mod C) Bunker
One break ADF test (Zivot and Andrews, 1992)		
ADF Stat	-5.36***	-5.23**
Break Date	175	175
Fraction	0.75	0.75
Lag	2	2
One break LM test (Lee and Strazicich, 2013)		
LM Stat	-2.35	-3.38
Break Date	178	145
Fraction	0.76	0.62
Lag	2	2
Two break ADF test (Narayan and Popp, 2010)		
ADF Stat	-6.11***	-6.06***
Break Date	58, 175	58, 175
Fraction	0.24, 0.75	0.24, 0.75
Lag	2	2
Two break LM test (Lee and Strazicich, 2003)		
LM Stat	-2.88	-5.30
Break Date	178, 186	142, 189
Fraction	0.76, 0.79	0.60, 0.81
Lag	2	2

Mod A refers to Break in Level and Mod C refers to Break in Both Level and Trend. ZA (1992) One Break in Level CVs: -5.34 for ***1%, -4.80 for **5%, -4.58 for *10%. ZA (1992) One Break in Level and Trend CVs: -5.57 for ***1%, -5.08 for **5%, -4.82 for *10%. LS (2013) One Break in Level CVs: -4.23 for ***1%, -3.56 for **5%, -3.21 for *10%. LS (2013) One Break in Level and Trend CVs: -5.11 for ***1%, -4.51 for **5%, -4.17 for *10% when λ is 0.5. NP (2010) Two Break in Level CVs: -4.95 for ***1%, -4.31 for **5%, -3.89 for *10%. NP (2010) Two Break in Level and Trend CVs: -5.57 for ***1%, -4.93 for **5%, -4.59 for *10%. LS (2003) Two Break in Level CVs: -4.54 for ***1%, -3.84 for **5%, -3.50 for *10%. LS (2003) Two Break in Level and Trend CVs: -6.32 for ***1%, -5.73 for **5%, -5.32 for *10% when λ_1 is 0.6 and λ_2 is 0.8.

Selected model for Bunker is ARMA (0, 1) with -2.138 AIC value. There is ARCH effect for lags of 1, 4, 8 and 16, and dependency in the squared residuals. BDS test results, which are presented in Table 43, indicated nonlinear structure in the series. In this case, it is concluded that it is appropriate to apply causality in variance test.

Table 43: BDS Independence Test Results for Bunker Price

Dimension	BDS Statistic	Std. Error	z-Statistic	Prob.
2	0.033465	0.005914	5.658848	0.0000
3	0.055320	0.009435	5.863190	0.0000
4	0.066467	0.011281	5.892171	0.0000
5	0.073512	0.011805	6.227035	0.0000
6	0.075473	0.011431	6.602327	0.0000

The results of the causality test in the variance applied between wheat and fuel price are presented in Table 44. According to the results obtained, a significant causality relationship was determined from the fuel price to the wheat price.

Table 44: Results of Bunker and Wheat

Causality-in-variance from	LM stat	p-value
Bunker to Wheat	5.934	0.0515
Wheat to Bunker	2.168	0.3382

H₀rejected ***1%, **5%, *10%.

4.3. EVALUATION OF THE GENERAL RESULTS

According to Cheung and Ng (1996), changes in the variance of a variable are related to how new information is received and evaluated. In this context, it can be said that supply-demand information is transferred from commodity prices to freights. Price changes in the commodities carry this information, as the prices of commodities mainly affect the demand for them or their supply, or are affected by these factors. For instance, price increase due to the increase in demand may reflect positively on the maritime freight markets, while price increase due to the supply interruption may reflect negatively on the market. All this information is reflected primarily on the price of the commodity and then on the freight levels.

When we evaluate the causality in variance test results in general, it can be stated that a result like Table 45 appears. There is a causal relationship in variance from iron ore and coal prices to all Capesize freight routes in the sample. When looking at the situation for wheat commodity, there is a causality relationship both from wheat price to all routes and from all routes to wheat price. Results obtained for the Panamax market show similar characteristics to the Capesize market. A significant causal relationship was obtained from iron ore and coal prices to two of the four routes in the sample, which are Hamrot (Hamphthor Road - USA to Rotterdam - Netherlands) and Ricrot (Richard Bay - South Africa to Rotterdam - Netherlands). When the relations for wheat were examined, a significant causality relationship was determined from wheat prices to all routes, while a significant relationship was determined from wheat prices to two routes, which are again Hamrot and Ricrot. For Handymax, significant relationships detected are relatively less. While a significant causal relationship with ore price could not be spotted, causality relationships were determined from USJAP route to coal price and from PANSAR route to wheat price.

Table 45: General Results According to the Freight Market

Commodity Price	Causality Direction	Freight Market
Iron Ore	→	Capesize
Coal	→	Capesize
Wheat	↔	Capesize
Iron Ore	→	Panamax
Coal	→	Panamax
Wheat	↔	Panamax
Iron Ore	X	Handymax
Coal	←	Handymax
Wheat	←	Handymax

Considering that Capesize type ships are specialized in iron ore cargoes and according to Meersman et al. (2014), 70-80% of the total iron ore cargo is carried by this type ships, it is inevitable that any situation related to iron ore will affect this market. Price changes in iron ore spillover to Capesize freights. In other words, the variance of the ore price affects the variance of the freights by generating a flow of information. Although iron ore is heavily transported by Capesize-type ships, the

impact of ore price on the Panamax-type ships may be due to the neighboring market impact as we have reviewed while examining the industry reports. Because Capesize traffic, which intensifies when iron ore demand increases excessively, and increased freights may cause Panamax type vessels to enter the iron ore market. Although transportation costs per unit are not as low as Capesize ships, they can still make a profit after a certain level of freight in the iron ore transportation.

The fact that there is a causal relationship from the iron ore price and the coal price to the Capesize and Panamax market routes may be related to the intensive use of these products in the industrial area. The general areas of use of iron ore are construction, infrastructure, automotive, white goods and machinery industries, while the general areas of use of coal are power generation, steel and cement production, coal liquefaction and household consumption, which are important areas for national economies and household welfare. For all these reasons, the demands of these commodities may not be affected by the transportation costs, and therefore a significant causal relationship from freight rates to commodities may not be detected in Capesize and Panamax markets. In contrast to these markets, in the Handymax market, a significant causality relationship was determined from the freight route to the commodity price. This may be related to the transportation costs of ship types per unit. For example, the average shipping freight per ton on routes included in the study are \$ 17.83 for Capesize routes, \$ 19.25 for Panamax routes and \$ 48.17 for Handymax routes. Although the rate of transportation of coal by Handymax type ship is relatively low, the price of coal tends to response according to the information flow in the Handymax freight routes as the average transportation cost is high compared to the coal price in this market. The absence of any significant relationship between Handymax freights and the price of iron ore is probably due to the very rare use of this vessel type in the transportation of iron ore. They are used in inland waters and ports where large ships cannot berth due to physical conditions. Freight owners are therefore willing to pay high transportation costs per unit.

This situation in iron ore and coal may also be due to the market structure. In some sources, 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). In this context, due to companies that have the power to influence the prices of these commodities, the information flow may have occurred from commodity prices to freights. In addition, according to the results of the BDS test, these two markets could not be determined as efficient in the weak form, and it was demonstrated that the prices are dependent on the historical values and can be estimated.

The situation differs partially for wheat commodity. While there are one-way relations of freight routes with other cargoes types, there are routes with two-way relations with wheat. This may be due to the structure of the wheat market or its close relationship with oil. Since the market is defined as a perfectly competitive market, 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). As there are many companies in this respect, they may adjust the price according to the information from the freights in order to maintain commercial activities in the market.

Grains can be used extensively in bio fuel production depending on the situation in oil prices. As production costs are relatively high, they are affected by volatility in oil prices. This situation has been confirmed by many studies in the literature (Alghalith, 2010; Alom et al., 2011; Nazlıoğlu et al., 2013). In this context, a volatility spillover from freight to wheat price may have been achieved since the most important voyage costs of ships are fuel costs and freight is affected by volatilities in this commodity.

Another finding for wheat commodity is the findings related to the validity of the Efficient Market Hypothesis (EMH) in the weak form, although it is not within the scope of this study. BDS Independence test has been used in many studies (Blasco et al., 1997; Afonso and Teixeira, 1998; Dorina and Simina, 2007; Lim and Brooks, 2011; Bhattacharai and Margariti, 2018) to measure market efficiency before. In this study, the method we use for testing non-linearity also provides information about the structures of the markets since it tests whether there are possible hidden dependencies between the values through the time. In this respect, the null hypothesis of the BDS

test could not be rejected in the tests performed for all three ship-type samples for wheat price. This situation shows that wheat price is efficient and moves randomly. In other words, tomorrow's price is independent of today's, and future prices cannot be estimated using information in the historical data. This can be explained by the fact that wheat depends on seasonal conditions and there are many irregularities in its production. In this respect, since wheat is a commodity that is difficult to maintain and store compared to other industrial products (iron ore and coal), it may be affected by volatility from freight due to commercial concerns regarding export activities. Generally speaking, the most logical situation about wheat is that it is affected by the volatility in the freight due to its close relationship with the price of oil.

The finding related to Capesize and ore price relationship also accords with the results of the studies conducted by Tsioumas and Papadimitriou (2018), Aık and İnce (2019) and Aık and Baer (2019), which reveals that iron ore price movements are effective in the Capesize freight market. The finding regarding to coal and Capesize relationship is determined in the study conducted by Tsioumas and Papadimitriou (2018). The impact of ore price and coal to Panamax market is empirically found in Aık and İnce (2019). In addition, while the only study in the literature containing analysis related to the Handymax market conducted by these researchers, it was determined that iron ore and coal prices were effective in Handymax freights, while the causal relationships were determined from freight rates to commodity prices in our results. Finally, in the study conducted by Tsioumas and Papadimitriou (2018) on the Panamax market, causality relationship was determined from wheat price to Panamax freight in a similar way to us.

CONCLUSION

We started our research by addressing commodity trading around the world, because it was important to understand the market for which commodities are traded intensively for which countries. The commodities we have chosen represent 3 main bulk cargoes that are mainly transported in dry bulk transport; iron ore, coal and grain. Since there is no general grain price, we aimed to apply our analysis based on the wheat price, by considering it as a proxy variable. Then, we talked about the role of

maritime transport in global commodity trading through various statistics. Since each cargo type has different parcel size distribution functions, ships used these carrying activities mostly specialized in carrying special cargoes. The source of the main research questions of our study has emerged from this situation, it is related to whether there is a difference in the relations between commodity price and freight rates according to the vessel specializations. After this general introduction, since the main scope of our study is freight rates, we have mentioned transportation costs and factors affecting these costs, which is one of the most important factors for shipowners in determining freight levels. Since maritime transport has a derived demand structure, we tried to examine which factors affect this demand. Then, we investigated how ship owners responded to this demand and how the carrying capacity in the market was determined. Basically, it was important to examine these supply-demand factors, as the freights emerged from the interaction of supply and demand. After addressing these factors, we examined how freight rates were affected by the interactions of supply and demand in the short and long run. We touched upon the freight cycles generated by this interaction in the short and long run. The freight market is the basis of the maritime market, but there are also newbuilding, sale & purchase and demolition markets, so we briefly explained these markets and tried to draw a general framework for the whole maritime market. At this point, we have completed evaluating the freight market, which is one of the two main parties of our study, and started to examine the structure of commodity prices, the other party. In general, we theoretically examined how commodity prices are formed in the short and long run, and we determined that the short run mechanism is similar to the short run mechanism of maritime transport. Then, we found that commodity prices fluctuate like many other financial markets and were very volatile. We completed the section on commodity prices by examining the iron ore, coal and wheat markets used in the study, and examined the academic studies examining the freight market and commodity market relationships. At this point, we examined the studies in the literature and tried to position our study. After examining the general literature, we tried to determine how the commodity price-freight relationship is evaluated in practice in the market by researching the market reports. After drawing the general framework about the freight and commodity markets, we came to our own research section and started our analysis.

In the analysis of causality in variance, which is the method we use in our study, the series should be stationary. Therefore, as a result of the unit root test we applied, we determined that all the variables we included in the study were stationary when the structural breaks were taken into account. Also we detected both level and trend-breaks in the freights of Capesize and Panamax ships in the period of 2008. For Handymax, although the date of structural break varies since the dataset started after 2009, the freights were determined as stationary for all ship types considering the structural breaks. The global economic crisis in 2008 also hit maritime markets which have derived demand structures, resulting in very serious declines in freight, leading to structural breaks in the series, causing changes in the level and trend. In the study conducted within the context of this thesis (Açık and Başer, 2019a), where we examined the effect of this break on the freight-commodity relationship, we found that there was a break in 2008 for the Capesize Salbe freight route, and the effect of the iron ore price on freight was different when the sample was divided into two from this date. The results revealed that positive shocks in ore price are causes of positive shocks in freight in the pre-crisis, and negative shocks are causes of negative shocks in the post crisis period. This showed that market dynamics differed after the crisis. As a result, we found that the series is stationary for all freights and commodities. This shows that all prices temporarily carry shocks and tend to return to the average.

In addition to the stationary condition, since the method used is a non-linear one, we have passed the stage of testing the linearity of the series. We applied BDS Independence (Brock et al.,1987), ARCH (Engle, 1982) and LB (Ljung-Box, 1978) tests. In the linearity tests, separate analyzes were applied for Capesize, Panamax and Handymax samples. In all series except wheat, nonlinear structures have been confirmed by many tests. For wheat, non-linear structure was determined by ARCH and LB tests in Capesize sampling. It was not detected in other samples. Based on the first determination in this Cape sample and the fact that the routes are not linear in other samples, it was thought that there was no inconvenience in the inclusion of wheat in the analysis. The fact that the variables are not linear indicates that they are affected by many shocks and unexpected events globally. This disrupts the structures of the series and causes the parameters to change over time in the modeling. In addition, since the BDS test is also used for EMH validity test in weak form, it can be said that wheat

price is efficient in the weak form. This shows that the price is moving randomly and cannot be estimated on the forecasting methods. In this way, it is not possible to make extraordinary profits by using historical data. After deciding that the series are stationary and non-linear, we applied apply causality in variance analysis.

Causality in variance analysis is a method used to analyze the information flow between the series, volatility spillover between markets and hence the risk transmissions between them. In this context, we tested the causality relationship between the prices of iron ore, coal and wheat cargoes, which are 3 main dry bulk cargoes, and the 3 main ship types, which are Capesize, Panamax and Handymax, used to transport these cargo types.

When the subject is examined in terms of Capesize freights, significant causal relationships were determined from all commodity prices to all freight routes in the sample. This situation indicates that commodity price volatilities originating from production cost and supply-demand relations spread to Capesize freight markets, in other words, the risk has spread to the freight markets as it also shows volatility risk. In fact, in a study we conducted within the scope of the thesis (Başer and Açıık, 2019a), we found that iron ore prices are determinant even for the second hand values of Capesize type ships, which can be presented as an evidence of how important the commodity market is. At the same time, significant volatility spillovers from freights to wheat price were determined. An additional application has been carried out considering that this is a result of the oil price-grain price interaction encountered in the literature research. As a result of causality in variance analysis between bunker price and wheat price, a significant spread was determined from the bunker price to the wheat price, so that the relationship from freight to wheat price is thought to be emerged due to this interaction, since the main voyage cost item of the ships is the oil price. Similar results regarding wheat price were determined for Panamax and Handymax routes and this hypothesis was confirmed.

According to the Panamax market results, volatility spillovers from the price of iron ore and coal to Panamax freight routes were determined for 2 of the 4 routes subject to the study. This may be related to the characteristics of the routes under consideration, as significant and insignificant routes are the same. Similar results of Capesize and Panamax routes for coal and iron ore prices can be explained by two

situations; (i) complementary cargoes, (ii) neighboring market conditions. Since iron ore and coal are industrial products, and one of the common uses of coal is the steel industry, demand for steel can also affect demand for coal and volatility spillovers can yield similar results. Because the coal in the world is intensely carried by Capesize and Panamax type ships. The neighboring market situation also includes the term "Cape-split", which emerged as a result of examining sectoral reports in the previous sections. When the Capesize market is extremely alive, ore cargoes shift to Panamax vessels, which may explain the spillover of volatility in iron ore prices to Panamax freights. In fact, Cape-split cargoes may be carried more intensively on routes which are significant in the Panamax market application. For the Panamax market, significant causal relationships were determined from the wheat price to the same 2 routes, which are significant in ore and coal price analysis. On the other hand, causality in variance tests from wheat prices to all routes are significant. As we mentioned before, this situation is thought to arise from the interaction of grain and oil prices.

For the Handymax market, we could not find any significant relationship with iron ore. This can be explained by the fact that these types of ships are used very little for this cargo and the cargo transmittance with other type of ships is low. For coal, a significant relation was determined from a route to coal price. Freight volatility may be affecting wheat prices, as transportation costs per unit are the highest in this type of ship compared to other ones. For wheat price, 1 out of 2 routes has a significant spillover from route to wheat price, and is probably a situation related to oil price again.

In general, we determined significant causality in variance relationships from some cargoes to some routes. These relationships can be interpreted as information flow and spread. Commodity prices, which are shaped by factors such as production costs, supply-demand balance, natural events and market expectations, carry this information and transfer it to the maritime market which has a derived demand structure. Whether positive or negative, volatility in prices spillovers to the freight markets and the risk in the commodity market is transferred to freight market. In this context, price discovery in freights is shaped according to the information carried by commodity prices. The high risk in commodity prices causes high risks in the freight market. Within the framework of the research questions, it has been determined that

the information flow may differ according to the commodity type and there is not only information flow to the freight of the ships from which the cargoes are transported intensively, there are also spillovers to other kind of ships.

Originality of the Research

This study differs from the studies in the literature in two different ways. Firstly, some studies tried to derive results by using general freight indices in their analysis. However, depending on the weights of the variables in the indices, different types of ships and routes can direct the index by pulling up or down other variables. In this study, we applied our analyzes on individual routes of each ship type. We then tried to achieve generalizable results through these individual results.

Secondly, no study examining the flow of information due to the change in variance at current prices has been encountered. Derivative markets may be lacking in understanding the relationship between variables, as conditions at that time in the future are uncertain. However, it is still important for the current studies to show the leading indicator situation and the information flow between them, so that the ship owners can make their decisions more positively. Our study aims to examine the information flow and spillover between commodity prices and freights based on the events that have taken place. In this respect, it can be said that understanding the past mechanism is important for understanding possible future relationships.

Practical Implications

The maritime market is a high-risk market by nature. In this respect, it is important for ship owners to reduce the risks arising from uncertainty in order to carry out sustainable commercial activities. As a result of our research for 3 major ship types subject to our study, we examined their relationship with 3 major dry bulk cargoes. Ship owners or charterers who operate such ships and carry out their commercial activities can benefit from our findings in the cargo they target. For example, the risks in iron ore and coal cargoes spillover to the freight of Capesize and Panamax vessels, while Handymax vessels are not affected by these risk transfers. Accordingly, people

who will charter their ships for a long period may also choose customers based on the commercial philosophies of the shippers and prefer risk-free cargo markets.

Limitations of the Study and Further Research

Some limitations of the study posed obstacles to more comprehensive analysis. The first one is the availability of the freight information for 3 routes for the Capesize market and only 2 routes for the Handymax market. For Panamax market, conducting analyzes with information about 4 routes has made it possible to obtain more comprehensive results. A second constraint is that the route information obtained for Handymax type ships includes freights after 2009. More generalizable results would have been possible with a more comprehensive data set.

In subsequent studies, information and risk transfer trends in different periods can be examined by taking into account the breaks in the data set. For example, the 2008 economic crisis is a very important breaking point for both the world economy and the shipping market. As a result of unit root tests that take into account the breaks we have done, significant breaks were detected in the 2008 period. This finding is an important research question to examine the situation before and after the crisis, as we conducted in a study (Açık and Başer, 2019a) by a different method.

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