Interdepartmental Master of Science (MSc) in International Shipping, Finance and Management (ISFM)

«Empirical investigation on how oil prices affect container freight rates»

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CERTIFICATION OF THESIS PREPARATION

"We hereby declare that this particular thesis has been written by us, in order to obtain the Postgraduate Degree in International Shipping, Finance and Management, and has not been submitted to or approved by any other postgraduate or undergraduate program in Greece or abroad. This thesis presents our personal views on the subject. All the sources we have used for the preparation of this particular thesis are mentioned explicitly with references being made either to their authors, or to the URL's (if found on the internet)."

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Abstract

This paper examines the impact of crude oil prices on container freight rates in four (4) different routes of container shipping services. Specifically, data from 4 different routes for the period 2016-2021 were used. The research is focused on this period because data were limited and for some routes did not even exist. The econometric model was estimated using the least squares method and panel data analysis was also performed using fixed and random effects estimators. The findings show that the crude oil prices affects container freight rates in a positive way, while the oil demand does not play any role in determining container freight rates.

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Chapter 1: Introduction

The shipping sector is one of the most important sectors of the economy, generating high profits and making an excellent contribution to it. This means that changes in the economic environment affect it. The link between the shipping sector and the oil market and its derivatives is also direct, since the fleets of shipping companies require fuel to move in order to operate and transport goods and services. After all, oil is the main source of energy and fuels both for the global economy and transport. It is becoming increasingly expensive to extract, and reserves are dwindling, making it a scarce commodity. If the inability of maritime transport to use alternative energy sources is taken into account, it is understandable that the cost of maritime transport services is increasing. This raises the question of how oil prices may affect the freight rates.

The answer to the question about the impact of oil prices and their changes on maritime freight rates is an important issue, especially for countries that rely heavily on shipping and whose ports serve an important number of vessels on daily basis. Over the years various studies have been conducted in order to examine this relationship, but mainly in the dry bulk sector, in the shipping sector and in the transport sector. In the container sector, research is scarce and does not focus on the effect of oil prices, but mainly on the container market itself.

The purpose of this paper is to examine the effect of oil prices and its standard deviations on container freight rates. At the same time, the effect of oil demand on freight rates is also examined. Thus, on the basis of the studies carried out both in the container sector and in other sectors of shipping, an increase in oil prices leads to an increase in container freight rates (UNCTAD,2008a; Hummels, 2007, 2009; OECD, 2008). Of course, there are also unquantifiable factors that may influence freight rates.

The study focuses on four (4) cargo routes for specific periods. The second chapter analyses the markets that take part in the analysis, such as oil and containers. The third chapter presents the results of all the studies conducted so far that examine the relationship between oil prices and container freight rates. Although the literature is

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limited, all the results show the positive relationship between freight rates and oil prices. The fourth and final chapter of the paper presents the results of the estimations carried out. The hypotheses under which the estimated models are tested and the independent variables used in each model are reported.

Chapter 2: Analysis of the markets

Shipping has for many years been, and remains, the core activity of many economies, on which they rely for their growth. According to UNCTAD (2022), over 80% of the world's trade volume is moved by sea, and particularly in the midst of the COVID-19 pandemic, seafarers ensured that many goods essential for survival were distributed around the world. Based on this, it can be understood how important maritime trade is to any economy, one must be able to estimate freight rates for the transport of goods in order to understand the operation mechanisms of each market.

In this thesis we are using an econometric model to understand the relationship between freight rates and the price of crude oil. In order to understand the results of the model, we must first analyze the theory surrounding the industries under consideration and understand how freight rates are set and how they are affected. Knowledge of the industries under consideration will help to interpret better the results of the empirical analysis later on.

2.1 Shipping Container Market

The first sector to be analyzed is containers' sectors. Levinson (2006), states that in the nineteenth century, the shipping industry began to experience significant changes as railways, steamships and canals merged into a global transport network. Due to steamship technology, shipowners began to offer scheduled services via ships with multiple decks, called cargo liners. Shipping companies that offer regular shipping services for any cargo that can be packed in containers at predestined ports, are called shipping line. These companies operating with liner services offer customers the advantage of knowing in

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advance both the schedule and the freight rate, which does not have the large fluctuations that the bulk shipping market has. As a result, freight rate levels are predictable and services are considered reliable (Stopford, 1997).

A major advantage of the cargo liner service was the flexibility to transport a mix of industrial products, semi-industrial products, small cargo and passengers. The problem, however, was that despite the flexibility in transportation, the process of loading and unloading all the cargo to and from the ship was very slow, requiring many hours of labor to complete. This development in the transport process also had a significant impact on the cost of transport, because in the late 1950s, a percentage of 60-75% of the cost of transporting cargo by sea was done at the port, whereas at that time, in the context of ocean container transport, this figure had fallen to 37% of total maritime costs.

Furthermore, Stopford (2009) points out that due to the containerization of maritime transport there has been a reduction in port time, with data showing that the port time of a container ship has decreased to only 17% in comparison to the port time of a cargo ship. Another conclusion drawn by the researcher is that in addition to the reduction in port time, containerization has also changed the way liner shipping companies operate. The innovation of containerization has forced the shipping sector to consolidate, leading to the consolidation of liner shipping. There have even been changes in ships, as the market for ships carrying containerized cargo has disappeared. Small bulk carriers were specialized into categories, open hatch bulk carriers, tankers carrying parcels, car carriers, truck carriers, multipurpose vessels (MPPs) and heavy lift vessels. Of course, the changes in the shipping industry also led to changes in the global economy, which were more significant. Transport between different regions became faster, more reliable and cheaper than before containerization. It is worth noting that in 2004, the cost of transporting a container from the Far East to Europe was very cheap, with the price being less than $1 per unit. Given this, cost and distance cease to be important factors in the manufacturing industry (Stopford, 2009).

Notteboom (2004) states that the maritime container shipping industry is similar to the original liner market. As far as the liner market is concerned, the companies in the

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industry are basically organized in joint ventures and other types of strategic alliances, with each individual company having uniform freight rates, which are often quite high. McLellan (2006) describes this relatively high charge as "charge what the traffic can bear". As in any market where strategic alliances are observed, in the liner market these alliances have policies to deal with internal and external competition and because of these policies there is a concentration of industry power in a few companies (i.e 2M, Ocean Alliance, The Alliance). The competition among container liner shipping companies is centered on the quality of services provided, since, as already mentioned, there is uniformity in the charging of freight rates. Due to the high investments necessary for containerships, the companies involved seek to achieve economies of scale through the optimization of their fleet (Levinson, 2006).

The container market has made great progress in the past decades due to technological advances, geopolitical developments and the expansion of global trade. For example, while in 1980, cargo shipping volume accounted for 23% of global trade, in 2009 it ranged from 77%-90%. Even cargo tonnage has increased over the same period of time, resulting in an increase in high-capacity ships (Rodrigue et al, 2009; Barthelemi, 2011; Ducruet and Notteboom, 2010). Another factor that contributed to the rapid growth of the market, according to Kaluza et al (2010), is the globalization phenomenon. The increase in capacity on ships and thus the increase in the capacity to carry larger cargo, along with the increase in the size of ships, help companies to achieve the economies of scale mentioned earlier and reduce the cost of freight rates (McCalla et al, 2005).

In 2019 the global container market was worth $8.7 billion and was forecast to reach $12.08 billion in 2027. Owing to the efficiency in transporting cargo and the safe mode of transportation offered by waterways, there has been an increase in the demand for this way of cargo transportation. In addition, the cheap leasing of ships for cargo to be moved from point A to point B makes this way of transportation more attractive than transporting cargo via road or air. Over the years, merchant ships have become more efficient, equipped with the latest technology and this creates more demand for transporting cargo through them. This also helps the container market to grow more (Singh, 2020).

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The Covid-19 pandemic affected the global economy, thus the container market could not be unaffected. The effects of the pandemic were evident in all economies, as many businesses ceased to operate, productivity in countries decreased, trade between countries was disrupted and tourism practically stopped because travel was banned. As Irakli (2021) explains in his study, the effects of the pandemic on the global container shipping industry were both short and long term. In the short term impacts were the shortage of containers and space on ships, which he believes will remain unchanged. Given the imbalance between supply and demand, freight rates will remain high. As for the long-term impact, the researcher believes that the global container shipping industry will turn to digitalization of processes to support the automation of the industry to minimize the impact of labor shortages due to the pandemic. Apart from this, according to the author, the increase in the international division of labor, rising incomes and consumption opportunities are some of the consequences we should expect in the future in developing economies. To avoid the gap between the potential future growth in container levels and the capacity of the global container shipping industry, companies are expected to charter larger ships and use more efficient systems for loading and unloading them, which will create leverage in the exploitation of economies of scale by firms. As global chains appeared to be vulnerable to national lockouts, the global container shipping industry will adopt changes to protect itself from such threats. Such changes include the development of smaller supply chains, increase in alternative logistics systems, such as the introduction of multifunctional warehouses close to markets to reduce transit time to destinations. This means that companies may return to the just-in-case model, abandoning the just-in-time model they have been using so far.

Another phenomenon that has drastically affected the container market is the war in Ukraine. Due to the war, many countries have been forced to source oil, gas and grain from more distant suppliers. According to a study by the United Nations Conference on Trade and Development (UNCTAD, 2022), the war in Ukraine increased shipping costs around the world as trade in the Black Sea was fragmented. Those countries that sourced oil, gas and grain from Ukraine were forced to turn to other countries to import these commodities. The shutdown of ports in Ukraine, the destruction of important

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infrastructure at trade destinations, increased insurance costs and higher fuel prices are some of the reasons that prevented trade in the Black Sea region. For cereals in particular, the study is concerned because both Ukraine and Russia were leaders in the agri-food market and these in turn are linked to poverty reduction and food security.

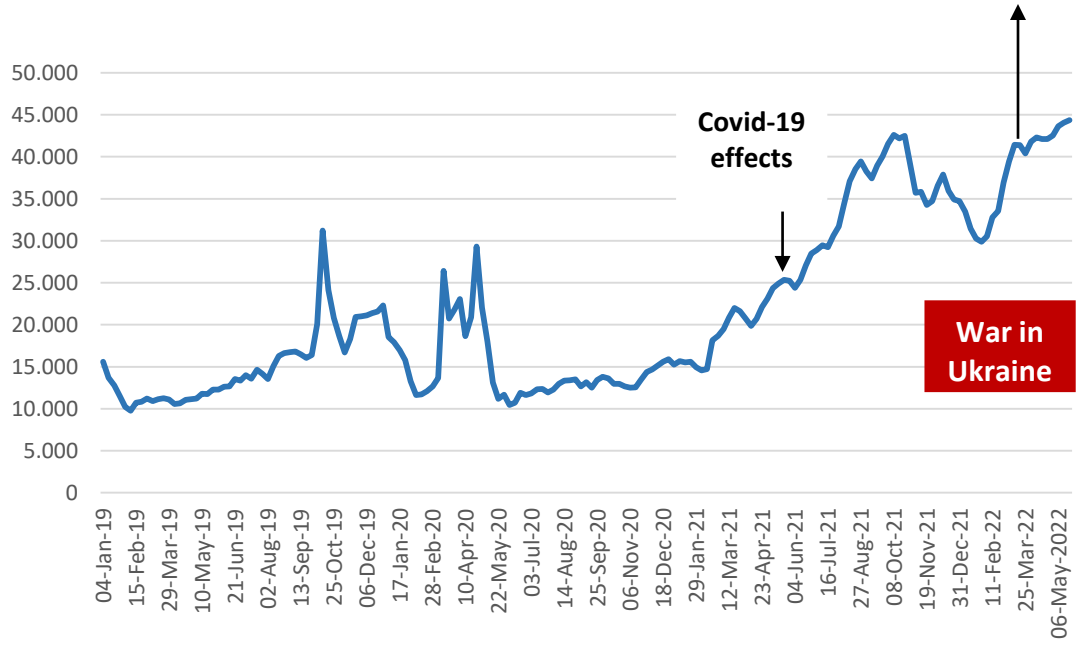

Figure 1: ClarkSea Index in Thousand USD/day– all shipping markets.

Source: UNCTAD Secretariat, based on data from Clarksons (2022)

Notes: ***The series tracks average vessel earnings across the major shipping sectors, including tankers, bulkers, containerships and gas carriers, weighted by the number of ships in each segment.***

Figure 1 above shows the evolution of the Clarksea index, which is produced by Clarkson Shipping. The index captures the average dollar earnings per day of all fleets. The calculation of the index includes from the Tankers sector the average earnings of the VLCCs, Suezmax and Aframax; from the Dry Bulk sector the average earning of Capesize, Panamax, Handymax and Handysize; the Line sector is represented by 1700-TEU Containerships and the Gas sector by VLGCs[1].

[1] https://shippingresearch.wordpress.com/2012/07/05/the-clarksea-index-the-heart-rate-monitor-of-the-shipping-industry/

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It is also important to show graphically the evolution of container traffic in the ports. Figure 2 below shows the increase in container traffic in ports worldwide, but especially in ports that are key to the analysis. From 2000 onwards the increase in traffic is very high showing the boom in container leasing for the transport of goods and materials.

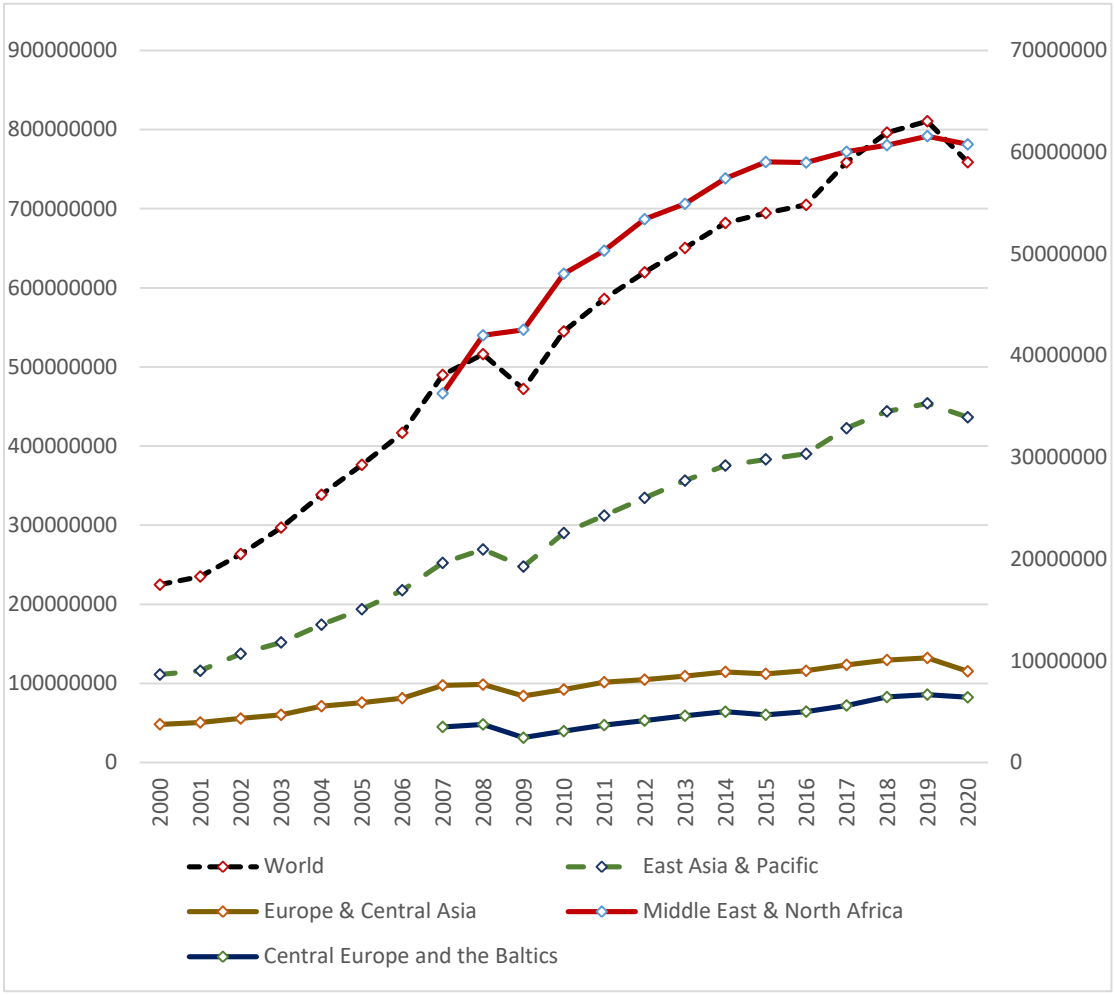

Figure 2: Container Port Traffic (TEU: 20 foot equivalent units)

Source: World Bank (2022) (IS.SHP.GOOD.TU)

For Central Europe and the Baltic countries (Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic, Slovenia, Turkey) in particular, the increase is negligible and shows that traffic has remained stable at low levels. The data for Europe and Central Asia (Albania, Armenia, Azerbaijan, Belarus,

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Bosnia and Herzegovina, Bulgaria, Croatia, Georgia, Kazakhstan, Kosovo, Kyrgyz Republic, Moldova, Montenegro, North Macedonia, Poland, Romania, Russian Federation, Serbia, Tajikistan, Turkey, Turkmenistan, Ukraine, Uzbekistan) show the same. Container traffic in ports in 2020 is clearly higher than in 2000, but this increase is very small. In contrast, in East Asia and the Pacific (American Samoa, Australia, Brunei Darussalam, Cambodia, China, Fiji, French Polynesia, Guam), the increase in container traffic at ports is very high. From 111,180,913 units in 2000, it reached 436,372,016.4 units. Finally, although for the Middle East and North Africa (Algeria, Bahrain, Djibouti, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, United Arab Emirates, West Bank and Gaza, Yemen) the data starts from 2007, it appears that there too the increase in container traffic from 2000 to 2020 is very high. It is worth noting that for all regions from 2019 to 2020, there has been a drop in traffic, which is of course due to the Covid-19 pandemic and the blockades in the transport of goods and materials that it brought.

2.2 Oil market

The second market that we are interested in and that we will be looking at is the oil market and more specifically crude oil. Stopford (2009) states that oil includes in its term many derivatives, different from each other, and crude oil is one of them, referring to the initial state of oil before it is processed to create other products. Gasoline and kerosene are some of the 'pure' derived products from the processing of oil and this category of products is mainly transported by ships with cleaning tanks with coatings to prevent contamination of the cargo and corrosion. A different category of derived products is the so-called "dirty" products, which includes lower oil distillates. Such products are residual oil and fuel oil, which are transported from ships with steam heating coil cargo tanks because of their low viscosity.

Petroleum, or crude oil, is an important commodity-product that is traded worldwide and the tankers required to transport it carry huge volumes of this commodity. Usually crude oil is exported to remote areas so in order to reach those areas for consumption or refining crude oil should be transported by sea. The reason that makes it a valuable

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commodity is that it is the main source of energy, despite the fact that in recent years interest in renewable energy sources has increased. Of course, this shift in the markets towards renewable energy has stopped the dominance of crude oil in international trade, but it still continues to affect the global economy to a very large extent. The main types of crude oil are three, West Texas Intermediate (WTI), Brent Blend and Organization of Petroleum Exporting Countries (OPEC) basket. The first type, WTI, is exported to the Gulf of America and transported for refining in the Midwest regions of the US. The quality of each type is measured in degrees of gravity by the American Petroleum Institute (API) in order to characterize the density of the oil in relation to water. WTI is considered high quality with a gravity of 39.6 degrees. In general, crude oil gravities range from 15 to 45. For grades 15 to 25, crude oil is classified as heavy, while for grades 35 to 45, crude oil is classified as light, which is of higher quality[2]. The second type, Brent Blend, is a blend of oils from different locations in the North Sea, the so-called BFOE (Brent, Forties, Oseberg and Ekofisk). Its name comes from the Brent system in Scotland. In terms of gravity, it has a gravity of 38.3 degrees[3]. The third and last type to be analyzed is the OPEC basket. This contains 7 different oils from OPEC countries. OPEC is the Organization of Petroleum Exporting Countries, which was founded in 1960 by Saudi Arabia, Venezuela, Iraq, Iran and Kuwait. Countries that have subsequently joined are Libya, the United Arab Emirates, Algeria, Nigeria, Ecuador, Gabon, Angola, Equatorial Guinea, Gabon, Angola and the Republic of Congo - bringing OPEC membership to 14 as of January 2019. The importance of the organization lies in the fact that more than one third of the world's oil production comes from it, and a large proportion (80%) of oil reserves are held by its member countries. These make the organization a geopolitical power. However, in recent years, the rise of the American fracking industry has weakened OPEC's influence on the price of oil[4].

The price of each of the three types of crude oil presented above is used as a benchmark for different markets. For example, the price of Brent crude oil is a benchmark for international markets, while the price of WTI crude oil is a benchmark for the domestic

[2] https://www.ig.com/uk/glossary-trading-terms/wti-definition
[3] https://www.ig.com/en/glossary-trading-terms/brent-crude-definition
[4] https://www.ig.com/uk/glossary-trading-terms/opec-definition

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market of the United States of America. Previously, there was also a discussion about the weight of these types of crude oil, with WTI being considered lighter. This also makes it more suitable for use for refining oil into its derivative products (Tamvakis, 2015; Geyer-Klingeberg and Rathgeber, 2018).

All of the above help to understand that there are different categories of oil, each with different characteristics in terms of gravity or Sulphur content, shaping different prices. The types of crude oil that are considered light have a higher price, since less processing is required. It should be noted that even the distance of the oil extraction area from the sea plays a role in its quality. Oils extracted in areas close to the sea have a lower price because they have lower extraction and transportation costs, for example Brent. OPEC oil costs less than both Brent and WTI because of its high Sulphur content and higher gravity.

The crude oil market has gone through several crises in previous years. Tamvakis (2015) notes that in the period '73-'74 there was a shock in oil prices, which was due to the rapid increase in crude oil prices. The latter, for its part, was the result of the Yom Kippur war and the increase in demand for oil with a simultaneous decrease in US production. The next crisis occurred in 1979, the Iranian Revolution and the decision of the government to nationalize the oil companies established in the country were responsible for this. This decision led to an increase in oil prices and forced the companies to look for new and better ways to preserve the commodity, while also contacting politically safe locations such as Alaska and the North Sea for new reserves. As a result of the second oil market crisis, consumers' consumption of oil decreased, thereby reducing demand. The second crisis was the emergence of a third crisis. OPEC members, sensing the fall in demand, tried to adjust their production in order to increase their revenues, going against the policies that the organization had decided to implement. This arbitrary action by member countries led to an even greater fall in prices for all oil producers, both within and outside OPEC. Other notable crises to mention are the market crisis with Iraq's invasion of Kuwait, the market crisis due to the 1997 Asian crisis and more recently, the market crisis due to the 2008 global financial crisis.

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As already mentioned, oil is a valuable commodity that affects the global economy, but is also affected by it. This therefore makes it vulnerable to various crises that can occur over the years, whether health, political or economic. Sun et al. (2014) state that the price of oil fluctuates around equilibrium since demand and supply are relatively stable. Glen (2007) states that friction between supply and demand can create imbalance in the relationship between oil price and spot fares. The reasons explaining this phenomenon according to the author are two. First, if there is an increase in the demand for oil, which leads to an increase in its price, the demand for its transportation increases at the same time, so that a positive correlation between oil price and freight rates is created. The second reason is that an increase in the price of oil can also be caused by a decrease in the supply of oil, in which case this implies a decrease in the demand for oil transport and therefore a decrease in freight rates.

Figure 3: Monthly Brent Crude oil price for the period 1/1992-6/2022

Source: Clarksons (2022)

The above line graph shows the evolution of the price of Brent crude oil from January 1992 to June 2022. From 1992 to 1999 the price of Brent crude oil fluctuated at very low levels and was stable with small fluctuations. Since 2000, an upward price trend began,

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which peaked in 2008 with the price of crude oil per barrel reaching 133.21 $/bbl. Then, with the onset of the global financial crisis, the oil market was affected as the price of crude oil plummeted to 39.71 $/bbl. However, from 2009 onwards, the market recovered and the price rose, but without reaching the levels of 2008. The price of crude oil fluctuated at relatively high levels until 2015, creating a problem in the ship market because fuel costs were high. This is followed by a further decrease in price, but not as low as between 2008 and 2009. In 2016 it rises again, but at a slower rate, and in April 2020 there is a rapid decline, reaching 26.60 $/bbl. This large decrease was a consequence of the emergence of the health crisis of the Covid-19 virus, which hit transport and the global economy in general. From that moment onwards the price started to rise again and at a faster pace, and Russia's war with Ukraine contributed to this, because the countries faced with trade restrictions turned to seeking alternative sources of oil supply from more distant locations.

Angelier (1991), in his analysis of Brent and WTI, refers to factors that affect the spot prices of these oils depending on the period. In the short term period prices are determined on the basis of supply and demand, in the medium term period prices depend on the structure of the oil market in the current period, while in the long term period prices are determined on the basis of marginal production and its relationship with world demand for oil.

2.3 Greek Shipping Sector

Magirou, Psaraftis and Christodoulakis (1992) state in their study that the shipping sector is an important pillar of the Greek economy and its activity directly affects the entire economy. When the shipping sector is booming then the Greek economy is also booming, while when the shipping sector goes through periods of recession, the Greek economy also experiences recession. On the labor market side, they argue that the shipping sector has recruited unskilled and skilled labor, reducing the likelihood of rising unemployment, even for other sectors of the economy. This of course had negative consequences, because every time the shipping sector faced a contraction, there were also repercussions on the labor market. They recommend, however, that in order to draw clearer conclusions

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about how Greece's labor market is affected by periods of recession in the shipping industry, research should be conducted. Moreover, they note that the shipping sector has always contributed to Greece's current account deficits, due to foreign currency deposits from Greek seafarers and remittances from them. They observed that until 1985, income from abroad derived from activity in the shipping sector in particular was much higher than income to abroad. They then analyzed the ship-building industry, stating that it is one of the most advanced sectors of the construction industry in Greece. Due to the industry's determinacy in supply, a change in supply affects prices and other market variables. A strong link also appears between the industry and the naval armed forces, as they play a prominent role in national security. Because of this link, the shipbuilding industry may have a different future than if it were to be considered in simple economic terms.

2.4 Freight rates market

Freight rates are determined on the basis of demand and supply for freight transport. Demand refers to the service offered by a vessel and is considered inelastic, since the cost of transport is much lower than the final price of the goods.

In the literature the charter market is categorized into four (4) different categories which are the following, the Voyage Charter Market, the Contract of Affreightment Market (COA), the Time Charter Market and the Bareboat Charter Market. In the first market the charterer leases the vessel at an agreed price per ton for the carriage of the cargo. Thus, the shipowner has to manage and negotiate the charter rate and the time for the charterer to deliver the cargo. When freight rates are high, when there are expectations of a reduction and when the demand of the commodity markets is unstable, shippers prefer this type of purchase. In the second type of freight market, the shipowner and the charterer enter into a contract to move the cargo on a regular basis without naming any ship. This is an advantage for owners of large fleets or for those who are members of a “pool”. The third market is divided into short-term, medium-term and long-term, depending on the period for which the fleet is chartered. For example, before 1970, most owners leased a large proportion of the fleet for long-term chartering, because this gave

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them stability in their business because their revenues were easy to calculate over long periods of time. However, all of them faced serious financial problems later in 1973 due to high inflation. Thus, they decided that the charters should be either short-term or medium-term. In these charters there are likely to be a lot of challenges in the share of the cargo, which the charterer has to accept, and for this reason the negotiations are complex. In the latter market, the shipowner leases the bare ship to the lessee, who will operate the best way he decides. However, contracts in this market do not have a specific form because their terms vary, depending on the negotiation between the lessee and the shipowner, and usually the lease is for a long period of time, which may be the lifetime of the ship. Often such contracts are used to finance the ship, particularly in times of tax advantages that shipowners may enjoy, because the financiers enjoy the benefits of ship ownership without the problems of operating a vessel. There is also a preference for direct ownership by manufacturers and traders who move large annual volumes on the charter market (Alderton and Rowlinson, 2015).

Chrzanowski (1985) identified the factors that determine the demand for maritime transport, which are the volume and quantity of cargo to be transported and the transport distance. The fundamental tools for meeting this demand were provided by a combination of the charter market and direct owned tonnage. This inherently raises the question of what type of allocation method is best suited to meet these requirements. Market mechanisms have been clearly endorsed by leading ocean economists. In the 1970s, a new wave of maritime economists rigorously defined the economic principles governing freight markets. A strong tradition of neoclassical economic analysis survives in marine economics from this period. Given the emphasis on cost competitiveness in open cargo markets, marine economists have argued for the effectiveness of market forces.

Svendsen (1958) in his paper provides an important analysis of the neoclassical microeconomics of freight markets, highlighting the intrinsic comparative costs of shipping and the importance of achieving competitiveness in world markets. Thorburn (1960) in his study developed a detailed model of the transport freight market using effectively the supply and the demand, identifying approximately 36 supply and 24 demand terms found in the labor market.

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Goss (1968) reflects new macro factors that began to affect the shipping market. The model of open freight markets has been called into question following changes in the global political order. Countries that had previously been colonies began to seek full economic independence, including control and ownership of merchant ships. In response to these conditions the freight market turned to protectionism, which should be challenged by Goss as it denies the benefits of competitive markets. His attitude towards open markets is a hallmark of the literature on shipping, with him stating in 1993 that "International shipping services are usually bought and sold in competitive markets that lead to the survival of those with the lowest private costs...the relevant principle is that of comparative advantage".

Gillman (1983) in his study spoke of a leap in technology and innovation, which will bring a revolution in containers. To draw his conclusions he analyzed major liner lines such as the Pacific and North Atlantic, attributing the gains of containerization to the competitive process, which would push the leading lines to continually increase their efficiency. In contrast to Goss, Jansson and Schneerson (1987) identify benefits in a strictly competitive liner shipping industry, which aims to optimize the most economic use of global capital and labor stocks by stating that to achieve a better division of labor in international shipping, efficient operators should become price leaders.

The war between Ukraine and Russia cannot leave the freight market unaffected. The consequences will be significant and far-reaching. The most significant impact lies in the impact on the ability of businesses to transport goods quickly and efficiently. The supply also of goods and materials will be affected and as a result their transport will also be affected. Delays are a natural consequence and the logistics industry will negatively affect the global economy as a whole[5].

2.5 Container market and freight rates

Stopford (2008) points out that freight rates are the price one has to pay for the transport of cargo. Freight rates are volatile because they depend on the relationship between

[5] https://dfreight.org/blog/freight-market-updates/

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demand for transport of goods and materials and supply for transport. Fluctuations in freight rates are the hallmark of the shipping risk faced by shipping fleets. Rates vary according to the ownership structure of ships between cargo owners and shipowners. When the fleet of cargo owners' vessels increases, the risk increases, while the more vessels are chartered from the spot market, the higher the risk for shipowners. In order to ensure the smooth transport of cargo, it is necessary for shippers, carriers and anyone involved in the transport of cargo to conclude transport contracts well in advance. If it is necessary to charter a ship at short notice or in the short term, then the contracts depend on the forecast of the freight rate trend. Even selling, buying, buying, building, or scrapping ships as decisions on the part of shipowners are made with freight rates in mind (Jeon, Duru, & Yeo, 2020). It is therefore understandable that in order to have good information and for the decisions taken to lead to profitability, it is necessary to have a good forecast of the future development of freight rates.

Brooks (2000) points out that the shipping industry is a capital-intensive industry and the cost of freight forwarding items fluctuates greatly and therefore, they must be managed properly in order for the liner shipping business to be successful. Notteboom (2012) on his part states that freight rates in the container market are shaped by the risk profile of each firm operating in this industry and that part of the risk is the high capital investment requirements given that the market is capital intensive and the stability in schedules regardless of the volume of cargo carried. Theofanis and Boyle (2009) add that the reasons why a company can often be driven into immediate operating losses are high fixed costs, perishability of the products transported and oversupply conditions. All these reasons give firms an incentive to load ships up to marginal cost.

The container market has several fluctuations and volatilities in freight rates, which is why the pricing policies followed are complex. For the most part, Freight All Kinds (FAK) are used in most transactions. These are flat rate totals for the hire of a container from a particular origin, going to a particular destination, without consideration of the contents and the quantity to be stowed in each container by the carrier. Then there are additional charges, some of which are, Bunker Adjustment Factor (BAF), Currency Adjustment Factor (CAF), port congestion surcharges and Terminal Handling Charges

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(THCs). Apart from these, there are additional charges relating to equipment and containers. Regarding the BAF surcharges, they are affected by changes in fuel prices, mainly in the short term and in particular by an increase in fuel prices. The reason is that companies use BAF surcharges as a revenue management tool[6].

The use of BAF surcharges divides the international literature. On the one hand, Notteboom and Cariou (2011) and Meyrick et al (2008), report in their studies that firms use BAF surcharges in order to recover costs and achieve additional profitability, while on the other hand, Cariou and Wolff (2006) argue that an increase in fuel prices is an anticipatory factor of these surcharges, but does not emerge as a tactic of firms. THCs surcharges are equally important, which according to the European Commission (2009) account for a high proportion of the port-to-port transport price during periods of collapsing freight rates.

Concerning FAK tariffs, they also show large price fluctuations, influenced by the economic and technological characteristics of the routes. In terms of economic characteristics, these can be the availability of cargo, the competitive conditions in the shipping industry and the commercial imbalance. Technological characteristics mainly concern the maximum permitted size of the vessel. Various ports, such as those in West and East Africa, are more expensive as destinations because they pose risks such as congestion in ports and imbalances in container flows. The market structure also affects the cost of destinations, because some are characterized by a small pool of container service providers and limitations in terms of vessel scale. Other ports, such as those in the Far East, have low freight rates because of economies of scale due to the use of a large number of vessels, the large number of companies competing with each other and more favorable trade flows. On this basis, it is clear that freight rates are not clearly related to the distance of the container transport route (Notteboom, 2012).

Parola and Musso (2007) highlighted another factor that influences the setting of fares and that is market concentration, since there are many strategic alliances between firms

[6] https://www.marineinsight.com/maritime-law/what-are-common-freight-surcharges-and-accessorial-fees-in-container-shipping/#Currency_Adjustment_Factor_CAF

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operating in the shipping sector in order to achieve economies of scale. This has been demonstrated through other studies, which have observed the increase in acquisitions over the years, indicating that the main motives for the increase in strategic alliances were the desire to obtain greater size, to ensure further growth, to gain direct access to markets, distribution networks and new technologies, to diversify the base of the wagering assets and to achieve economies of scale (Yap, 2010; Fusillo, 2006). Therefore, given the continuous increase in concentration observed, the containership shipping market is directly dependent on its oligopolistic character (Sys, 2010). The European Union in an effort to make the market more competitive, in 2008 the European Union revoked Regulation 4056/86 that exempted the liner shipping market from the antitrust block that allowed liners to set freight rates.

Figure 4 below shows the development of the global container freight index. Since January 2019 freight rates have increased dramatically. The largest increase occurred through 2021, peaking in September 2021, when the rate equaled 10,400 U.S. dollars. From there, the decline in the freight rates begins, ending in July 2022 at 6,800 U.S. dollars.

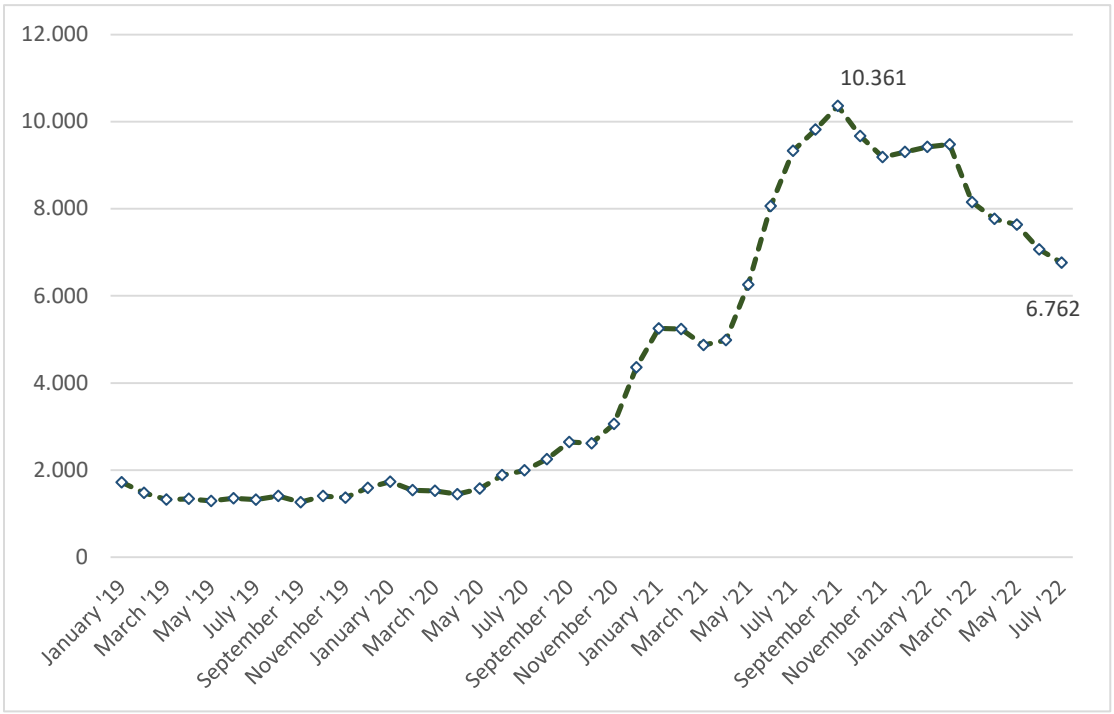

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Figure 4: Global container freight rate index from January 2019 to July 2022 *(in U.S. dollars)*

Source: Statista (2022) (freight-index)

As already reported, the Covid-19 pandemic hit the container shipping market as it faced labor shortages, port closures and congestion and a shortage of new containers. As a consequence, maritime transport prices soared, as can be seen in Figure 4 above. The same seems to be the case with the war between Russia and Ukraine, even though the two countries are not deeply integrated in the container shipping industry. The war has forced container carriers to reduce the capacity of vessels assigned to Russia and suspend their activities in Ukrainian seaports. The disruption of container services to Russia and Ukraine led the carriers to change ports. With the delays suffered by shippers, the cost of detention and delay at ports will increase. Freight rates, on the other hand, are under upward pressure due to the war, despite the increase in them in the midst of the pandemic (UNCTAD, 2022).

Chapter 3: Literature Review

Container shipping has flourished in recent years, but still the literature on its study and economic modelling is limited. Especially as far as the literature related to our topic is concerned, there are not many studies and the main reason is that the container shipping market is an imperfect market. Most papers and researchers consider freight rates and containers separately and those of them who consider freight rates do not include containers in their research (Sys, 2009).

Slack and Gouvernal (2011) in their research on freight rates state that their price is determined by the origin and destination of the cargo and not by the value of the goods and materials transported. The latter, moreover, can accept surcharges and depends on various fuel adjustment factors, which are determined by the carriers (Wang et al., 2011; Notteboom and Cariou, 2013). Sys in his earlier research (2008) had observed the fact that the container market is highly concentrated as there are many strategic alliances and the market behaves more like an oligopoly than a competitive one. UNCTAD disagrees

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with these findings and argues that the container market is monopolistic, with firms that have small market shares being quite vulnerable. Research conducted by Caschili and Medda (2011) showed that freight rates and tariffs of shipping companies are the result of partnerships and alliances between them.

An understanding of the shipping cycle for a private company and the public sector is a prerequisite in order to analyze, examine, model and predict the price of freight rates. Liner shipping remains a complex market in which many parties with different interests and requirements are involved, divided into providers and users of its various services (Lee & Song, 2017). On the understanding of shipping cycles, Stopford (2009) showed how maritime trade is generally related to changes in GDP and tried to link shipping cycles to macroeconomic factors of major economies. To achieve this, the supply and demand model must be used, identifying the factors that influence these two. Demand is influenced by the global economy, international maritime trade, political events, transport costs and average achieved profit. Supply on the other hand is influenced by the world fleet, its productivity, shipbuilding, ship scrapping and freight rates . At the point where supply and demand are in balance is the freight rate Jugovic, Komadina and Peric Hadzic, 2015; Beenstock & Vergottis, 1993). Of the factors mentioned, the most important one according to Chi (2016) is GDP.

Freight rates can also be influenced on the supply side, using flexibility tactics to influence the fleet (Mason and Nair, 2013). Further, Kutin et al (2018) showed that freight rates are negatively affected by the global fleet, particularly in times of economic downturns. As mentioned in a previous section, the container market is characterized by high capital requirements; therefore the majority of container ships are financed through debt capital. This means that, because interest payments are made without interruption, freight rates have a threshold in the short-term period, beyond which, firms are not willing to operate container ships without being able to cover their operating costs (Adland and Strandenes, 2007).

A variety of econometric models have been used to forecast container freight rates. Nielsen et al. (2014) used an autoregressive integrated moving average model (ARIMA),

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which appeared to explain well the changes in container freight rates and could predict them with high accuracy. This model appeared to be able to reflect the gross rate increases realized by carriers (Munim & Schramm, 2017; Chen et al., 2017). Of course, the ARIMA model does not take into account the influence of external factors on freight rates, such as the supply of shipping capacity, the demand for transportation of goods and materials, and the price level of fuel. In their study Munim & Schramm (2017) found that the ARIMA model is more suitable for out-of-sample forecasting of container freight rates, and in their more recent research they conclude that the ARIMA model has better predictive ability for out-of-sample forecasting than the VAR model that uses supply and demand as exogenous variables (Munim and Schramm, 2020). Yingbo and Yinhao (2018) observed that container freight rates exhibit seasonality, with the peak period for the majority of firms being in autumn and spring, the periods that for China correspond to Christmas and New Year.

Pioneers in predicting freight rates in the container market were Luo et al. (2009), who predicted freight rates based on the within-sample model and compared the predictions with actual freight rates for the period under consideration. Through their study, they tried to show how flexible and tradable container freight rates are and to highlight the market trends in the short-term period and risks. The model was shown to have good predictive ability, even with different assumptions. These assumptions concerned either the demand side or the supply side.

Some other studies on the container industry have looked at strategic alliances. For example, Fenn et al. (2008) analyzed the relationship between market share and cost-efficiency. Earlier, Slack et al. (2002) tried to examine the role of service transformation, fleet size and composition, and port coordination in shaping strategic alliances. The research by Merk et al. (2018) follows the same logic, concluding that global alliances in container shipping help carriers to acquire large ships and reduce unit costs. However, in the same study they stress that alliances are inherently unstable. Midoro and Pitto (2000) agree with the latter conclusion. The latter also point out that the main reasons for this instability are intra-alliance competition and organizational complexity.

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Forecasting freight rates is a challenge, as such work requires timely data, but data on the container market is collected with a long time lag, so most studies insist on using quarterly data for this market (Drewry, 2021; MDS Transmodal, 2021). Gouvernal and Slack (2013) attempted to identify how container freight rates vary globally, regionally and over time. To carry out this research they assumed that freight rates are a measure of economic distance. They concluded that distance cannot explain variations in freight rates and that regional differences in freight rates do not affect the price of transport.

Studies on estimating the impact of oil prices, especially crude oil, on container freight rates, which is the objective of this research, are scarce. One of them is the study by UNCTAD (2010), in which they report that an increase in oil prices will also lead to an increase in maritime freight rates. Specifically with regard to container freight rates, they consider that the effect of oil prices is higher in periods of sharp price increases and price volatility than in periods of low and stable oil prices.

Chapter 4: Empirical Analysis and Results

4.1 Model

As has already been noted, studies on the relationship between the price of oil and container freight rates are scarce. This chapter will present the results of an attempt to estimate container freight rates using the price of oil and how the latter affects them. A variant of the model developed by UNCTAD (2010) was used for the research and is presented below. The original model is given by equation (1) and the variant finally used is given by equation (2).

$$fre_{iqy} = a + \lambda_i + \delta \cdot T_y + \beta_1 \cdot bre_{qy} + \beta_2 \cdot vol_{qy} + \beta_3 \cdot flow_{iqy} + \beta_4 \cdot imb_{iqy} + \beta_5 \cdot harq_{qy} + \varepsilon_{iqy} \quad (1)$$

$$fre_{iy} = a + \delta \cdot T_y + \beta_1 \cdot bre_y + \beta_2 \cdot vol_y + \beta_3 \cdot flow_{iy} + \beta_4 \cdot imb_{iy} + \beta_5 \cdot clarkavear_y + \varepsilon_{iy} \quad (2)$$

In its model, UNCTAD uses as independent variables the price per barrel of crude oil, the standard deviation of the price per barrel of crude oil, container movements for each

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destination considered, the measure of the imbalance of container paths, the Harper index, the time trend and the direction fixed effects. Similarly, container freight rates shall be used as the dependent variable.

All variables are expressed in logarithms in order to estimate the elasticities. As UNCTAD (2010) states in its study, the reason for including the variable of the standard deviation of the crude oil-Brent price in the model is that it wanted to examine, in addition to the natural level of the crude oil price, whether fluctuations in the crude oil price affect container freight rates. As for the variable of container flows, because these cannot be measured, the demand for containers shipping services to and from each destination is used. They also note that the imbalance of movements is taken into account because, according to the literature, it has always played a role in the liner carrier market. In practice, the term imbalance is used to indicate how empty the container is when carrying cargo. The greater the imbalance, the emptier the container and therefore the higher the operating costs. The use of the Harper index is based on two reasons. The first is that through estimates it has been established that only 40%-60% of the fleet managed by the main shipping companies is chartered. The second reason is that the variable can be used as an alternative to the cost of capital, which has been shown by studies to have a positive effect on the level of freight rates (Hummels, 2009; Cariou and Wolff, 2006).

The reason for not using the UNCTAD (2010) model as such, but its variant (equation 2) is the fact that it was not possible to find data for the Harper index. Thus it was decided to use the Clarkson's average earnings index instead. Still, the variable of direction fixed effects was not included. More generally, reliable data is one of the biggest challenges when examining container fares and transport costs. Because of this, data that has not been shown through the literature to affect the cost of maritime transport, especially container shipping, cannot be used as variables. Through the inclusion of fixed effects, UNCTAD captures any unobservable characteristic relating to each direction estimated and addresses the exclusion of all data that do not affect freight costs. There are also variables that are not included in the model because they cannot be estimated, such as distance. Finally, the time trend in the model helps to capture any unobservable shocks that may affect trade directions.

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4.2 Sample and Data

The freight rate data used for this study were obtained from the Clarkson's (https://www.clarksons.net/n/#/portal) database, are annual and cover the period 2016-2021. They reflect what prices prevail in both directions of major trade routes (Far East/N.Europe/Far East, US East Coast/N.Europe/US East Coast) and are expressed in dollars per TEU ($/TEU). The freight rates include handling charges (THC), as well as gate and container loading rates. Exceptionally, for some routes, the time span starts some year later due to lack of data for the variables used.

Most studies in the literature use monthly or quarterly data, but in Clarkson's database, for container freight rates, the data is only annual and there is not much range since it starts from 2016 onwards. Table 1 below shows the routes estimated and how many observations each contains.

Table 1: Distribution of observations of the total sample (2016-2021)

Direction	Frequencies	Percent	Cumulative
Far East-N.Europe	6	30.00	30.00
N.Europe-Far East	6	30.00	60.00
USEC-N.Europe	4	20.00	80.00
N.Europe - USEC	4	20.00	100.00
Total	**20**	**100.00**	

According to the table, most of the observations come from the Far East-N. Europe and N. Europe-Far East routes. This is due to the fact that for the US East Coast-N. Europe route and vice versa, data was available from 2018 onwards. The cumulative frequency

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shows that the route between North Europe and Far East, for both directions, represents 60% of the sample, while the route between North Europe and the US East Coast, for both directions, represents 40% of the sample.

Several challenges were encountered in the process of finding data. Initially, the biggest challenge was the fact that there was not a large amount of data on container freight rates, making it difficult to draw firm conclusions in our study. The next challenge concerned the data set and the mismatch in terms of the base period. Most of the data could be found on a monthly basis and for several periods, except for freight rates, but also for container demand. As regards the variable container demand (flow), the data, although going back a long time, were only available on an annual basis. These are the two most important reasons why the sample for the present analysis had to be reduced. An attempt was made to obtain data from other sources by contacting a firm from the container shipping industry, but it was not possible to obtain more detailed data on container freight rates.

Data on Brent crude oil was available on a monthly, quarterly and annual basis. The annual data were used for the BRE variable, while the quarterly data were used to calculate the standard deviation of Brent crude oil. Figure 5 below also shows the evolution of the Brent crude oil price, with the largest decrease occurring in 2020. This is due to the outbreak of the covid-19 pandemic which triggered an unprecedented demand shock in oil industry as forced all markets to remain inactive[7].

[7] https://www.aa.com.tr/en/energy/stock-market/oil-prices-down-with-coronavirus-related-low-demand/29320

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Figure 5: Historical Data on Brent crude oil prices

Source: https://www.macrotrends.net/2480/brent-crude-oil-prices-10-year-daily-chart

Given the paucity of literature on the relationship between oil prices and container freight rates, an attempt was made to measure this relationship and assess whether and how oil prices affect freight rates in the container market. The studies carried out so far, as has been mentioned, use monthly or quarterly data. In the case of the latter, they either use the net freight rates for each quarter (Lixian, F., 2011) or calculate the monthly average for each quarter (UNCTAD, 2010). There are, however, some studies that use data on an annual basis (Shen et al, 2009).

The literature has shown that crude oil prices have a positive impact on freight rates in the container market. As crude oil prices increase, there is an increase in freight rates. The same is true for the fluctuation of oil prices, with periods when crude oil prices are high and constantly changing having a much greater impact on container freight rates than periods when oil prices are low and stable (UNCTAD, 2010).

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The aim of this empirical analysis is to examine the effect of crude oil prices and their standard deviation on container freight rates and whether they can be estimated through a variety of factors. The variables BRE and VOL represent the Brent crude oil price for each year and its standard deviation respectively. The latter was calculated using the quarterly Brent crude oil prices for each year. Based on the above, we formulate the following hypotheses:

H1: There is a positive relationship between the price of Brent crude oil and container freight rates.

H2: There is a positive relationship between the standard deviation of the Brent crude oil price and container freight rates.

There is not enough empirical research on this issue to provide a clear picture of how and in what way the price of Brent crude oil affects container freight rates. Given that the container market is monopolistic, as the literature suggests, it is possible that the price of Brent crude oil may not affect freight rates as much, but nothing can be said with absolute certainty. After all, the demand for oil is of great importance for the price of oil itself, so it would be appropriate to examine the effect of oil demand on container freight rates. With the reduction in the demand for oil, the prices of all its derivatives fall, and this should also push container freight rates down. This leads to the third hypothesis of the analysis, which is:

H3: Container freight rates are expected to be positively affected by the demand for oil.

To test the latter hypothesis, an oil demand variable called OILD is introduced into equation 2. The model then becomes:

$$fre_{iy} = a + \delta \cdot T_y + \beta_1 \cdot bre_y + \beta_2 \cdot vol_y + \beta_3 \cdot flow_{iy} + \beta_4 \cdot imb_{iy} + \beta_5 \cdot clarkavear_y + \beta_6 \cdot oild_y + \varepsilon_{iy} \qquad (3)$$

The analysis followed in this paper is multivariate, since several variables are used, such as Brent crude oil price (BRE), its standard deviation (VOL), demand for oil (OILD), demand for containers (FLOW), which expresses container flows from and to the selected

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directions, the measure of imbalance in container flows (IMB) from and to the selected directions, the container average profit index (CLARKAVEAR) and the time trend (T). In particular, the IMB variable is created from within the FLOW variable and its mathematical formula is:

$$imb = \ln\left(1 + \frac{FLOW_{jk} - FLOW_{kj}}{FLOW_{jk} + FLOW_{kj}}\right)$$

Where j and k are the two ends of a given route i. It is noted again that all variables are expressed in logarithms to measure elasticity. As regards the dependent variable of the model, this is the logarithm of the freight rates of containers. Finally, the data used are panels. Table 2 below presents the definitions of all variables in the model.

Table 2: Definition of Variables

FRE	Annual freight rate
T	Time trend
BRE	Price per barrel of crude oil-Brent
VOL	Standard deviation of the price per barrel of crude oil-Brent
FLOW	Flows of containers – Container demand
IMB	Measure of imbalance of container flows
CLARKAVEAR	Average Containership Earnings
OILD	Oil Demand

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4.3 Descriptive Statistics

Table 3 presents the descriptive statistics, such as the mean, standard deviation, minimum and maximum values of the variables and the values of the quartiles, for all variables for each route. The total sample size for the 4 routes is 20 observations.

FRE

The average value of container freight rates for the four (4) routes in the sample is in the range of 7.18348 units and the average freight rate value of each route deviates from the average value by .77511 units. The average freight rate (7.18348) is close to the median (7.22751) and the freight rate distribution is characterized by a slightly positive asymmetry (skewness = .9270726). Also, the freight rate value for the routes of the sample of firms ranges from 6.07702 to 9.32222.

BRE

The average price of Brent crude oil for the periods considered (2016-2021) is in the range of 4.06685 units and the price of Brent crude oil deviates on average from its average price by .21520 units. The average crude oil price (4.06685) is close to the median (4.16184) and the oil price distribution is characterized by a slightly negative asymmetry (skewness= -.526989). Also, the oil price ranges from 3.76630 to 4.26324 units for the years 2016-2021.

VOL

The average value of the standard deviation of the Brent crude oil price for the periods considered (2016-2021) is 1.67264 units and the standard deviation of the Brent crude oil price deviates from its average value by .37673 units. The average value of the standard deviation of the crude oil price (1.67264) is close to the median (1.77065) and the distribution of the oil price is characterized by a slightly negative asymmetry (skewness = -.538112). Also, the standard deviation of the oil price ranges from 1.07007 to 2.04574 units for the years 2016-2021.

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FLOW

The average value of container demand for the periods considered (2016-2021) and for each sample route is 1.98763 units and each container demand value deviates from its average value by .64672 units. The mean value of container demand (1.98763) is close to the median (2.04129) and the distribution of container demand is characterized by a slightly negative asymmetry (skewness = -.135079). Also, container demand ranges from .975434 to 2.83725 units for the years 2016-2021.

IMB

The average value of the imbalance of container flows for each sample route is -.056739 units and each value of the calculated imbalance of container flows for each route deviates from its average value by .34932 units. The mean value of the imbalance of container flows (-.056739) is relatively close to the median (-.03443) and the distribution of the imbalance of container flows is characterized by a slightly negative asymmetry (skewness = -.026351). Also, the imbalance of container flows ranges from -.47067 to .318759 units for the years 2016-2021.

CLARKAVEAR

The average value of average containership earnings for the periods under consideration (2016-2021) , is in the range of 9.66428 points and each value of average containership earnings deviates from its average value by .63789 points. The mean value of average containership earnings (9.66428) is relatively close to the median (9.52281) and the distribution of average containership earnings is characterized by a positive asymmetry (skewness = 1.043666). Also, the average container earnings range from 8.87220 to 10.8356 units for the years 2016-2021.

OILD

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The average price of oil demand for the periods considered (2016-2021), is in the range of 4.57240 units and each oil demand price deviates from its average by .01950. The mean value of oil demand (4.57240) is relatively close to the median (4.56828) and the distribution of oil demand is characterized by a slightly positive asymmetry (skewness = .1420899). Also, the oil demand values range from 4.55029 to 4.59698 units for the years 2016-2021.

Table 3: Descriptive Statistics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	N	mean	sd	p25	p50	p75	min	max	skewness
FRE	20	7.18348	.77511	6.47322	7.22751	7.50191	6.07702	9.32222	.9270726
T	20	2018.9	1.6189	2018	2019	2020	2016	2021	-.293192
BRE	20	4.06685	.21520	3.77482	4.16184	4.25858	3.76630	4.26324	-.526989
VOL	20	1.67264	.37673	1.47889	1.77065	1.99784	1.07007	2.04574	-.538112
FLOW	20	1.98763	.64672	1.60834	2.04129	2.73895	.975434	2.83725	-.135079
IMB	20	-.056739	.34932	-.41233	-.03443	.291093	-.47067	.318759	-.026351
CLARKAVEAR	20	9.66428	.63789	9.41824	9.52281	9.55414	8.87220	10.8356	1.043666
OILD	20	4.57240	.01950	4.55534	4.56828	4.59112	4.55029	4.59698	.1420899
Number of id	4	4	4	4	4	4	4	4	4

Tables 4 and 5 below present the correlation matrix of the variables for equations 2 and 3 respectively, which were estimated. The correlation coefficients between the variables

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used in the regression estimates are shown. It is observed that container freight rates with crude oil prices have a positive correlation coefficient, as well as with the standard deviation of crude oil prices, indicating that when the price of crude oil increases, container freight rates will also increase. This does not mean, of course, that the increase in freight rates is due to the increase in the price of crude oil, but simply that it affects them. It is worth noting the negative relationship between demand for containers and crude oil prices. This seems to be logical, since if container freight rates increase when crude oil prices increase, demand should decrease due to the increased cost of chartering containers. However, it is paradoxical that the standard deviation of the crude oil price seems to have a positive correlation with the demand for containers.

When oil demand is introduced as an independent variable in the model, the results on the correlation coefficients do not seem to change. The correlation coefficient between container freight rates and the price of crude oil remains positive. However, oil demand has a negative coefficient, implying that when oil demand increases, freight rates tend to decrease. Also, another correlation coefficient worthy of attention is that between oil demand and average containership earnings, which are negative, indicating that an increase in oil demand will lead to a decrease in average containership earnings.

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Table 4: Correlation Matrix of equation 2

	FRE	T	BRE	VOL	FLOW	IMB	CLARKAVEAR	OILD
FRE	1							
T	0.3923	1						
BRE	0.1966	0.2403	1					
VOL	0.2845	0.3284	-0.4011	1				
FLOW	0.4997	-0.2371	-0.1206	0.0261	1			
IMB	0.7045	-0.0067	-0.0057	-0.0161	0.5192	1		
CLARKAVEAR	0.4758	0.8607	0.5090	0.3958	-0.1623	-0.0164	1	

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Table 5: Correlation Matrix of equation 3

	FRE	T	BRE	VOL	FLOW	IMB	CLARKAVEAR	OILD
FRE	1							
T	0.4081	1						
BRE	0.2499	0.2571	1					
VOL	0.3326	0.4149	-0.3633	1				
FLOW	0.3990	-0.1958	-0.1069	0.0120	1			
IMB	0.4713	-0.0067	-0.0060	-0.0163	0.5780	1		
CLARKAVEAR	0.5626	0.7575	0.4952	0.5314	-0.0837	-0.0198	1	
OILD	-0.3467	-0.4401	0.3990	-0.9866	-0.0264	0.0167	-0.5538	1

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4.4 Empirical Results and Discussion

In this section we present the results of the estimations of the two models. As already mentioned, a variant of the subsample developed by UNCTAD (2010) in their study and the same model has been estimated by introducing oil demand as an independent variable. The two estimated models are illustrated below.

$$fre_{iy} = a + \delta \cdot T_y + \beta_1 \cdot bre_y + \beta_2 \cdot vol_y + \beta_3 \cdot flow_{iy} + \beta_4 \cdot imb_{iy} + \beta_5 \cdot clarkavear_y + \varepsilon_{iy}$$

and

$$fre_{iy} = a + \delta \cdot T_y + \beta_1 \cdot bre_y + \beta_2 \cdot vol_y + \beta_3 \cdot flow_{iy} + \beta_4 \cdot imb_{iy} + \beta_5 \cdot clarkavear_y + \beta_6 \cdot oild_y + \varepsilon_{iy}$$

Where, fre_{iy} is the natural logarithm of the container freight rates for the direction i in the year y, bre_y is natural logarithm of the price per barrel of crude oil-Brent of year y, vol_y is the natural logarithm of the standard deviation of the price per barrel of crud oil-Brent of the year y and $oild_y$ is the natural logarithm of oil demand of the year y. All other variables are calculated as specified in section 4.2 of this chapter.

The two equations above are estimated in two ways, by ordinary least squares (OLS) and by panel data analysis, using fixed and random effects estimators. In all estimates, robust estimates were used. Fixed effect models assume that the explanatory variable has a fixed relationship with the response variable across observations, while random effects models assume that explanatory variables have fixed relationships with the response variable across observations, but that these fixed effects may vary from one observation to another.

Table 6 captures the results of each regression run. In column 1, the first equation is regressed using the least squares method, while column 2 and column 3 present the results based on the fixed and random effects estimators respectively. It is observed that the BRE variable has a positive but statistically insignificant effect on the FRE variable at

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the 5% level of significance. Specifically, the coefficient of the variable is equal to .6103492, in other words, holding all other variables constant, a 1% increase in the price of crude oil- Brent, the FRE variable will increase by 0.61%. Of the remaining independent variables, the only one that is statistically significant at each level of statistical significance is the IMB variable; all other variables (VOL, FLOW, CLARKAVEAR) are statistically insignificant at each level of statistical significance. However, looking at the F statistic of the model, we conclude that the model as a whole is statistically significant.

Similarly, columns 4, 5 and 6 show the estimation results of the second equation, where oil demand has been introduced as an additional independent variable. Thus, with the introduction of the new variable, there is a change in the estimates for the worse. The estimator of the BRE variable remains positive, but equals 103.7357 points, which means that if we increase the price of crude oil by 1%, holding all other variables constant, container freight rates will increase by 10373.5% points, leaving the variable statistically insignificant.

Comparing the results of the two models, it can be concluded that oil demand is not a good explanatory variable of container freight rates, showing that it does not affect them at all. This is because by introducing oil demand as an independent variable, the values of the coefficients of all other independent variables change too much, showing signs of multicollinearity in the model. Therefore, the oil demand variable should be dropped from the model.

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Table 6: Estimates of equations 2 and 3

VARIABLES	(1) OLS	(2) FE	(3) RE	(4) OILD OLS	(5) OILD FE	(6) OILD RE
T	.0814459	.0660989	.080687	198.928	-702.6415	198.928
	(.17441)	(.153961)	(.155917)	(853.7975)	(878.3131)	(853.797)
BRE	.6103492	.604491	.6101178	103.7357	-112.2547	103.7357
	(1.1669)	(1.03237)	(1.04312)	(510.0992)	(451.5265)	(510.099)
VOL	.4355169	.4597517	.436918	-959.1255	1825.597	-959.125
	(.55205)	(.739690)	(.493796)	(5610.375)	(5015.042)	(5610.37)
FLOW	.3605337*	.3722466	.3644984	115.3035	3975.456	115.3035
	(.18271)	(8.91120)	(.320440)	(108.0297)	(2143.517)	(108.029)
IMB	1.23689***	5.352724	1.435228**	2271.413	364.5487	2271.413
	(.32300)	(9.39187)	(.597811)	(1563.949)	(17561.97)	(1563.94)
CLARKAVEAR	.2640679	.3425325	.2677365	-.0125441	.1551673	-.012544
	(.66039)	(.745678)	(.590562)	(.4658176)	(.4069303)	(.465817)
OILD	-	-	-	-158055.9	198141.2	-158055.9
	-	-	-	(843214.2)	(745216.3)	(843214.2)
Constant	-163.656	-133.2375	-162.158	321588.6	472807.1	321588.5
	(350.48)	(308.075)	(313.320)	(2592491)	(2225146)	(259249)
Observations	20	20	20	20	20	20

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R-squared	0.8067	0.6605	0.8042	0.5946	0.1744	0.5946
Number of id	4	4	4	4	4	4
Hausman test	chi2(6)= 2.56; Prob>chi2 =		0.8620	chi2(5)= 7.21; Prob>chi2 =		0.2058
Breusch-Pagan test	chibar2(01)=0.10; Prob>chibar2= 0.3786			chibar2(01) = 0.00; Prob> chibar2 =		1.00
F-test	0.0005	0.0139	0.0000	0.0139	0.0531	0.0770

Robust t-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1

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Of the few studies in the literature that have attempted to look at the effect of oil price on container freight rates, they have shown that oil price has a positive effect on container freight rates and all other modes of transport in the shipping industry (UNCTAD, 2010; VORTEXA, 2022; Zipline Logistics, 2022). This conclusion can also be drawn from the estimation made in both models. It therefore appears that the results of the above research are in line with the literature. Also, regarding the VOL variable, the estimation results also show that the estimation results are in agreement with the literature as its coefficient is positive. Since the price of crude oil has a positive effect on container freight rates, the same should be the case with its standard deviation.

Next, the variable FLOW, which shows the demand for containers each year for each route considered, has a positive coefficient, the interpretation of which is that as the demand for containers increases by 1%, container freight rates increase by 36% in the case of the OLS estimation, by 37% in the case of the fixed effects model estimation and by 36% in the case of the random effects model estimation. In the case of estimating the first equation using the ordinary least squares method, the FLOW variable is statistically significant for a statistical significance level of 10%.

The IMB variable, which measures the imbalance of container flows in direction i in year y, also seems to have a positive effect on container freight rates. Thus, as the imbalance of flows increases, freight rates increase. This is logical, since the variable IMB, is created by the variable FLOW, so it should affect freight rates in the same way. For both the FLOW variable and the IMB variable, the estimation results are in agreement with the results of the UNCTAD (2010) study, even in the coefficient values. What is more interesting, however, is the fact that the estimates of the IMB variable are statistically significant at each level of statistical significance for each model. The coefficient of the variable, which is the elasticity, is equal to 1.23689, 5.352724 and 1.435228 respectively for every column from 1-3 of Table 1.

As for the estimation of the first equation, the last independent variable in the model is the average containership earnings. There is no previous study in the literature that uses this variable to estimate container freight rates, but since the variable replaced the Harpex index from the study of UNCTAD (2010), its effect is expected to be the same as the effect of the aforementioned index. Of course, according to the studt of

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UNCTAD (2021), it seems that high freight rates also pushed up profits in the container market for 2020 and 2021. Of course, according to the UNCTAD study (2021), it seems that high freight rates also pushed up profits in the container market. So according to this study container profits have a positive impact on freight rates. The estimation of the first equation confirms these findings, with the coefficient of the variable CLARKAVEAR being positive for each estimation method in the model.

Further, to test the appropriateness of the model, attention must be paid to the values of R-squared. The closer to unity its values are, the better the explanatory power of the model. As shown in Table 6, the R-squared of both the least squares method and the random effects (RE) method are very high and equal to 0.8067 and 0.8042 respectively. And for the fixed effects (FE) method of course the value of R-squared is quite high (0.6605), showing that even with this method, a change in the independent variables can explain a change in the dependent variable quite well.

Next, two tests for the models were conducted. The first test is that of Hausman. This test examines which method gives better estimates, between the fixed effects method and the random effects method. Thus, based on the Hausman test, the emphasis is placed on the random effects estimators, since the probability p=0.8620 is greater than the 5% statistical significance level, which indicates this method as the most appropriate for all versions of the BRE variable. The second test performed is that of Breusch Pagan, which examines which method gives better estimates, between the fixed effects method and the least squares method. The result of the test indicates that the least squares method gives better estimates for the independent variables because the probability p=0.3786 is greater than the 5% statistical significance level. We therefore conclude that the least squares method estimates are representative and more reliable.

Columns (4), (5) and (6) of Table 1, show the estimates of the second equation using the least squares method, the fixed effects method and the random effects method respectively. The results for the coefficients of the independent variables, introducing oil demand as an independent variable, do not differ in sign from those obtained by estimating the first equation without oil demand. Only the effect of the BRE variable changes when using the fixed effects method, as does the effect of the VOL variable and the CLARKAVEAR variable when using the least squares method. The

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coefficients of these variables for the methods reported showed a negative sign. Another change is the negative sign of the coefficient of the VOL variable when using the random effects method to estimate the model.

Intriguing are the results of the estimates of the variable OILD, which shows negative coefficients with the least squares and random effects method, while it shows a positive coefficient with the fixed effects method. However, since the introduction of this variable into the model shows large changes in the coefficient values of the other independent variables, it is safe to say that it should not be considered in the model. Thus, the estimates for this variable do not matter.

In conclusion, based on the assumptions made when estimating the two models, using each estimation method, it is concluded that the first hypothesis, i.e. the positive effect of the oil price on container freight rates, is valid, as is the second hypothesis which states the positive effect of the standard deviation of oil prices on container freight rates. In contrast, the third hypothesis, which states the positive effect of oil demand on container freight rates, does not seem to hold, as oil demand as a variable creates a problem in the model.

Chapter 5: Conclusion

There are very few studies in the literature that have attempted to investigate the effect of the oil price on container freight rates. Container ship chartering increased after the financial crisis of 2008. In particular, containers accounted for 60% of the global fleet, leading to a drop in freight rates. Of course, according to recent studies new container ships cannot meet the existing demand. Recently, shipping companies have seen their profits fall and together with the non-compliance of fleets on emissions, they have postponed order placements. This demand-supply imbalance is forcing container freight rates to remain high (FitchRatings, 2021a). With regard to oil prices, the few studies that exist on this issue have shown that the price of crude oil has a positive effect on container freight rates.

In this study, in addition to the Brent crude oil prices, the standard deviation of each year was used to investigate their effect on freight rates. The analysis performed

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focused on 4 routes for the time period 2016-2021. The results show that crude oil prices and their standard deviations do indeed have a positive impact on freight rates, while considering other factors at the same time. A 1% increase in crude oil prices implies a 61% increase in freight rates. This is in perfect agreement with theory and existing studies. The conclusions of the estimates are even more valuable given that during the periods considered some externalities in the world economy (Covid-19, Russia-Ukraine war) occurred, which had a significant impact on the shipping sector.

On the other hand, the results on the effect of oil demand on freight rates were not so reliable. The use of oil demand as an independent variable in the model appeared to create a multicollinearity problem, so that it was assumed that it should be excluded from the model. The least squares method estimated that the coefficient of oil demand is equal to -.0125441, the panel data fixed effects method estimated that the coefficient is equal to .1551673, while the random effects method estimated that the coefficient is equal to -.012544.

However, availability of data and the constraints imposed by the lack of available data raise reservations about the results and analysis of the estimates. Attempting to find accurate data is a priority for extending the above analysis. Since the findings on the effect of crude oil prices on freight rates are consistent with the literature to date, this paper provides useful information on the relationship between these two variables and helps to further consolidate these findings. However, there are still many unanswered questions, leading to many avenues for future research. Certainly, the fact that the observations of this study are limited to a very short period of time does not make the results as reliable, although they are in line with the findings so far. Therefore, more periods should be examined to show that this positive relationship between freight rates and crude oil prices is consistent across years. Other key determinants of freight rates, such as oil supply, should also be examined. Furthermore, the same relationship can be examined using different models, such as models that take into account the time lags of each variable. In addition, the analysis can be deepened by splitting the years between those in which oil prices are high and those in which prices are low, in order to examine the possible influence of different prices. More generally, finding a suitable model to estimate freight rates through oil prices would be useful.

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