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Factors affecting crude oil and VLCC market

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FACTORS AFFECTING CRUDE OIL AND VLCC MARKET

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Declaration

We certify that all the material in this dissertation that is not our own work has been identified, and that no material is included for which a degree has previously been conferred on us.

The contents of this dissertation reflect our own personal views, and are not necessarily endorsed by the University.

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Abstract

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The United States and Singapore are major oil importing countries; these two routes are considered due to the large amount of crude oil transportation from the Middle East. The West Texas Intermediate Spot price (WTI), which is also a global oil benchmark, is considered for crude oil. This study uses the parametric analysis to determine factors the affect the crude oil price and Very Large Crude Carrier (VLCC) market along the Routes Middle East to United States Gulf (TD_1) and Middle East to Singapore (TD_2). The results from the Classical Linear Regression Model (CLRM) shows that the Baltic Dirty Tanker Index (BDTI) can effectively determine the freight rates of VLCC along both TD_1 andTD_2. Thus, the trend of BDTI is similar to the trend of VLCC freight along these routes. Concerning the West Texas Intermediate Spot Price (WTI), the results indicate that this crude oil price is negatively affected by TD_1. Thus, we noticed that an increase of 100% of WTI price leads to a decrease of 6.4% of the freight rate in TD_1 route. Furthermore, the variables -Bangladesh scrap price, OPEC crude oil production, U.S seaborne crude oil imports and bunker price Genoa have a significant positive impact on the WTI. Bunker Genoa affects the TD_1 and WTI significantly. This indicates that the oil trade between the Middle East and the United States passes mainly through the Mediterranean Sea, where Genoa is the major Bunkering port of VLCC along this route. Firstly, the research identified BDTI as a relevant tool to study the crude oil trade along TD_1 and TD_2 and secondly, it shows that the port of Genoa is a choke point for VLCC sailing along in the Middle East to the United States route. The other significant variables for WTI oil price are in line with the macroeconomic aspects of the oil market.

KEYWORDS: WTI Spot price, VLCC, the Middle East to the United States, the Middle East to Singapore

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List of Abbreviations

ADF	- Augmented Dickey and Fuller
AIC	- Akaike Information Criterion
AR	- Autoregressive
BCTI	- Baltic Clean Tanker Index
BDTI	- Baltic Dirty Tanker Index
BLUE	- Best Linear Unbiased Estimators
CLRM	- Classical Linear Regression Model
CPI	- Consumer Price Index
EIA	- Energy Information Administration
FFA	- Forward Freight Agreement
GDP	- Gross Domestic Product
IEA	- International Energy Agency
IMF	- International Monetary Fund
MA	- Moving Average
NB	- New Building
NGL	- Natural Gas Liquids
OLS	- Ordinary Least Square
OPAEC	- Organization of Arab Petroleum Exporting Countries
OPEC	- The Organization of the Petroleum Exporting Countries
PP	- Philips and Perron
RMSE	- Root Mean Squared Error
SG	- Singapore
SH	- Second Hand
UNCTAD	- United Nations Conference on Trade and Development
US	- United States
ULCC	- Ultra Large Crude Carrier
VLCC	- Very Large Crude Carrier
WTI	- West Texas Intermediate

Chapter One – Introduction

Crude oil is a natural resource that is commercially produced by a limited number of countries[1] but is a major source of energy for most countries[2]. Due to its scarcity, crude oil remains the most important global commodity (Lang & Auer, 2020). Crude oil has been a major source of energy for both retail and industry as it serves as the raw material for petroleum products such as gasoline and jet fuel. The demand for crude oil and oil products continues to rise due to the change in people's life-style (such as an increasing dependency on technology) (Jammazi & Aloui, 2010), industrial production (Kaplan & Ünal, 2020) and the world economy (Braginskii, 2009).

Fundamentally, similar to the general commodity market, crude oil prices are the result of the demand and supply equilibrium. However, as crude oil is a major source of energy globally, it's demand and supply is prone to various global and regional shocks such as geo-political unitability (Li et al., 2020), the world economy (Elekdag et al., 2008), and even pandemic (OECD, 2020) creating price uncertainty. Additionally, studies also provide an endogenous relationship between crude oil prices and the demand or supply (He et al., 2010); that there is a bi-directional relationship between the prices and the demand/supply for crude oil. For example, with an increase in demand of crude oil (as can be observed between 2002 – 2007 due to rise in industrial production in China), the average crude oil prices increased from 22.5 USD/barrel in 2002 to 66.56 USD/barrel in 2007 (EIA, 2021) and also with the decrease in crude oil prices in April 2021, even though there was slow down of industrial production, there was a surge in demand of crude oil. Since crude oil is a storable commodity, speculators also develop investment strategies by buying the commodity when the prices are low and selling them when the prices are favourable. The addition of these investors/speculators in the crude oil market also increases price volatility. Therefore, understanding crude oil prices becomes of great importance to the international economy.

[1] (N. Sönnichsen, 2021). Top ten oil producing countries
[2] (BP, 2021)

Maritime transportation in nature is derived from the demand of the commodity in the market (Stopford, 2008) mainly for two reasons: (i) the seaborne trade facilitates the transportation of commodities, hence the rise (fall) of commodity trade increases (decreases) the volume and the demand for maritime transport; (ii) subsequently, the change in commodity prices (as the result of supply-demand equilibrium) ultimately affects the freight rates[3]. For example, the freight rate for storable (perishable) commodities are inversely (directly) proportional to the corresponding commodity prices (Sahoo et al., 2020). Since crude oil is a storable commodity, its corresponding freight rate is strongly linked to the crude oil price. Crude oil is transported from the production region to various refineries through (i) pipelines and (ii) ocean going ships. VLCCs (Very Large Crude Carriers)[4] were responsible for over 29% of crude oil transportation in terms of tonnage in 2020 (Statista, 2021), making seaborne trade the major mode of oil trade globally. Further, even though there is a growing awareness for zero emission energy and environmental sustainability, crude oil will still serve over 30% of the global energy demand until 2030 (Finley, 2012). Hence, with the growth of the world economy and rise in energy demands, (i) crude oil consumption and (ii) maritime transportation of crude oil will still remain the centre of attention.

Since crude oil is one of the major sources of energy, it relies mainly on maritime transportation, this study aims to understand the factors affecting crude oil and its corresponding freight market/price contemporaneously. This research will also examine the effect of the demand and supply on crude oil and VLCC freight prices, and present an investment strategy for commodity houses and shipping investors/operators adding to the existing (but limited) ocean transport investment literature.

[3] The transportation cost is referred as the freight rate in this context.
[4] Ocean going oil tankers with DWT of 300,000 and above are considered as VLCCs.

1.1 Aim of our research

The aim for conducting this research is to determine what factors will affect the freight rate of VLCC tankers along the Middle East to US Gulf and from the Middle East to Singapore while using the West Texas Intermediate as the price of crude oil.

1.2 Plan of

The research will primarily address the factors that affect the freight rates for VLCC along the Middle East to the USA Gulf and the Middle East to Singapore. This research aims to find the common factors affecting the demand and supply of crude oil and VLCC. It will use Simple Ordinary Least Square (OLS) regression with monthly data from the Clarkson Intelligent database for the period under review from May 2008 to May 2021. Additionally, enabling the use of the VLCC Time Charter Equivalent (VLCC TCE), which is a measurement of the average revenue for VLCC.

1.3 Research Contribution

Various academics have written about the shipping market in general terms and on the wet tanker market. However, in order to better comprehend the changing aspects of the VLCC market regarding its seasonality, cyclicality and volatility, it is necessary to understand the factors that-affect the demand and supply of crude oil and VLCC. Therefore, a study into this market is very important in order to identify the factors affecting VLCC freight rates. The knowledge gained from this research will help in understanding the factors that affect crude oil transportation and the findings generated from this research are expected to be beneficial to investors in the shipping industry. As a capital intensive market that is uncertain and unpredictable, freight rates provide the majority of income for ship-owners aside from asset play; thus, it is crucial to find out the factors that affect the freight rates of VLCC which will prove beneficial for all the players in this market, and especially to the ship-owners.

1.4 Research Structure

The research is divided into five chapters. Chapter one presents an introduction and overview of the research undertaken, the objective of the research and the potential contribution of the research to the shipping industry.

Chapter two revisits previous literature reviews from academic scholars. The literature review focuses on both the supply and demand of VLCC and crude oil with the research gaps specified and the development of the research as an addition to the existing literature.

Chapter three presents an analysis of the data collected and methodology used and follows the steps taken to reach the final Classical Linear Regression Model. Chapter four details the empirical results of all the work.

Chapter five is a discussion of all the significant variables that may affect the tanker market.

Chapter six presents the conclusion.

Chapter Two – Literature Review

As can be witnessed today, the evolution of the shipping industry is mainly attributed to globalisation and the restructuring of the world economy. After World War 2, the need for food and goods manufactured in other countries led to the need for seaborne transportation. Seaborne transportation is divided into containerised-liner services and bulk cargo-tramp shipping. Liner shipping is a monopolist market that transports containerised cargoes, RoRo service, and Bulk cargo service on a long-term charter. They operate on regular routes, fixed schedules and tariffs, and their contracts are through a Bill of Laden. Tramp shipping is a competitive market that operates under a charter party. The ship-owner and the charterer agree on the terms and conditions to carry cargo anywhere on freight rates influenced by demand and supply. Cargo transported under this market consists of dry bulk-mostly iron, iron ore, steel and steel products, coal and grains and liquid bulk-primarily crude oil and oil products (Stopford, 2008).

2.1 Investment in Very Large Crude Carriers (VLCC)

The interaction in the shipping market is based on the capacity adjustment loop, which takes roughly 20 years, and the capacity utilisation loop of 4 years cycles, and both cycles have been used since the early 1980s to forecast freight rates (Jorgen & Ulrich, 2007). Investing in the tanker market, especially VLCC, is a risky venture because of its high volatility of the returns (tanker freight rate) (Lyridis, 2004). The investment decision and assets appraisal of ship-owners when purchasing a VLCC can be either to purchase a New Built (NB) or a Second Hand (SH) vessel based on the relative price ratio (SH/NP), in determining which VLCC to purchase, the expectations formed by the ship-owner, broker and entrepreneur determined the movement of the ratio (Merikas et al., 2008). The characteristic of buyers (charterers) and sellers (ship-owners) and their matches are significant microeconomic determinants of freight rate levels in individual contracts, and the charterer fixed effect is substantial in the VLCC market (Adland et al., 2016).

2.2 Shipping Freight Rate

As a capital intensive, highly volatile, seasonal, and cyclical, parties in the shipping industry need to understand the risk involved and use price series (derivative return) to determine another price (spot returns). Understanding the lead-lag relationship in returns and volatilities between the spot and Forward Freight agreements (FFA) differs due to the non-storability of the underlying commodity. For a shipping service, the transaction costs are higher in the spot market than in the forward market. An understanding of the activities of spot and FFA is needed by investors, ship-owners, charterers for better risk management and budget planning decision-making (Kavussanos & Visvikis, 2004).

The determinants of freight rates in the shipping industry vary across different factors ranging from economic shocks, financial situations of the shipping industry, lay-can period, the vessel age, hull type, fixture deadweight utilisation ratio and voyage routes. Seasonality of freight rates varies as per the contract (spot, 1- year and 3- years' time charter), vessel size and the market conditions, with spot rates for larger vessels showing greater seasonal fluctuation when compared with smaller vessels. However, the seasonal fluctuations of freight rates differ as per the elasticities of supply and demand under the different market conditions (Kavussanos & Alizadeh-M, 2001).

The dynamic between freight rate volatility and fleet size shows that freight rate volatility is always varying, and any fleet size changes will positively affect freight rate volatility (Xu et al., 2011). Although these factors also affect the operating cash flow of the vessel's owner and the transportation cost of the charterer, the duration of the lay-can period is a significant determinant of the shipping freight rate for tankers (Alizadeh & Talley, 2011). Aside from these factors, another essential microeconomic determinant of freight rate level is the characteristics of charterer's, ship-owners and their matches (Adland et.al, 2016).

2.3 Tanker Freight Rate

The evolution of tanker freight depends on the employment status and geographical location of the VLCC fleet. The capacity of the available vessel for hire will always influence the volatility of freight rate as the freight rate directly influences the market participants: a ship-owner's profitability and the charter's expenditures (Regli & Nomikos, 2019), as there is always a difference between spot freight earnings between different geographical regions for bulk carriers. These differences are both consistent and temporary based on the chartering strategies used by individuals in these regions. However, every geographical region has its market spatially efficient during normal freight market conditions when there is a surplus of vessels (Adland et al., 2017).

The nature of changes in freight volatility of VLCC business cycles shows that the freight rate volatility generally increases during the upswings and downswings period of the market. It becomes more intense during the upswings seasons (Merikas et al., 2008). The volatility of shipping seasonality behaviour of the tanker freight market varies depending on the vessel's size and market conditions; however, it is an important factor in the formulation of shipping transport policy as it affects the ship-owners cash flow.

Depending on the vessel size and market conditions, seasonality rates movements are pronounced when the market is recovering compared to more minor changes when the market is falling; thus, rates fall from January to April and increase during November and December (Kavussanos & Alizadeh-M, 2002). However, there is always an existence of large-varying volatility spill overs across shipping freight markets that were more intense during and after the global economic crisis (Tsouknidis, 2016).

2.4 Demand and Supply of VLCC

The demand curve of tankers is assumed to be utterly inelastic in regards to freight rates, and this assumption is because there has been a lack of alternative ways of transporting crude oil and its products, which makes the demand independent of freight rates. However, this assumption will differ in situations where there are substitutes for crude oil and in situations where freight rates increase a great deal to crude and its products, thus making the demand elastic (Adland & Strandenes, 2007).

The demand for tankers is a derived demand from the trade of oil and oil products, while the supply depends on the availability of tonnage, shipbuilding activities, bunker fuel prices, scrapping market, and the available tanker fleet. The freight rates for the tanker services are affected by both short and long-term factors, and in the short term, both demand and supply of tankers are price inelastic. As such, any shift in demand or supply schedules are likely to produce substantial freight rate changes (Hawdon, 1978). However, in the long term, the supply of tankers is expected to be affected by current and expected world trade values.

The demand for tankers is a derivative of the demand for crude oil, and as such, when there is a high demand for oil, there will be a high demand for tankers to transport the oil, which can prompt tanker companies to raise the oil Spot tanker rates. The volatilities in crude oil prices caused by non-supply factors have no direct impacts on the demand for crude oil transportation services but directly impacts shipping companies' transportation cost (Poulakidas & Joutz, 2009). However, the response of stock returns to oil price shocks may differ greatly depending on whether the increase in the price of crude oil is driven by demand or supply shocks in the crude oil market (Kilian & Park, 2009). Therefore, ship-owners and operators in the crude oil tanker market need to distinguish crude oil supply shocks from crude oil non-supply shocks since they affect the tanker market through different channels.

2.5 Economic Indicators

All economic indicators, which analysts used to interpret current or future investment possibilities, will either show a positive or negative influence on the data that they interpreted (Sariannidis et al., 2010). Government, non-profit organisations to judge the overall health of an economy, uses these indicators and as such, they range from the consumer price index (CPI), Gross Domestic Product (GDP), Unemployment Figures and the price of oil. Crude oil is more reactive to market sentiments as both macroeconomics factors and geopolitical risks in crude oil-exporting countries or regions can contribute to its price volatility quicker than other tradable commodities (Hu et al., 2020).

The relationship between oil price volatility and economic indicators is a short-term one. Still, oil price volatility has significant importance in investment, interest rates and unemployment rates, which can transmit to a budget deficit of a country (Rafiq et al., 2009). Economic indicators are usually different in how they affect each country; however, global oil price shock will always affect the GDP growth of the country (Cross & Nguyen, 2017).

2.5.1 Gross Domestic Product

According to some estimations, the oil and gas exploration industry accounts for around 3 per cent of global GDP. As reported by the International Monetary Fund (IMF), a 10 per cent rise in oil prices causes a 0.2 per cent reduction in the global GDP (Miao et al., 2017)**.**

It is worth noting that the negative GDP growth in 2009, which came because of the 2008 financial crisis, followed the same downward trend as oil output levels. This is because the global economy and living standards and the demand for oil products are reflected in world GDP. As a result, oil refineries modify crude oil demand to the appropriate levels to fulfil global demand for oil products (Ekmekcioglu, 2012).

Crude oil demand has climbed to greater levels in recent years. As a result, the benefits of its trades are widely accessible around the globe. In addition, various initiatives have been thought to contribute to the crude oil trade. This has been accomplished by revenue produced from crude oil sales, which allows substantial infrastructure to be built in the quickest amount of time feasible (Guo & Kliesen, 2005).

Those nations that produce crude oil, on the other hand, proceed to flourish in terms of significant economic development. All of the Gulf nations produce crude oil, and they continue to prosper because of Gulf oil exploitation. The extraction of crude oil from developing nations benefits many industrialised countries (Ekmekcioglu, 2012).

Increases in oil prices reduce future GDP growth by raising production costs in countries all over the world. On the other hand, significant oil price fluctuations boost or decrease total output in various methods (Ekmekcioglu, 2012).

Rises in crude oil prices are closely linked to a country's GDP. It is also clear that the level of crude oil prices and the variations accompanying them have little impact on

GDP growth. As a result, several conditions under which an increase in oil prices are unlikely to be economically viable. Any linear link between oil price fluctuations and economic development generally presents any oil decrease as an enormous stimulus to economic growth. However, in the past few years, increased economic production has aided reducing the oil price fluctuation mechanism. This is accomplished by enacting substantial measures aimed at thoroughly addressing and resolving the problem.

Crude oil is typically essential for economic growth since it adds to a significant financial foundation. This is true for both oil-producing countries and those that rely solely on imports. As a result, numerous powerful countries are rising and expanding, pushed by rapid economic expansion. Thus, the macroeconomic consequences of crude oil are significant from various viewpoints (Ekmekcioglu, 2012).

2.5.2 Crude Oil Production

Crude oil has been recognised as one of the world's most significant commodities. Shocks have been shown to significantly affect crude oil prices, both in terms of supply and demand. As a result, efficient and effective growth has been fostered in all areas of the world. Crude oil has changed business circumstances by assuring that companies continue to develop at a rapid pace. This has also improved the economic situation of these countries that produce crude oil (Blanchard & Gali, 2007). Crude oil has a number of benefits connected with its products. Crude oil is generally broken down into various products, all of which are highly useful and vital in promoting legitimate economic growth (Ekmekcioglu, 2012).

Crude oil is commonly regarded as one of the most influential commodities in global economic development (Miao et al., 2017). Crude oil extraction refers to the amount of oil produced from the oil fields after removing inert matter and impurities. Crude oil, natural gas liquids (NGLs), and additives are all included. Crude oil is a natural gas made up of a bundle of natural hydrocarbons that colour from yellow to black and have a variable density and viscosity. Natural gas liquids (NGLs) are liquid or liquefied hydrocarbons produced during natural gas production, purification, and stabilisation. Non-hydrocarbon compounds are applied to or mixed with a chemical to change its qualities. The generation of secondary oil products from an oil refinery is referred to as refinery production (OECD, 2021). Heavy crude oil has a high density, whereas light crude oil has a low viscosity (Li et al., 2020).

Romania produced the first commercially recorded petroleum in 1857, and the United States followed in 1859. The growth of industrial oil production in the United States, Russia, the Middle East, and Norway will be examined in greater depth in order to demonstrate the extent of innovation in different parts of the world. According to the Statista 2021 data, the daily demand for global crude oil in 2020 was 91 million barrels per day, slightly decreasing than in 2019.

The volatility of oil prices, according to (Killian & Park, 2009), reflects the gap between production and consumption, and the market mainly influences the price of crude oil. Furthermore, when crude oil became more financially viable, numerous publications have recognised the importance of speculations and examined its influence on the oil market. Liu et al., (2016) distinguished between genuine demands, supply, and oil price speculation, according to their data that revealed that after 2000, oil prices were affected considerably by demand from the United States and China.

2.5.3 World Crude Oil Trade

Crude oil is not only the most traded commodity on the planet, but it is also the most significant source of energy for economic activity (Peng etal., 2020). Wei et al. (2017) stated that oil price changes substantially influence supply and demand, particularly throughout the world. According to Aloui et al. (2016), supply and demand influence changes in the uncertainty index. Therefore, oil demand changes that directly affect aggregate demand and oil prices should be identified. As a result, an increase (reduction) in the uncertainty index might have a beneficial effect on the economy. This destabilises oil prices by increasing supply and demand for crude oil.

Crude oil is sold as an energy fuel on the commodities market, and supply and demand influence the long-term trend in crude oil prices. The spike in crude oil prices in 2006–

2007, for example, can be explained in part by aggregate demand shocks generated by rapid development in China and emerging nations at the time (Peng et al., 2020).

The United States, Russia, Canada, Saudi Arabia, and China are the five major oil-producing countries. OPEC and non-OPEC nations are the two types of oil producers globally, with OPEC member countries accounting for 40% and 60% of global crude oil production and exports, respectively (EIA, 2016). The law of supply and demand clearly shows that OPEC's production levels significantly affect oil prices. Despite the fact that the market has been in turmoil since the 2014 oil price crash, crude output levels for 2016 are predicted to be similar to those of 2015 (EIA, 2016).

Crude oil price volatility is the influence in the short run by foreign currency fluctuation, and in the long run, foreign currency fluctuation follows the crude oil price movement and these changes have the currency flotation to affect world crude oil prices (Brahmasrene et al., 2014).

2.5.4 The demand for Crude Oil Trade

There are various ways to explain and analyse the whole picture underpinning the demand for oil. Cynical demand, alternative pricing, climate change, and market speculation are among them (Ekmekcioglu, 2012). The demand for crude oil and the pace of global economic growth is inseparably related to the crude oil market. The fact that crude oil is one of the most widely used and essential commodities facilitates this relationship. When the economy is generally expanding and rising, oil consumption is expected to rise as well. This may be observed in the growing economies of the world, such as China. In this sense, rapid expansion in national production across all energy-intensive criteria has resulted in a significant increase in crude oil consumption (Ekmekcioglu, 2012).

The relative pricing of various oil alternatives in an economy, such as the market price of gas, can significantly influence crude oil demand. The creation of cheaper options for crude oil will substantially affect the price of crude oil in the future. This will ensure that the energy industry has a healthy level of competition. Over the last several years, the high price of oil has prompted extensive study into the development of replacements capable of trading crude oil (Riley & College, 2006).

The heat treatment of crude oil is the primary issue that relates crude oil to climate changes. The price of crude oil growth extends a high range when the heating impact reaches a certain degree. Customers will find it challenging to obtain the product due to this (Ekmekcioglu, 2012). In the global markets, there is always determined speculation related to oil prices. As a result, the most prevalent method associated with a hypothesis is an increase in oil prices. As a result, a high level of demand is well correlated with worldwide petroleum exchanges (Wei, 2003).

2.5.5 Random Shocks

Market participants and policymakers must comprehend the underlying reasons for oil market stability to enhance forecasting accuracy. For example, the complexity of the crude oil market, global oil commerce and demand have a role in predicting oil instability. In addition, random shocks can significantly influence the transportation sector and the worldwide economy as a whole. The weather, as well as economic and political events, are part of the random shock. Variations in climate or natural disasters can harm natural resources and associated infrastructure, disrupting economic activity and lowering commodity demand (Li et al., 2020).

Oil shocks have an asymmetrical effect. In fact, higher oil prices have a stronger influence on economic growth and little impact on inflation (Elmezouar et al., 2014). Crude oil shocks are known to influence all macroeconomic activity by diverting main economic methods significantly. Significant fluctuations in oil prices, in particular, generally raise or decrease. The majority of crude oil prices have a solid link to future prices and substantially affect the gross domestic product (Barsky & Kilian, 2004)**.**

The impact of big price swings and regulations on the crude oil market is a major worry for policymakers worldwide. Accordingly, the Organization of Petroleum Exporting Countries (OPEC) abandoned maintaining steady and rising oil prices to protect its market dominance. As a result, oil prices fell, whereas freight rates began to rise in response to the increasing demand for low-cost oil. The effect on the economy might be amplified or trigger a domino effect when a random shock occurs. For example, the 1929 Wall Street crash began the Great Depression, while the financial crisis of 2008 was primarily precipitated by several major businesses taking on bad credit and housing risk at the same time, with insufficient diversification to mitigate their losses (Li et al., 2020).

Political events are also an additional form of random shocks. Oil prices are influenced by specific both supply and demand as well as expectations. Global geopolitical events and weather impact supply, causing delays in cargo loading and disturbances in production and refineries (Li et al., 2020). Numerous geopolitical and economic actions have made the oil sector very volatile, resulting in severe oil shortages and price swings. These variations result from shifts in the demand for and supply of oil.

Complex challenges like the financial crisis and national elections are part of OPEC's capability. The influence of economic policy uncertainty (EPU) can potentially cause oil price fluctuations, according to Balcilar et al. (2016)**.** It can be said that a high EPU can create a significant divergence in oil consumers, producers, and speculators' perceptions at the same time, affecting crude oil demand, supply, and speculation stock. However, numerous researchers have studied the influence of EPU on the stock market and have used EPU indices to project stock market returns (Baker et al., 2013). A wide range of facts, including oil shocks, financial crises, and political events, significantly influence the oil market and create price volatility.

2.6 The Demand for Crude Oil Transportation

Crude oil is often delivered from the oil fields to the beach through pipelines or shuttle ships. They may then be sent as crude oil or processed and shipped as finished goods. The biggest tankers, having a maximum deadweight capacity of up to 300,000 tonnes, are often used to transport heavy and light crude oil (Stopford, 2008). It is the smaller boats, generally about 30,000 tonnes, are used to convey clean materials with specialised demands during transit (Li et al., 2020).

Transportation of crude oil by sea began around the end of the nineteenth century. The volume of crude oil carried by water has continuously risen since then. Refinery requirements are the primary driving force behind crude oil transportation. Crude oil is used in refineries to make a variety of petroleum products (Hennig, et al., 2012).

Oil tankers transport the world's most precious commodity, oil. The oil tanker business has been around for over a century. Around 1860, when European industrial development required oil imports from the United States, the demand for oil transportation via sea-going boats developed. Thus, oil transportation demand is derived from the market. As a result, fluctuations in oil demand and supply unavoidably affect the performance of the oil tanker sector. Due to the fact that most boats worldwide utilise oil fuel, these distortions influence the demand for seaborne freight and vessel operating costs (Dimitriou, 2016).

Oil has the ability to change the global economy as well as the tanker business. A classic example was the 1973 oil crisis when the OAPEC issued an oil embargo in reaction to the United States' involvement in the Arab-Israeli War. Consequently, the price of oil accelerated during this period, stopping economic development. This price increase directly influenced the oil tanker sector, as demand for oil transportation fell, resulting in increased lay-up and scrapping levels and increased vessel-operating expenses. Simultaneously, the oil tanker industry's headwinds caused several ship-owners to abandon their new building ships straight from the shipyards (Dimitriou, 2016).

The need for oil transportation and storage has soared to new heights, resulting in massive profits for ship owners. Many traders have been buying oil in order to sell it at a much greater price in the future. They have been stockpiling oil in tankers off the coast of major ports to satisfy future demand at a higher price, profiting from the price differentials, a phenomenon known as "Contango". Furthermore, refineries that produce petroleum products require oil as a feedstock. Because of the cheap oil price, refineries worldwide have boosted their oil demand and output levels. Various geopolitical and/or economic developments have reshaped the oil tanker business over its history. The tanker sector, like the maritime industry in general, is characterised by cyclicality and volatility. On the other hand, auto-correcting driving factors stabilise the market and bring demand and supply for seaborne oil trade-in tonnage into balance (Dimitriou, 2016).

Crude oil and product tankers are the two most common types of oil tankers. According to UNCTAD's 2015 assessment of marine transport, seaborne trade accounted for roughly four-fifths of global trade in 2014, totalling $9.84 billion, with crude oil tankers accounting for 17 per cent and product tankers accounting for 9 per cent (UNCTAD, 2015). These two types of commercial ships are used to deliver oil in bulk by sea. Crude oil ships transport unprocessed crude oil from wellheads to refineries all over the world. Meanwhile, product tankers are responsible for the seaborne bulk transportation of clean and dirty oil products generated from the crude oil process. They are comparable to crude oil tankers but smaller. However, because this study focuses on crude oil tankers, we will not detail product tankers. Low oil prices and rising demand for oil from emerging nations result in increased demand for seaborne oil transportation (Dimitriou, 2016)

2.7 Influence of crude oil prices on VLCC trading routes

The global economic activity, level of consumption and production of crude have over the years affected the price of crude as well as the freight rate for VLCC trading routes (Demirbaş et al., 2017). As oil is, also a raw material used by modern industries, fluctuations in crude oil prices would be transmitted to all aspects of the economy through the relevant industrial chain, which will add uncertainty to the global economy (Jiang & Liu, 2021).The volatility of crude oil prices has trigger the fluctuation in the demand and supply of seaborne transportation over the years with an increased in oil production triggering rates to increased towards the end of 2007 when a higher demand for tankers to be used as storage facilities leads to a higher freight rates for the tankers (UNCTAD, 2008). Also reported by UNCTAD (2010), as at the end of October 2009, there were some 143 million barrels of oil stored on 129 tankers which was as a result of the reduction in oil price, thus tankers were employed to serve as floating storage by investors who were willing to resell the crude when the prices go up.

The production of Shale Oil by the United States will significantly affects the WTI crude oil price, as an increase in Shale production will always follow a decrease in the WTI price this is because the evolution of the price of oil in the United States is determined by the increase in Shale oil production (Monge & Gil-Alana, 2021).The 2014-2016 fall of 70% oil price drop has been one of the biggest decline in global history since World War II; this was caused by the oversupply of oil from production countries and the United States booming Shale Oil production, which caused slowdown in both 2015 and 2016 (Stocker et al., 2018). The pandemic caused the WTI to go into the negative for the first time in history with plummeting prices going from $18 a barrel to -$37 a barrel causing an oversupply of oil and forcing tankers to be used as storage facilities by producers (Blessing, 2021).

The freight rates have a great impact on the international trade of crude oil as well as crude products (Bertoloto & Oliveira, 2020). This was evident in 2014 when a rapid price decline of world crude oil boosted the surging demand of crude oil and thus 80% of VLCC and Suezmax were utilized (Wu et al., 2019).

2.8 Research Gap and Contribution

Several real-world problems have been addressed in previous research on crude oil tankers and VLCC transportation. However, there is still little research on the ways to increase the ship-owners wealth (Kavussanos & Alizadeh-M, 2001). Roar et al. (2016) only concentrated on the contribution of owners, charterers and owner-charterer matches to variation in freight rate, leaving further research on the possibility of interactions between market conditions and relationship effects to see how the power of charters to use market power when freight rate is low in comparison of when the fleet is fully utilised. In addition, a further research area on the best practice for system dynamics for the shipping freight rates was highlighted in (Jorgen & Ulrich, 2007).

As shipping is a very risky venture, Xu et al. (2011) presented an article that contributed to understanding the systematic risk of the shipping market. Thus, leaving a further research area comparing the systematic risks across different markets and exploring their side effects. The interactions between market conditions of charterers, owners and matches concerning their market power of controlling freight rates (Roar et al., 2016). Seasonality movements of freight rates vary at different times during the year; however, ship-owners and charterers use strategies when booking vessels during each season. The extent of decisions and short-run speculative strategies used by ship-owners increased their wealth under each market condition (Kavussanos & Alizadeh-M, 2001).

AIS has been used to explain the freight rate evolution on the short-term voyage charter on the movement of vessels within commercial segments. However, the interplay between freight rate and AIS based measures is extended sample periods and other commercial shipping segments (Regil & Nomikos, 2019).

In Poulakidas & Joutz (2009) article, they presented a possibility of using the same approach for other tanker markets. Furthermore, due to cointegration in their research, further analysis in an error-correction modelling framework for VLCC operating on the same route can also be conducted to help determine the seasonal impacts and its short-term market effects. The fundamental reasons why macroeconomics factors play a critical role in the commodity market of crude oil remains unclear. Therefore, a time-series approach with economic analysis will help unravel these reasons (Hu et al., 2020) (Cross & Nguyen, 2017).

Aside from contributing to the existing literature on factors affecting crude oil and VLCC transportation, this research will also look at the fluctuations of crude oil transportation demand in this new economic cycle and VLCC supply. It is also expected to be very useful to countries emerging in the exploration of crude oil. It will show what factors have influenced the prices of oil and the availability of VLCC, thus providing them information that will be helpful in understanding and participating in crude oil transportation. Finally, it will look at crude oil transportation demand fluctuations in this new economic cycle and VLCC supply.

Chapter Three – Data and Methodology

3.1 Data

The data was collected from monthly secondary data of the WTI oil prices from the United States Energy Information Administration (EIA) website, and the rest of the data are collected from the Clarkson Shipping Intelligent network database from May 2008 to May 2021. The use of supply and demand related variables, as well as micro-economic factors, would be used for this analysis. As a joint dissertation, we use the VLCC freight rate as one dependent variable and crude oil production as another dependent variable, giving each dependent variable and a set of independent variables to work on. The table below is an Explanatory of all our independent variables used for this analysis:

Table 1. Explanation of Independent Variables

Category	**Independent Variables**
Economic Factors (Indicators)	OPEC-Crude oil production, Global oil production, West Texas Intermediate (WTI) oil price
Demand for Crude Oil	Import of crude oil, export of crude oil
Supply of VLCC	The new building price of VLCC, Order book of VLCC, second-hand price of VLCC, scrap price, steel price, Japan Steel production, World Steel Production
Baltic Indexes	Baltic dirty tanker index**,** BTDI-TD_1, BDTI-TD_2
Maritime factors	Bunker price, the Middle East to the U.S. Gulf, the Middle East to Singapore

Economic Indicators

The West Texas Intermediate Crude oil price is part of the three global benchmarking of crude oil prices alongside Brent oil price and Dubai oil price. It serves as a reference for crude traders and has been coated along with the Brent oil price (Investopedia, 2020). As it is sourced in Texas and sold in the United States, it has been selected as both our independent variable of crude oil price (y_1) and as a dependent variable for the Middle East to US gulf route (y_3).

OPEC crude oil production is the total of all OPEC producing countries, and as a major oil-producing country, they have a way of controlling the price of crude oil by reducing its oil production when there is an oversupply and producing more during periods of minimal supply in the market.

Global Oil Production constitutes all the nations that are not registered under the OPEC countries and the production of OPEC countries as well. As these counties also produce crude oil and some are also major oil-producing countries, they will impact the price of the West Texas Intermediate Crude Oil and the Middle East to the U.S. Gulf route (Ramcharran, 2002).

Demand for Crude Oil

The demand for Crude Oil comprises both the import and exports of crude from Producing to Consuming Countries. This will be needed for our model as it shows the oil that is produced by the limited countries is consumed globally, thus the need.

Supply of Tonnage

The supply of tonnage is included to show the global availability of tonnage.

Indexes

The indexes are chosen, as they comprise twelve international routes used for seaborne transportation of crude oil and its products. Published by the Baltic Exchange, it is the world's only independent market source of maritime information used for trading in both physical and derivatives markets (Exchage, 2021).

Maritime factors

Bunker prices are also used, as they are major expenses for ship-owners. Fluctuation in bunker prices, therefore, can influence the freight rates of tankers.

The Middle East to US Gulf, as represented by RasTanura_Loop, is the primary route used by VLCC to transport crude from the Middle East to the United States. The frequency of this route is due to the growing oil dependency of oil imports from the Middle East by the United States (Salameh, 2003). According to EIA (2021), the United States imported 5.88MMb/d in 2020, and as the biggest consumer of oil in the world, this was termed as its lowest level of imports from 1991. The crude oil is refined at the US refineries to petroleum products and exported to other countries as well as for the population consumption.

From 1954 to date, the US has been a major crude oil importer from the Middle East and other regions (EIA, 2021). The need to transport crude from the Middle East due to the region's concentration of global oil suppliers and the decline of suppliers from other regions has prompted the region to need seaborne transportation. As a result, the United States continued to reduce its crude oil imports from the Middle East and other OPEC countries to importing heavier crude oil from Canada. This importation doubled to an average of 3.6 million b/d in 2020, which was more than their combined total crude oil imports from all countries (EIA, 2021).

This reduction from importing crude from the Middle East will significantly affect the freight rates of Ras Tanura to US Gulf, as not much of the VLCC trading on that route will be engaged. Therefore, the other ways from the Middle East to other consuming countries will have more tankers moving to that area, thus causing an oversupply of tonnage and lower freight rare for those routes.

The Middle East to Singapore, as represented by RasTanura_SG, is also considered due to the importance of Singapore as a major oil refining centre (Merican, 2007). Singapore built its economy in the 1960’s through oil refining, trading and supporting oil and gas exploration and production (Ng, 2011). The country currently serves as a major port for local cargo from the neighbouring Indonesian Islands and a transhipment hub through the ports to and from Europe, East/ North – East Asia, Australasia and the Indian subcontinent with over 200 shipping lines calling at their port (Cullinane et al., 2006) and as such they are a major bunkering facility for many liner services.

3.2 Methodology

In 2020, almost 1.9 billion metric tons of crude oil was transported through the ocean. As oil pipelines between all trading partners are limited, producers and consumers between Panama and China, the Strait of Hormuz to Japan and from West Africa to India have frequently used land or sea to transport large volumes of crude. The use of tankers to transport the crude oil between these regions has prompted tankers to be the third most important vessel type to be constructed (Statista, 2021). As VLCC mostly does the transportation of crude oil from the point of production to the point of consumption, there will always be the fluctuation of demand and supply, which will affect the freight rate of the VLCC market. To understand the volatility of the crude oil price and VLCC freight rate, the demand and supply changes in this market need to understand to see how the increase in demand for crude will affect the supply of tonnage and how the oversupply of tonnage caused the reduction of freight rate for crude transportation. The interaction of demand and supply in the tanker market is the cause of the volatility of the tanker freight rate.

We will use qualitative time series data for two dependent variables, y_1: VLCC Freight transportation and y_2: crude oil. These dependent variables with independent variables consisting of economic indicators and maritime factors will be used to describe, evaluate and explain which factor affected the volatility of tanker freight rate. With the use of a Classical Linear Regression Model (CLRM), to show and explain which factors affect the crude oil and VLCC markets and how they have influenced the volatility of VLCC freight rate. This analysis will be useful to forecast the trend of the VLCC freight rate in the coming years, and it will also be essential to guide countries that are emerging into the production of crude oil by getting the information of how the demand and supply of crude and tonnage will affect their business. It will also help investors in the shipping market to know when to go in for additional tonnage to be able to benefit from the higher rates.

3.2.1 The Classical Linear Regression Model (CLRM)

To explain the relationship between crude oil and VLCC freight rate between the period under review 2000 to 2020, thus capturing the 2008 financial crisis, the 2020 COVID-19 pandemic and the post-Covid effect on the VLCC and crude oil transportation, to see which variable is more significant to both dependents variables (y1 and y_2).

As per (Brooks , 2008), an equation of $y=\alpha+\beta x$ will be used to show that there is a piece of evidence for a linear relationship between the dependent variable (y) and the independent variables (x). The linear parameters are not divided, multiplied, cubed, squared, or multiplied, etc. Certain models can be turned into linear ones with the appropriate modification or substitution. In a linear relation, there will always be one variable influencing the other, and thus, an increase in x will cause an increase in y and to make this model realistic, we will add a random disturbance term μ to the equation to make it:

Equation 1 for VLCC: $y_1= \beta_1 x_1+\beta_2 x_2+\beta_3 x_3+\ldots\mu$

Equation 2 for crude oil: $y_2=\beta_1 x_1+\beta_2 X_2+\beta_3 X_3+\ldots\mu$

Where y_1= VLCC dependent variable

y_2= Crude Oil dependent variable

x = independent variables

β_1, β_2, β_3 is the slope or coefficients of x_1, x_2, x_3 respectively

μ = error

The Best Linear Unbiased Estimators (BLUE) are the determinations of the estimators α and β with the use of OLS. To get the standards of BLUE, we need the following assumptions;

(1) The errors have zero mean,

(2) The variance of the errors is constant and finite overall values of $x_{t,}$

(3) The errors are statistically independent of one another,

(4) There should be no relation between the error and the corresponding x variable,

(5) The error is normally distributed.

3.2.2 Descriptive Statistics

Descriptive statistics, such as structuring time-series graphs and preliminary statistics for all variables, are the next step in the OLS regression after choosing dependent and independent variables. We are able to obtain information regarding the timeline by plotting line graphs. These graphs should be continuous, and if there is a gap in the data, we must step backwards and rectify it.

3.2.3 Preliminary Statistics

As statistical procedures normally required distribution data, we will use the preliminary statistics to acquire information about the distribution of our variables through the broad category (mean, median, mode), variability around the mean (standard deviation and variance), measures of deviation from normality (skewness and kurtosis), information on the spread of the distribution (maximum, minimum and variance) (George & Mallery, 2016).

These figures must be finite (quantifiable number). The purpose of skewness is to enhance the precision of determining distribution locations by implementing adjustments to moderate skewed data for more accurate significance tests and improving sampling precision. Skewness indicates the non-symmetric distributions of a credible random variable's probability about its mean in both statistics and theory. Skewness can have a positive, negative, or undefinable value. From the theoretical point of view, skewness determines which side of distribution has a longer tail. If the skewness is positive, the long tail is on the right side, whereas the skewness is negative when the long tail is on the left. An ideal distribution should be symmetrical, meaning that the two tails of the distribution should be at the same distance from the mean (Billat et al., 2020). This data will then be transformed to logarithm to have all the distribution on a normal based.

3.2.4 Stationarity Test (Unit Root Test)

The stationary test (unit root test) function will be used after the preliminary statistics. Before performing the regression, use this test to ensure that all variables are stable. It indicates whether the variables have returned to their original position after being shocked. When the shock is larger than one, the scenario is referred to as a severely stagnant situation or an explosive process, and the system's influence is prolonged. If the shock equals one, the system does seem to be weakly stationary; if the shock is less than one, the system is stationary, and the effect will diminish with time. We used a specific sort of hypothesis test called the t-ratio or t-statistic to avoid infinite shocks caused by non-stationary series. In practice, stationarity is required for all dependent and independent variables.

Each variable will have to be tested using Augmented Dickey-Fuller (ADF) and Philips Perron (PP) to show that the probability value is less than 5% as per ADF and PP test. The null hypothesis will be accepted, indicating that the variable is non-stationary and has a unit root. However, in an instance where both ADF and PP tests have different variables, then Kwartuwski Philips Schmidt Shin (KPSS-Test) will be conducted (Dickey & Fuller, 1979).

3.2.5 Multicollinearity

Following the unit root test, the correlation test is done. This is the first step towards limiting a considerable level of correlation across dependent variables. When running an OLS regression, the independent variables are not correlated and reconsidered correlated when the coefficient is more than 80% (Damodar & Dawn, 2010).

3.2.6 Hypothesis Testing-The T-Test

We use the coefficient diagnostics test (t-test) to test our hypothesis for the significance of (x) to both (y). A significant x value should have a p-value of less than 5%, and the last results having only significant variables will be used for the regression (Brooks, 2008).

3.2.7 Engle & Granger Cointegration Test

We use this test to consider the significant variables that affect the y variable by comparing the p-value of the residuals (of y and each individual of x); it makes a paired comparison of the natural log between dependent variables y and each independent variable x. If the p-value as per PP/ADF Test is more than 5%, it is not stationary, but if less than 5%, it is stationary (Engle & Granger, 1991). Relying on static regression, it calculates residuals (errors). The residuals are used to determine if there are any unit-roots.

When we integrate variables with various integration orders, the optimum level of integration will be observed. Although the majority of the time series are non-stationary, they do tend to trend together throughout time. When the variables are cointegrated, their linear combination becomes essentially stable, which can be considered a long-term relationship. Once the variables are cointegrated, the error correction term must be introduced. The addition of the error correction term is for the rectification of yesterday's errors in order to be enhanced today.

3.2.8 Autoregressive and Moving Average (ARMA)

The Bayesian method will be used for testing the time series model as well as to forecast the observations. The ARMA method will be used to determine the presence of a unit root in the time series. The presence of unit root will indicate that the non-stationarity and hence the need to reduce the model to stationarity (Said & Dickey, 1984).

3.2.9 Residual Diagnosis

Table 2. Heteroscedasticity and Serial Correlation

Arch Effect	**Serial Correlation**	**Correction Method**	
No Arch	No Serial	Perfect Model-Do nothing	Continue to Ramsey test
Arch	No Serial	White Correction	
No Arch	Serial	Newey-West Correction	
Arch	Serial	Newey-West Correction	

We will use the Bera-Jarque to test if our data is normally distributed. In the instance that the P-value is less than 5%, the errors are not normally distributed; dummies will be added until the instance that they are normally distributed. When the model is normally distributed, we will conduct the following test (table 2) to see if the variance changes over time (Brooks, 2008).

3.2.10 Stability Diagnosis (Ramsey Test)

This test will be used to examine the linearity in our model with a p-value of more than 5%, and our hypothesis will be acceptable, thus making our model linear for running our regression (Brooks, 2008).

Chapter Four – Empirical Results

4.1 Descriptive Statistics of all variables

The table below showed the descriptive statistics of all the variables. It showed all the independent variables that can possibly affect all the independent variables (y_1, y_2 and y_3). For the distribution to be normally distributed, the mean value has to be symmetric and not skewed. These variables have been tested and normally distributed.

Table 3. Descriptive Statistics

	Maximum	Mimimum	Mean	Median	Std_Dev	Skewness
WTI_OilPrice	133.88	16.55	70	65.17	23.95	0.33
RasTanura_Loop	144.38	15.5	36.09	30.63	21.61	2.9
RasTanura_SG	237.5	27.63	60.66	52.88	32.35	2.91
BangladeshScrapPrice	740	235	406.19	415	86.08	0.89
IndiaScrapPrice	740	235	399.94	410	89.93	0.5
GlobalOilProd	102.07	83.93	93.01	92.5	5.11	0
NAmericaOilProd	25.83	12.56	18.57	18.81	3.74	0.27
OPEC_CrudeOilProd	33.9	22.52	30.33	30.55	2.19	-1.25
MEastOilProd	28.77	20.79	23.95	23.53	1.78	0.28
US_SeaborneCrudeOil_Imp	8.45	1.83	5	4.74	1.7	0.05
VLCC_FleetDev	259.25	145.32	198.86	193.21	32.23	0.21
BunkerPrices_Genoa	742.2	145.5	440.16	432.7	155.05	0.13
BunkerPrices_SG	733.3	159.63	441.82	433.63	154.08	0.15
BDTI_TD1	142.84	15.24	35.9	30.83	21.17	2.92
BDTI_TD2	231.49	26.9	59.9	52.69	30.64	2.9
BDTI_TD1_TCE	128926.1	-28972.3	7212.42	-523.73	26494.81	2.01
BDTI_VLCC_TCE	152588.1	-17022.2	19406.2	9732.17	29178.39	2.02
BDTI_Index	2071.83	419.5	798.16	741.48	264.91	2.2
SecondhandPrice	135	34	51.63	47.5	18.17	3.06
ScrapValue	28.39	9.53	16.83	17.28	3.51	0.32
JapanSteelProd	10547	5479	8613.39	8793.36	914.33	-1.4
WorldSteelProd	174375.8	82060	132631	132869	17772.81	-0.4
Orderbook_Fleet	54.59	7.48	20.81	15.18	12.38	1.12

4.2 Natural Log

We ran the descriptive statistics and took both the dependent and independent variables to a natural log. They were collected using different units (tons, values, number of indexes, percentages); it also reversed any negative data to positive.

4.3 Stationarity (unit root) Test

As per the table below, all our variables were found to be stationary at first difference as per both Philip Perron (PP) and Augmented Dickey-Fuller (ADF).

Table 4. Stationarity (Unit root) test

Variables	ADF			PP			KPF			Stationary
	Level	1st Diff.	2nd Diff.	Level	1st Diff.	2nd Diff.	Level	1st Diff.	2nd Diff.	
WTI_OilPrice	0.415	0.001		0.415	0.001		0.01	0.1		1st Diff.
RasTanura_Loop	0.232	0.001		0.232	0.001		0.01	0.1		1st Diff.
RasTanura_SG	0.292	0.001		0.292	0.001		0.01	0.1		1st Diff.
BangladeshScrapPrice	0.535	0.001		0.535	0.001		0.01	0.1		1st Diff.
IndiaScrapPrice	0.534	0.001		0.534	0.001		0.01	0.1		1st Diff.
GlobalOilProd	0.81	0.001		0.81	0.001		0.01	0.1		1st Diff.
NAmericaOilProd	0.947	0.001		0.947	0.001		0.01	0.1		1st Diff.
OPEC_CrudeOilProd	0.364	0.001		0.364	0.001		0.01	0.1		1st Diff.
MEastOilProd	0.619	0.001		0.619	0.001		0.01	0.1		1st Diff.
US_SeaborneCrudeOil_Imp	0.154	0.001		0.154	0.001		0.01	0.1		1st Diff.
VLCC_FleetDev	0.999	0.001		0.999	0.001		0.01	0.1		1st Diff.
BunkerPrices_Genoa	0.526	0.001		0.526	0.001		0.01	0.1		1st Diff.
BunkerPrices_SG	0.493	0.001		0.493	0.001		0.01	0.1		1st Diff.
BDTI_TD1	0.22	0.001		0.22	0.001		0.01	0.1		1st Diff.
BDTI_TD2	0.285	0.001		0.285	0.001		0.01	0.1		1st Diff.
BDTI_TD1_TCE	0.389	0.001		0.389	0.001		0.01	0.1		1st Diff.
BDTI_VLCC_TCE	0.398	0.001		0.398	0.001		0.01	0.1		1st Diff.
BDTI_Index	0.37	0.001		0.37	0.001		0.01	0.1		1st Diff.
SecondhandPrice	0.105	0.001		0.105	0.001		0.01	0.1		1st Diff.
ScrapValue	0.521	0.001		0.521	0.001		0.01	0.1		1st Diff.
JapanSteelProd	0.522	0.001		0.522	0.001		0.01	0.1		1st Diff.
WorldSteelProd	0.846	0.001		0.846	0.001		0.01	0.1		1st Diff.
Orderbook_Fleet	0.029	0.001		0.029	0.001		0.01	0.094		1st Diff.

4.4 Multicollinearity

The results show a high correlation between dependent variables. BDTI TD1 Middle East to US Gulf (94%), BDTI TD2 Middle East to Singapore (98%), BDTI VLCC

TCE (92%) were all correlated with Y2 Ras Tanura to Singapore and thus, they were removed. Indian scrap price (88%) and scrap value (96%) were all correlated with Bangladesh Scrap Price. The two variables were removed, and Bangladesh scrap price was maintained as they have a high demand for scraps, which are converted raw materials for steel companies (Buxton, 1991). Middle East Oil Production (91&), Global Oil Production (81%) and OPEC Crude Oil were correlated. OPEC Crude oil was maintained whilst the other two were removed as they are also calculated in the OPEC oil productions. Bunker Price Singapore (91%) correlated with Bunker price Genoa. However, as both independent variables are routes from the Middle East (y_1 and y_2), Bunker price Genoa was maintained as a fuelling spot for the vessels.

Using three independent variables, on the regression model, RasTanuara_Loop, there was a high correlation between WTI oil price and RasTanura_SG. RasTanura_SG was removed as it is the route and it is bound to have a long-term relationship with the variables. The same was done for the RasTanura_SG, and the RasTanura_Loop was removed.

Table 5. Correlation table before removing the highly correlated variables

Row	RasTanura_Loop	RasTanura_SG	BangladeshScrapPrice	IndiaScrapPrice	GlobalOilProd	NAmericaOilProd	OPEC_CrudeOilProd	MEastOilProd	US_SeaborneCrudeOil_Imp	VLCC_FleetDev	BunkerPrices_Genoa	BunkerPrices_SG	BDTI_TD1	BDTI_TD2	BDTI_TD1_TCE	BDTI_VLCC_TCE	BDTI_Index	SecondhandPrice	ScrapValue	JapanSteelProd	WorldSteelProd	Orderbook_Fleet
RasTanura_Loop	100%																					
RasTanura_SG	95%	100%																				
BangladeshScrapPrice	9%	7%	100%																			
IndiaScrapPrice	5%	4%	88%	100%																		
GlobalOilProd	1%	3%	12%	15%	100%																	
NAmericaOilProd	-6%	-3%	23%	25%	53%	100%																
OPEC_CrudeOilProd	-5%	-4%	-3%	2%	81%	21%	100%															
MEastOilProd	-6%	-4%	0%	3%	78%	18%	91%	100%														
US_SeaborneCrudeOil_Imp	-11%	-13%	-13%	-9%	-6%	-12%	12%	11%	100%													
VLCC_FleetDev	-2%	1%	8%	9%	-3%	-3%	-10%	-8%	-14%	100%												
BunkerPrices_Genoa	-2%	-1%	27%	28%	-25%	-19%	-23%	-27%	4%	1%	100%											
BunkerPrices_SG	-5%	-2%	27%	28%	-14%	-11%	-14%	-19%	-7%	-5%	91%	100%										
BDTI_TD1	99%	94%	8%	4%	2%	-6%	-5%	-4%	-12%	-3%	-4%	-6%	100%									
BDTI_TD2	94%	98%	7%	3%	4%	-4%	-3%	-3%	-14%	0%	-2%	-1%	95%	100%								
BDTI_TD1_TCE	86%	84%	1%	-4%	5%	-3%	-3%	-1%	-2%	-2%	-20%	-24%	87%	84%	100%							
BDTI_VLCC_TCE	90%	92%	1%	-3%	5%	-3%	-3%	-2%	-9%	1%	-15%	-18%	90%	93%	96%	100%						
BDTI_Index	65%	65%	9%	10%	13%	3%	10%	11%	-13%	-5%	-6%	-1%	67%	67%	49%	54%	100%					
SecondhandPrice	15%	12%	39%	40%	17%	17%	4%	7%	-10%	-19%	4%	6%	14%	11%	8%	8%	19%	100%				
ScrapValue	6%	4%	96%	93%	13%	23%	-1%	0%	-11%	9%	26%	26%	5%	4%	-3%	-2%	10%	41%	100%			
JapanSteelProd	13%	10%	1%	9%	4%	-10%	6%	2%	8%	-19%	21%	13%	12%	9%	6%	4%	19%	9%	5%	100%		
WorldSteelProd	2%	2%	20%	23%	-4%	-5%	1%	3%	26%	-23%	23%	17%	1%	2%	0%	0%	8%	18%	22%	68%	100%	
Orderbook_Fleet	-2%	0%	-5%	-6%	6%	4%	10%	6%	10%	-45%	1%	1%	-2%	1%	-4%	-2%	0%	13%	-6%	9%	13%	100%

Note: The highlighted numbers are the variables that are more than 80% correlated with each other.

Table 6. Correlation table after removing the highly correlated variables

Row	RasTanura_Loop	BangladeshScrapPrice	NAmericaOilProd	OPEC_CrudeOilProd	US_SeaborneCrudeOil_Imp	VLCC_FleetDev	BunkerPrices_Genoa	BDTI_Index	SecondhandPrice	JapanSteelProd	WorldSteelProd	Orderbook_Fleet
RasTanura_Loop	100%											
BangladeshScrapPrice	9%	100%										
NAmericaOilProd	-6%	23%	100%									
OPEC_CrudeOilProd	-5%	-3%	21%	100%								
US_SeaborneCrudeOil_Imp	-11%	-13%	-12%	12%	100%							
VLCC_FleetDev	-2%	8%	-3%	-10%	-14%	100%						
BunkerPrices_Genoa	-2%	27%	-19%	-23%	4%	1%	100%					
BDTI_Index	65%	9%	3%	10%	-13%	-5%	-6%	100%				
SecondhandPrice	15%	39%	17%	4%	-10%	-19%	4%	19%	100%			
JapanSteelProd	13%	1%	-10%	6%	8%	-19%	21%	19%	9%	100%		
WorldSteelProd	2%	20%	-5%	1%	26%	-23%	23%	8%	18%	68%	100%	
Orderbook_Fleet	-2%	-5%	4%	10%	10%	-45%	1%	0%	13%	9%	13%	100%

4.5 Hypothesis Testing-The T-Test

A significant value will have a probability value of less than 5%. As three regressions were run, we have presented all three tables and the variables that are found to be significant for all three variables.

On y_1, which is the route for the Middle East to the USA, has three significant variables: WTI Oil Price, RasTanura to Singapore (SG), and ect_RasTanura to SG.

On y_2, which is the route for the Middle East to Singapore, has only the RasTanura to Loop as a significant variable.

On y_3, the WTI Oil price has the largest significant variables: Ras Tanura to SG, Ras Tanura to Loop, Bangladesh scrap price, OPEC crude oil, US seaborne crude oil imports, and bunker price Genoa.

Table 7. Significant variable for RasTanura_Loop

Dependent Variable: RasTanura_Loop Method: Ordinary Least Squares Regression Included observations: 152 after adjustments				
Variables	**Estimate**	**Std. Error**	**t-Stat**	**pValue**
(Intercept)	-0.006	0.015	-0.432	0.667
WTI_OilPrice	-0.619	0.194	-3.193	0.002
BunkerPrices_Genoa	0.600	0.223	2.692	0.008

BDTI_Index	1.001	0.095	10.502	9.696e-20
Number of Observation	156	Error Degrees of Freedom		152
Root Mean Squared Error	0.186	F-statistic vs. constant model		43.4
R-squared	0.461			
Adjusted R-Squared:	0.451	p-value		2.53e-20

Table 8. Significant variable for RasTanura_SG

Dependent Variable: RasTanura_SG Method: Ordinary Least Squares Regression Included observations: 152 after adjustments				
Variables	**Estimate**	**Std. Error**	**t-Stat**	**pValue**
(Intercept)	-0.004	0.017	-0.235	0.814
WTI_OilPrice	-0.464	0.214	-2.163	0.032
BunkerPrices_Genoa	0.502	0.246	2.038	0.043
BDTI_Index	1.108	0.106	10.508	9.330e-20
Number of Observation	156	Error Degrees of Freedom		152
Root Mean Squared Error	0.206	F-statistic vs. constant model		40.7
R-squared	0.446			
Adjusted R-Squared	0.435	p-value		2.28e-19

Table 9. Significant Variables for WTI Oil Price

Dependent Variable: WTI_OilPrice Method: Ordinary Least Squares Regression Included observations: 150 after adjustments				
Variables	**Estimate**	**Std. Error**	**t-Stat**	**pValue**
(Intercept)	-0.0002	0.006	-0.043	0.966
RasTanura_Loop	-0.075	0.022	-3.349	0.001
BangladeshScrapPrice	0.176	0.060	2.918	0.004
OPEC_CrudeOilProd	0.495	0.223	2.218	0.028
US_SeaborneCrudeOil_Imp	0.280	0.067	4.170	5.119e-05

BunkerPrices_Genoa	0.859	0.057	15.124	5.650e-32
Number of Observation	156	Error Degrees of Freedom		150
Root Mean Squared Error	0.069	F-statistic vs. constant model		65.4
R-squared	0.686			
Adjusted R-Squared:	0.675	p-value		5.99e-36

4.6 Engle & Granger Cointegration Test

The cointegration for the RasTanura_Loop shows a long-run relationship between WTI spot price and RasTanura_SG, and thus, an error correction term added made the R- squared 0.546 and the adjusted R-squared 0.534.

Table 10. Cointegration test for RasTanura_Loop

Dependent Variable: RasTanura_Loop Method: Ordinary Least Squares Regression Included observations: 151 after adjustments				
Variables	**Estimate**	**Std. Error**	**t-Stat**	**pValue**
(Intercept)	-0.006	0.014	-0.403	0.687
WTI_SpotPrice	-0.573	0.1789	-3.205	0.002
BunkerPrices_Genoa	0.539	0.205	2.624	0.010
BDTI_Index	1.057	0.088	11.957	1.320e-23
ect_BDTI_Index	-0.310	0.058	-5.318	3.705e-07
Number of Observation	156	Error Degrees of Freedom		151
Root Mean Squared Error	0.171	F-statistic vs. constant model		45.5
R-squared	0.546			
Adjusted R-Squared	0.534	p-value		5.04e-25

The cointegration for the RasTanura_SG shows a long-run relationship with RasTanura_Loop, and thus an error correction term added made the R-squared 0.617 and the adjusted R-squared 0.612.

Table 11. Cointegration Table for RasTanura_SG

Dependent Variable: RasTanura_SG Method: Ordinary Least Squares Regression Included observations: 153 after adjustments				
Variables	**Estimate**	**Std. Error**	**t-Stat**	**pValue**
(Intercept)	-0.001	0.014	-0.067	0.947
BDTI_Index	1.277	0.088	14.477	1.823e-30
ect_BDTI_Index	-0.680	0.078	-8.697	4.990e-15
Number of Observation	156	Error Degrees of Freedom		153
Root Mean Squared Error	0.17	F-statistic vs. constant model		123
R-squared	0.617			
Adjusted R-Squared	0.612	p-value		1.39e-32

The cointegration for the Y1 shows a long-run relationship of Bunker Price_Genoa, and thus an error correction term added, making the R- Square 0.725 and the adjusted R- Square 0.714.

Table 12. Cointegration Table for WTI_OilPrice

Dependent Variable: WTI_OilPrice Method: Ordinary Least Squares Regression Included observations: 149 after adjustments				
Variables	**Estimate**	**Std. Error**	**t-Stat**	**pValue**
(Intercept)	-0.0003	0.005	-0.047	0.962
RasTanura_Loop	-0.064	0.021	-3.032	0.003
BangladeshScrapPrice	0.146	0.057	2.566	0.011
OPEC_CrudeOilProd	0.430	0.210	2.048	0.042
US_SeaborneCrudeOil_Imp	0.272	0.063	4.312	2.928e-05
BunkerPrices_Genoa	0.873	0.0533	16.357	4.441e-35
ect_BunkerPrices_Genoa	-0.209	0.0453	-4.621	8.220e-06
Number of Observation	156	Error Degrees of Freedom		149

Root Mean Squared Error	0.065	F-statistic vs. constant model	65.4
R-squared	0.725		
Adjusted R-Squared	0.714	p-value	2.65e-39

4.7 Autoregressive and Moving Average (ARMA)

Autoregressive (AR) and Moving Average (MA) were added on each of the three regressions, and they have been presented on the tables below. ARMA was added but they were making the significant variable insignificant. It also made the model have a higher Akaike Information Criterion (AIC), and thus they were removed. The results presented below show the ARMA included in the model. However, both AR and MA were added to the model with 5:5, respectively. The final ARMA shows 0.1 but still, all the significant variables to be insignificant, and thus created a model with no ARMA.

Table 13. ARMA model for RasTanura_Loop

Dependent Variable: RasTanura_Loop Method: Ordinary Least Squares Regression Included observations: 149 after adjustments				
Variables	**Estimate**	**Std. Error**	**t-Stat**	**pValue**
(Intercept)	-0.006	0.013	-0.445	0.657
WTI_SpotPrice	-0.595	0.171	-3.480	0.001
BunkerPrice_Genoa	0.473	0.197	2.401	0.0176
BDTI_Index	1.165	0.089	13.151	1.043e-26
ect_BDTI_Index	-0.103	0.076	-1.345	0.181
MA	-0.477	0.119	-4.022	9.126e-05

Number of Observation	155	Error Degrees of Freedom	149
Root Mean Squared Error	0.164	F-statistic vs. constant model	43.2
R-squared	0.592		
Adjusted R-Squared	0.578	p-value	2.41e-27

The results presented below show the ARMA included in the model. However, both AR and MA were added to the model with 5:5, respectively. The final ARMA shows 1.1 but still, all our significant variables to be insignificant, and thus creating a model without the ARMA.

Table 14. ARMA model for RasTanura_SG

Dependent Variable: RasTanura_SG Method: Ordinary Least Squares Regression Included observations: 150 after adjustments				
Variables	**Estimate**	**Std. Error**	**t-Stat**	**pValue**
(Intercept)	-0.002	0.014	-0.158	0.875
BDTI_Index	1.306	0.088	14.823	3.479e-31
ect_BDTI_Index	-0.281	0.225	-1.251	0.213
AR	-0.033	0.073	-0.454	0.651
MA	-0.441	0.281	-1.568	0.119
Number of Observation	155	Error Degrees of Freedom		150
Root Mean Squared Error	0.17	F-statistic vs. constant model		64.4
R-squared	0.632			
Adjusted R-Squared	0.622	p-value		1.31e-31

The results presented below show the ARMA included in the model. However, both AR and MA were added to the model with 5:5, respectively. Therefore, the final ARMA sows 1.1 but still, all our significant variables to be insignificant, and thus we have to create a model with no ARMA.

Table 15. ARMA model for WTI_OilPrice

Dependent Variable: WTI_OilPrice Method: Ordinary Least Squares Regression Included observations: 146 after adjustments				
Variables	**Estimate**	**Std. Error**	**t-Stat**	**pValue**
(Intercept)	-0.001	0.005	-0.167	0.868

RasTanura_Loop	-0.063	0.022	-2.952	0.004
BangladeshScrapPrice	0.154	0.058	2.672	0.008
OPEC_CrudeOilProd	0.442	0.220	2.012	0.046
US_SeaborneCrudeOil_Imp	0.258	0.064	4.024	9.151e-05
BunkerPrices_Genoa	0.896	0.063	14.291	1.561e-29
ect_BunkerPrices_Genoa	-0.249	0.057	-4.411	1.988e-05
AR	-0.056	0.063	-0.883	0.379
MA	0.141	0.120	1.172	0.243
Number of Observation	155	Error Degrees of Freedom		146
Root Mean Squared Error	0.065	F-statistic vs. constant model		48.9
R-squared	0.728			
Adjusted R-Squared	0.713	p-value		1.38e-37

4.8 Residual Diagnosis

4.8.1 Heteroscedasticity and Serial Correlation

Table 16. Heteroscedasticity and Serial Correlation Table for RasTanura_Loop

Dependent Variable: RasTanura_Loop Method: Ordinary Least Squares Regression Included observations: 153 after adjustments				
Variables	Estimate	Std. Error	t-Stat	pValue
(Intercept)	-0.005	0.015	-0.301	0.764
BunkerPrices_Genoa	0.053	0.147	0.363	0.717
BDTI_Index	1.037	0.098	10.638	3.951e-20
Number of Observation	156	Error Degrees of Freedom		153
Root Mean Squared Error	0.192	F-statistic vs. constant model		56.6
R-squared	0.425			
Adjusted R-Squared	0.418	p-value		3.93e-19
hac result: 'with ARCH effect and no serial correlation'				

Table 17. Heteroscedasticity and Serial Correlation Table for RasTanura_SG

Dependent Variable: RasTanura_SG Method: Ordinary Least Squares Regression Included observations: 154 after adjustments				
Variables	**Estimate**	**Std. Error**	**t-Stat**	**pValue**
(Intercept)	-0.003	0.017	-0.164	0.870
BDTI_Index	1.130	0.106	10.717	2.266e-20
Number of Observation	156	Error Degrees of Freedom		154
Root Mean Squared Error	0.208	F-statistic vs. constant model		115
R-squared	0.427			
Adjusted R-Squared	0.423	p-value		2.27e-20
hac result: 'with ARCH effect and no serial coorelation'				

Table 18. Heteroscedasticity and Serial Correlation Table for WTI_OilPrice

Dependent Variable: WTI_OilPrice Method: Ordinary Least Squares Regression Included observations: 154 after adjustments				
Variables	**Estimate**	**Std. Error**	**t-Stat**	**pValue**
(Intercept)	0.001	0.006	0.156	0.876
BangladeshScrapPrice	0.159	0.062	2.561	0.011
OPEC_CrudeOilProd	0.531	0.230	2.305	0.023
US_SeaborneCrudeOil_Imp	0.301	0.069	4.350	2.492e-05
BunkerPrices_Genoa	0.868	0.059	14.804	3.344e-31
Number of Observation	156	Error Degrees of Freedom		151
Root Mean Squared Error	0.072	F-statistic vs. constant model		73.9
R-squared	0.662			
Adjusted R-Squared	0.653	p-value		1.38e-34
hac result: 'with no ARCH effect and no serial coorelation'				

4.8.2 Jargue Bera

All three models were found to each have a probability value of less than 5%; thus, dummies were added to make them normally distributed, and they are presented in the tables below.

Table 19. Dummies model for RasTanura_Loop

Dependent Variable: RasTanura_Loop Method: Ordinary Least Squares Regression Included observations: 150 after adjustments				
Variables	**Estimate**	**Std. Error**	**t-Stat**	**pValue**
(Intercept)	-0.014	0.012	-1.128	0.261
BunkerPrices_Genoa	0.271	0.121	2.249	0.026
BDTI_Index	0.774	0.085	9.164	3.534e-16
dummy143	1.233	0.160	7.719	1.527e-12
dummy145	-0.705	0.158	-4.474	1.511e-05
dummy138	0.688	0.161	4.276	3.378e-05
Number of Observation Root Mean Squared Error R-squared Adjusted R-Squared	156 0.153 0.642 0.63	Error Degrees of Freedom F-statistic vs. constant model p-value		150 53.7 9.62e-32

Table 20. Dummies model for RasTanura_SG

Dependent Variable: RasTanura_SG Method: Ordinary Least Squares Regression Included observations: 153 after adjustments				
Variables	**Estimate**	**Std. Error**	**t-Stat**	**pValue**
(Intercept)	-0.009	0.016	-0.573	0.568
BDTI_Index	1.064	0.100	10.598	5.036e-20
Dummy143	0.903	0.198	4.556	1.058e-05

Number of Observation	156	Error Degrees of Freedom	153
Root Mean Squared Error	0.195	F-statistic vs. constant model	75.2
R-squared	0.496		
Adjusted R-Squared	0.489	p-value	1.82e-23

Table 21. Dummies model for WTI_OilPrice

Dependent Variable: WTI_OilPrice

Method: Ordinary Least Squares Regression

Included observations: 147 after adjustments

Variables	Estimate	Std. Error	t-Stat	pValue
(Intercept)	-0.001	0.004	-0.123	0.903
BangladeshScrapPrice	0.167	0.045	3.680	0.0003
OPEC_CrudeOilProd	-0.060	0.178	-0.337	0.736
US_SeaborneCrudeOil_Imp	0.062	0.056	1.096	0.275
BunkerPrices_Genoa	0.704	0.047	15.078	1.219e-31
dummy145	0.542	0.059	9.249	2.454e-16
dummy143	-0.313	0.055	-5.75	4.984e-08
dummy144	-0.293	0.057	-5.179	7.231e-07
dummy8	-0.198	0.055	-3.637	0.0004

Number of Observation	156	Error Degrees of Freedom	147
Root Mean Squared Error	0.052	F-statistic vs. constant model	86.9
R-squared	0.825		
Adjusted R-Squared	0.816	p-value	8.01e-52

4.9 Stability Diagnosis (Ramsey Test) test

Table 22. Reset results for RasTanura_Loop

Dependent Variable: RasTanura_Loop

Variables	Estimate	Std. Error	t-Stat	pValue
(Intercept)	-0.011	0.017	-0.664	0.508
y_fit_p2	0.422	0.286	1.474	0.143

Number of Observation	156	Error Degrees of Freedom	154
Root Mean Squared Error	0.19	F-statistic vs. constant	2.17
R-squared	0.014	model	
Adjusted R-Squared	0.008	p-value	0.143

Table 23. Reset results for RasTanura_Loop

Dependent Variable: RasTanura_Loop				
Variables	**Estimate**	**Std. Error**	**t-Stat**	**pValue**
(Intercept)	-0.007	0.019	-0.399	0.691
y_fit_p2	0.232	0.260	0.892	0.374
Number of Observation	156	Error Degrees of Freedom		154
Root Mean Squared Error	0.207	F-statistic vs. constant		0.796
R-squared	0.00514	model		
Adjusted R-Squared	-0.00132	p-value		0.374

Table 24. Reset results for WTI_OilPrice

Dependent Variable: WTI_OilPrice				
Variables	**Estimate**	**Std. Error**	**t-Stat**	**pValue**
(Intercept)	0.001	0.006	0.077	0.939
y_fit_p2	-0.048	0.232	-0.207	0.836
Number of Observation	156	Error Degrees of Freedom		154
Root Mean Squared Error	0.0707	F-statistic vs. constant		0.0430
R-squared	0.0003	model		
Adjusted R-Squared	-0.006	p-value		0.836

4.10 The Final Model

After running all the functions for the Classical Linear Regression Model (CLRM), a compassion was made of the regression results of the T-Test and the regression result of the ARMA model and based on the Account Information Criterial (AIC). Therefore, the model selected was the one with the lowest AIC as our final models for all three independent variables and are presented based on the regression results with the lowest AIC which are attached as an appendix.

Chapter Five – Discussions

The use of linear regression to determine what factors affect the freight rate of VLCC and crude oil was conducted from the monthly data from May 2008 to May 2021. Three dependent variables and twenty-two independent variables; on each of the regressions was used, two of the dependent variables were used as independent variables to see whether they will all be significant variables.

As the Middle East contains half of the world's oil reserves, they are also suppliers of crude oil to both the United States and the Asian market (Balat, 2006), which have been used in this research. Both routes are used to export crude oil from the Middle East to America or Singapore and use the WTI spot price as both a dependent and independent variable. However, a decrease in the price of oil on these routes will cause an increase in the number of VLCC needed for the transportation of the crude that will cause an increase in freight rates for both routes.

The market price for crude oil is determined by demand and supply, and hence when the price for crude increases in one route (market), it causes a spill of demand and supply from one route to another (Klingeberg & Rathgeber, 2021). This is the same scenario that is presented in the research, and based on the regression results, the significant variables that affect crude oil and VLCC is stated below:

Significant variable from the final model based on the AIC criteria of different results-

1. Regression results for the Middle East to US Gulf show West Texas Intermediate oil price, bunker price Genoa and Baltic Dirty Tanker Index as the significant variables.
2. Regression results for the Middle East to Singapore show Baltic Dirty Tanker Index as the only significant variable.
3. Regression results for West Texas Intermediate Price show Ras Tanura to Loop, Bangladesh scrap price, OPEC crude oil production, U.S seaborne crude oil imports and bunker price Genoa as significant variables.

It is noticed that only the bunker price Genoa and the Baltic Dirty Tanker Index are the common variables that can influence both the crude oil transportation and the VLCC market.

5.1 Significant Variables for RasTanura to Loop route

Table 25. Final Model for RasTanura_Loop

Dependent Variable: RasTanura_Loop Method: Ordinary Least Squares Regression Included observations: 151 after adjustments				
Variables	**Estimate**	**Std. Error**	**t-Stat**	**pValue**
(Intercept)	-0.006	0.014	-0.403	0.687
WTI_OilPrice	-0.573	0.179	-3.205	0.002
BunkerPrice_Genoa	0.539	0.205	2.624	0.010
BDTI_Index	1.057	0.088	11.957	1.320e-23
ect_BDTI_Index	-0.310	0.058	-5.318	3.705e-07
Number of Observations	156	Error Degrees of Freedom		151
Root Mean Squared Error	0.171	F-statistic vs. constant model		45.5
R-squared	0.546			
Adjusted R-Squared	0.534	p-value		5.04e-25

5.1.1 West Texas Intermediate Oil Price

WTI represents the international trading price of the crude oil commodity. Indeed, Crude oil is a major commodity in the shipping business. The relationship between the United States oil production and the West Texas Intermediate (WTI) crude oil prices are volatile, depending on the situation, they have either moved together or separately, which suggests that oil production increases precede a decrease in the WTI oil prices (Monge et al., 2017).

As the fluctuation of crude oil prices depends on the world economies activities and the demand for tanker services is derived from the imbalance between demand and supply of crude oil (Shi et al., 2013). The volatility of crude oil prices is influenced by crude oil production which as per the laws of demand and supply thus an over production of crude will reduce the prices of crude in the market. The increase in demand of crude caused by rapid economic development of developing countries (Shi et al., 2013), the depreciation of the dollar exchange rate (Zhang et al., 2008) and geopolitical activities.

The price of crude oil is volatile, and any rise or fall of the price will cause a fluctuation in the demand and supply of seaborne transportation. In addition to global economic activity, the level of consumption and production of crude have over the years affected the price of crude as well as the freight rate for VLCC (Demirbas et al., 2017). This study is in line with the literature. Hence, as shown by the results of our first regression, WTI expresses the trend and production parameters as the demand and supply of VLCC follows the volatility or the changes in the oil prices as represented in the WTI index. The frequency of crude transportation along this route is determined by the oil prices and hence when oil prices are low, tankers are employed as floating storage facilities thus leading to a rise in the freight rate for VLCC due to more demand for tankers.

The production of Shale oil by the United States significantly affects the WTI crude oil prices. An increase in Shale production will always follow a decrease in the WTI price because the evolution of the price of oil in the United States is determined by the increase in Shale Oil Production (Monge & Gil-Alana, 2021). This research is in line with the literature, as the coefficient of the WTI Spot price is (-0.573) negative and in its long-term relationship with the Middle East to the US Gulf route. Thus, they have an opposite direction in their volatility. Therefore, when the oil transportations from the Middle East to the US Gulf increases, the WTI Spot will decrease.

This is because the tanker demand will always improve alongside increasing oil demand as well as refinery throughput. Therefore, the global recovery of the global oil demand and the seaborne oil trade will increase or decrease the freight rate for tankers.

The results of this study show that the WTI spot price negatively affects the route RasTanura to Loop, which means that an increase in the flow triggers a decrease in the spot price. The reduction of the supply of oil according to the WTI leads to a rise in the supply of VLCC in the RasTanura to Loop route. The Baltic Dirty Tanker Index represents a significant trend of the fluctuations in the RasTanura to Loop route.

5.1.2 Baltic Dirty Tanker Index

Table 26. Final model for Variable: RasTanura_SG

Dependent Variable: RasTanura_SG Method: Ordinary Least Squares Regression Included observations: 150 after adjustments				
Variables	**Estimate**	**Std. Error**	**t-Stat**	**pValue**
(Intercept)	-0.001	0.014	-0.067	0.947
BDTI_Index	1.277	0.088	14.477	1.823e-30
ect_BDTI_Index	-0.680	0.078	-8.697	4.990e-15
Number of Observation	156	Error Degrees of Freedom		153
Root Mean Squared Error	0.17	F-statistic vs constant model		123
R-squared	0.617			
Adjusted R-Squared	0.612	p-value		1.39e-32

The Baltic Dirty Tanker Index (BDTI) represents the crude oil tanker sector's daily market situation in terms of specific trading routes and vessel types. As part of its daily reporting, the Baltic Exchange in London provides the BDTI and BCTI to represent overall freight rate movements in the tanker market by collecting the information from maritime brokers and releasing it on a world scale (Acik & Baser, 2018).

According to Choi & Yoon (2020), the BDI and BCTI are associated with shipping companies' operating costs and crude oil demand, but the BDTI is closely linked to crude oil transportation services. A number of factors contribute to the Baltic Dirty Tanker Index, including the routes, regional production trends as well as port-and-canal tolls, bunker fuel prices and freight rates (Dirzka, 2017). Therefore, BDTI is one of the most prominent indicators for crude oil transportation and swings frequently and sharply because of a mix of the external environment and internal supply-demand interaction (Fei, et al., 2020).

From our regression results, for the spot freight rate of both from the Middle East Gulf to Singapore and from the Middle East Gulf to US Gulf from Ras Tanura to Loop route, the Baltic Dirty Tanker Index is one of the most significant independent variables in the time-series span from May 2008 to May 2021. Throughout this period, we can see from the graph that the trend of the spot freight rate of Ras Tanura to Loop route was slightly similar to the nature of the graph line of the BDTI index. When the peak of the BDTI index was in July 2008 with the value of 2071.83, the highest level of the spot freight rate of the Ras Tanura to Loop route was with 144.38 World scale rates. While the lowest point of the BDTI index was 419.50 in October 2020, the lowest spot freight rate of the Ras Tanura to Loop route was 15.5 in November 2020.

The BDTI of the shipping route from the Middle East to the US Gulf dropped to 477.84 in May 2009 as an impact of the 2008 financial crisis. However, the spot freight rate of the Ras Tanura to Loop route was more negatively impacted in the Covid-19 pandemic time, which was because of the connection between the Baltic Dirty Tanker Index and crude oil trading volume in general. In addition, the bunker fuel prices are taken into consideration. A greater value of crude oil price leads to the rise of bunker fuel prices, which corresponds with higher operating costs in the shipping industry, affecting the BDTI index and freight rates (Dirzka, 2017).

Additionally, according to the regression results of our final model, it can be said that the BDTI index has the highest and most long-term positive affect on the spot freight rate of the Ras Tanura-Loop and the Middle East to Singapore route.

This research concluded that the West Texas Intermediate oil price and the Baltic Dirty Tanker Index would affect the Middle East to United States shipping route. This shows that the spike or fall of the freight rates depends on the supply and demand of crude oil. Freight Rates for this route will increase when the demand for crude oil is higher than the available tonnage. However, in the instance more tonnage is available than what is required then there will be a fall of freight rate along this route.

5.2 Significant Variables for West Texas Intermediate Oil Price

Table 27. Final model for WTI_OilPrice

Dependent Variable: WTI_OilPrice Method: Ordinary Least Squares Regression Included observations: 146 after adjustments				
Variables	**Estimate**	**Std. Error**	**t-Stat**	**pValue**
(Intercept)	-0.0003	0.005	-0.047	0.962
RasTanura_Loop	-0.064	0.021	-3.032	0.003
BangladeshScrapPrice	0.146	0.057	2.566	0.011
OPEC_CrudeOilProd	0.430	0.210	2.048	0.0428
US_SeaborneCrudeOil_Imp	0.272	0.063	4.312	2.928e-05
BunkerPrices_Genoa	0.873	0.053	16.357	4.441e-35
ect_BunkerPrices_Genoa	-0.209	0.045	-4.621	8.220e-06
Number of Observation	156	Error degrees of freedom		149
Root Mean Squared Error	0.065	F-statistic vs constant model		65.4
R-squared	0.725			
Adjusted R-Squared	0.714	p-value		2.65e-39

5.2.1 Middle East to US Gulf

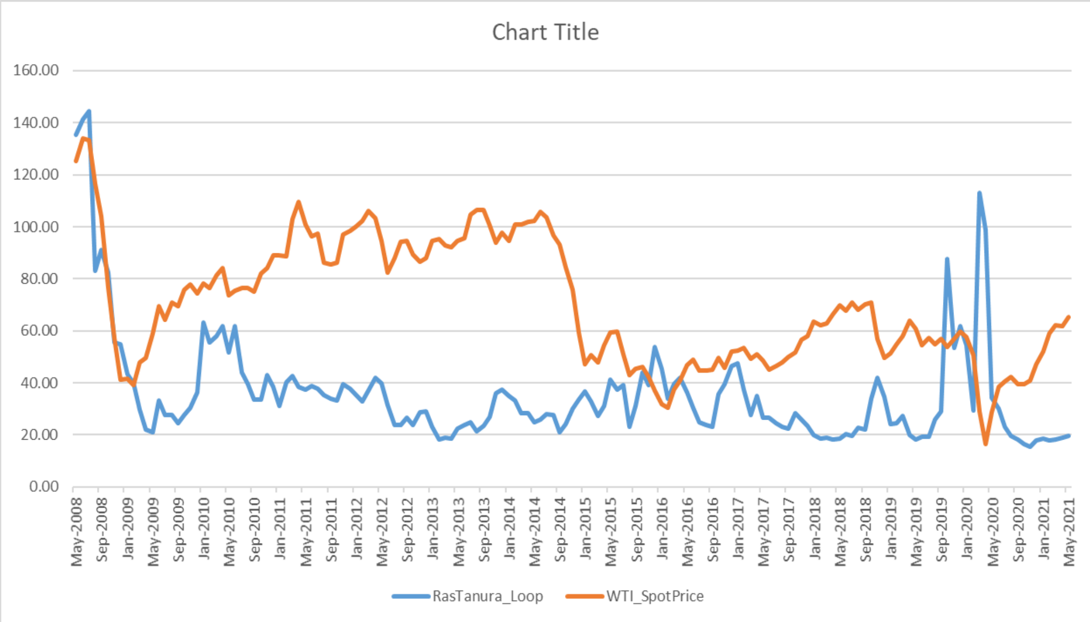

Figure 1. Line Graph of Ras Tanura Loop and WTI Crude Oil Price

This major route is used by VLCC to transport crude from the Middle East to the United States. The frequency of this route is due to the growing oil dependency of oil imports from the Middle East by the United States (Salameh, 2003). According to (EIA, 2021), the United States imported 5.88MMb/d in 202crude from the Middle East, which was termed as its lowest level of imports from this region since 1991.

The fluctuation of the freight rates with the price of crude oil along this route, as shown on the graph above, can be attributed to many factors from the global financial crises, causing a major drop in all seaborne transportation sector with a slowing economy leading to an oversupply of tonnage and reduction of freight rates.

The 2014-2016 fall of 70% in oil price as one of the most significant declines in global history since World War II; caused by the oversupply of oil from production countries (Stocker et al., 2018). The oversupply of oil caused the freight rates to increase as vessels have been used as storage facilities by investors who are willing to resell the crude when the prices go up.

The launch of war and conflicts in oil- producing countries in the Middle East and North Africa created a restriction in the oil supply, which eventually lead to an increase in the price of oil (Su et al., 2020) which did not only affect the freight rates but had an impact on the decrease of global crude oil prices (An et al., 2018).

The pandemic caused the WTI to go negative for the first time in history, with prices plummeting from $18 a barrel to -$37 a barrel, causing an oversupply of oil and forcing tankers to be used as storage facilities by producers (Blessing, 2021).

Based on the results from our CLRM, the United States booming Shale Oil production, sanction against Iran and the reduction of import of crude oil from the Middle East affected the crude oil transportation and VLCC freight rates of this route.

5.2.2 Bangladesh Scrap Price

India, Bangladesh, China, Pakistan, and Turkey are the top five countries where ship recycling is now taking place; according to a report, about 97% of the global volume comes from these five big countries, with Bangladesh accounting for just 30% and closely followed by India (Rahman, 2017). A rise in scrap prices has a more significant impact on Bangladesh's economy. As scrap prices rise, the chance of ships being scrapped will increase because of it. Bangladesh's recent entry into the demolition market may have made it more vulnerable to changes in the market than any other scrapping location (Knapp et al., 2008).

The possibility of scrapping increases with age and scrap price, while the potential of demolition decreases with freight rates. Prices dropped dramatically during the next two years because of the sharp rise of US shale production in 2014, which filled imported oil, as well as a decline in demand from China and other growing countries (World Bank, The World Bank Annual Report, 2018). Since 2016, oil prices have risen due to OPEC production reductions and improved global economic development. Scrap steel prices are tightly associated with oil prices and have followed the same trend (Barane & Njøten, 2018).

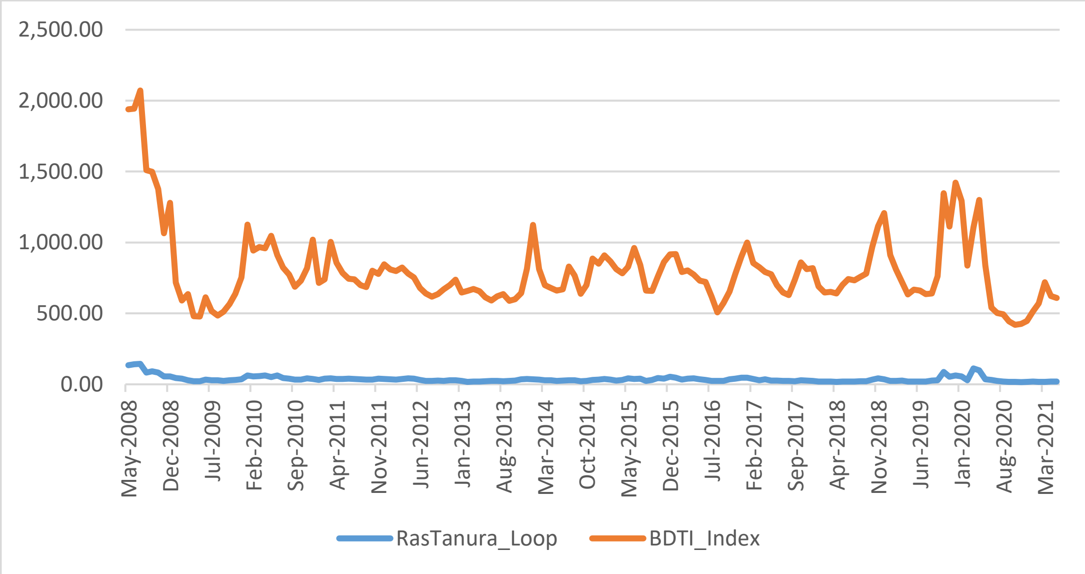

Figure 2. Line Graph of Ras Tanura Loop and BDTI Index

The highest value of Bangladesh scrap prices was in July 2008, with the price of 740 $/ldt, but it steeply declined to its lowest value in October 2008 of 250 $/ldt because of the 2008 global financial crisis. While the peak point of the WTI crude oil price was 133.88 $/barrel in June 2008, the second-lowest value was in December 2008 due to the impact of the 2008 financial crisis, but the oil price reached its lowest value of 16.55 $/barrel in April 2020 which was due to the consequence of the Covid-19 pandemic. From the results of this final model of regression, there was a positive relation between WTI crude oil price (0.146) and the Bangladesh scrap price, which means that the higher the Bangladesh scrap price leads to the increase of WTI crude oil price.

5.2.3 OPEC Crude Oil Production

The Organisation of Petrol Exporting countries (OPEC) controls oil exploration, production, and development, holding the majority of petroleum reserves. As they are primarily responsible for defining crude oil prices through steadily cutting back on production to increase or decrease the price of oil whenever the price falls below its profit maximising price. They invest in production capacity; influence the market through prediction quotas for crude prices as well as production cutback to maximise profit (Greene, 2010).

OPEC´s decision on the increase or decrease of crude oil production can cause a significant impact on the price of crude oil and VLCC transportation. Based on our result OPEC's decision to increase the Production of Crude oil will positively affect the crude price. This is due to the positive coefficient (0.430) of OPEC with the Crude (WTI) Spot price. Furthermore, to control the prices of oil OPEC will either increase or decrease its oil production. With an OPEC overproduction, the prices of the WTI will sell at a lower price and this has been evident based on our research during different periods, which lead to the tankers being used as floating storage facilities.

During the period of the research, the refusal of OPEC to cut down its production in 2015 (Brown & Huntington, 2013) led to the decrease of crude oil prices. OPEC and Global oil production can also influence the price of oil. When there is an oversupply of oil in the market and oil production is not minimized, it affects crude oil and VLCC prices, leading to tankers being used as floating storage facilities. This leads to the reduction of tonnage in the market, and the impacts from the Covid-19 pandemic and the OPEC oil supply limits has weakened the tanker market. Fleet capacity has been used as floating storage facilities continue to ease as of April 2021, thus apply further supply pressures.

Based on the results from the analysis, OPEC's decision to increase the production of crude oil will always affect the growth of seaborne transportation. This is because the tanker demand will always improve alongside increasing worldwide oil demands as well as refinery throughput. Therefore, the global recovery of the demand for oil globally and the seaborne oil trade will increase or decrease the freight rates for tankers.

5.2.4 US Seaborne Crude Oil Imports

In terms of crude oil, the United States consumed and imported more oil than it produced, and hence, are a major oil importer from both the Middle East and other regions, including Africa (Greene, 2010). The introduction of the Shale Oil by the

United States will have a significant effect on the oil prices (Monge et al., 2017). The U.S production of its own oil will reduce the quantity of oil imported from other regions, thus affecting the freight rate.

Geopolitical events and sanctions have always triggered a spike in the price of crude oil (Venn, 2002) and freight rates, especially in the VLCC tanker market. This was evident by the sanction the Trump Administration placed on the crude oil tanker owned by COSCO, which reduced the global tanker fleet capacity by 6% (Bai, 2021). The Iranian Sanctions and the presence of war and conflicts in oil-producing countries in the Middle East and North Africa has also created a restriction in the oil supply, causing a drop in oil prices (Su et al., 2020). These uncertainties have an impact on global economic activities and the demand for shipping services and freight rates (Bai, 2021).

The United States continued to reduce its crude oil imports from the Middle East and other OPEC countries to import heavier crude oil from Canada. This importation doubled to an average of 3.6 million b/d in 2020, which was more than their combined total crude oil imports from all countries (EIA, 2021).

As shown by the results of this study, the United States imports of crude oil is positively related to the crude oil prices. This is due to the positive coefficient of (0.28) and as such, any addition or reduction of the United States importing crude oil from the Middle East will significantly affect the freight rates of the Middle East to the US Gulf. The route will experience an oversupply of tonnage that will reduce the freight rates for VLCC.

Therefore, the other routes from the Middle East to the other consuming countries will have more tankers moving to that area, thus causing an oversupply of tonnage and lower freight rates for those routes.

5.3 Bunker Price Genoa

According to (Dirzka, 2017)**,** crude oil prices play a vital role as the bunker fuel price substantially impacts on the vessel operating costs. Around 50% of transportation expenses are attributed to bunker fuel, more than crew salaries (Choi & Yoon, 2020). Therefore, if the bunker costs are on the rise, it will force additional pressure on the market—the bunker price Genoa was taken as one of the WTI crude oil price independent variables. After running the regression, the results demonstrated that Genoa's bunker price could mostly influence the WTI crude oil price as well as the Ras Tanura to Loop route than other variables.

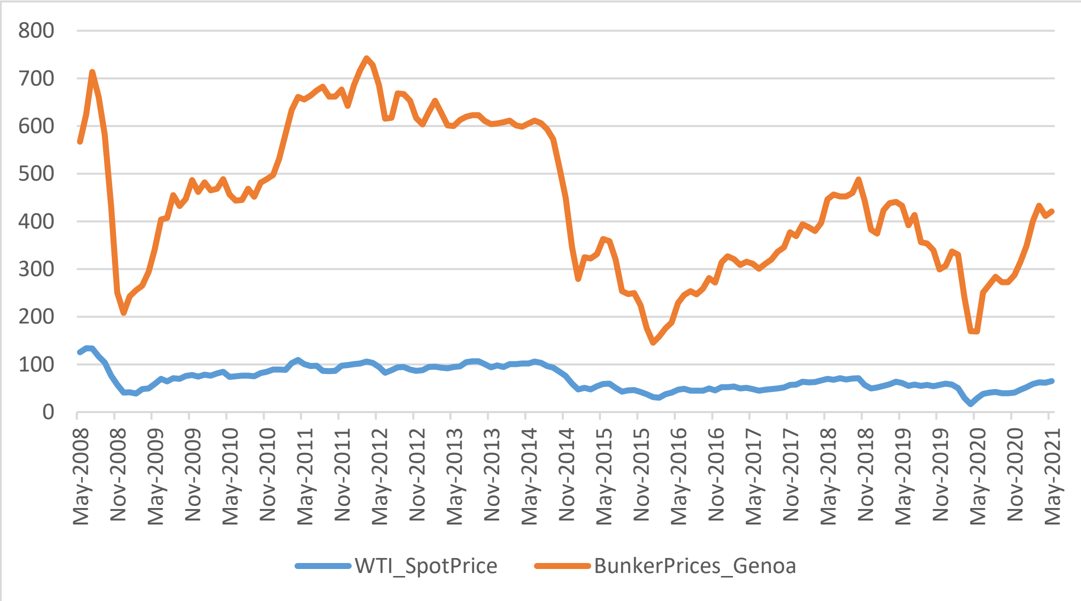

Figure 3. Line Graph of WTI Spot Price and Bunker Price Genoa

While overall considering the line graph of the WTI crude oil price and the bunker price Genoa, there were almost similarities between both trends. The lowest bunker price of the Genoa was in January 2016 with the value of 145.50 $/ton which was the effect of OPEC production reductions (Barane & Njøten, 2018)**,** while its peak was in March 2012 with the price of 742.20 $/ton. Like other variables, it also fell to one of its lowest values in May 2020 due to the impact of the Covid-19 pandemic.

After running the CLR of WTI as a dependent variable, through the chosen data set, our research concludes that there is a significant relationship between WTI spot price with RasTanura to Loop, Bangladesh scrap price, OPEC crude oil production, U.S crude oil imports and bunker price Genoa. This confirms the fact that the Middle East mostly determines WTI spot price to USA traffic parameters. The spot freight rate of the Ras Tanura to Loop route has negatively affected the WTI crude oil price, which means that the growth of the spot freight rate of that route leads to the decrease of the WTI crude oil price. Bunker price Genoa has a positive long-term relationship with the WTI crude oil price, and has a higher correlation than any other significant variables. Bangladesh scrap price slightly affects the WTI crude oil price, and OPEC crude oil production positively affects the WTI crude oil price. This finding of our model is 72% of the level of confidence.

5.4 Effect of WTI Oil Price on the Trading Routes

The results from this classical linear regression model (CLRM) indicate that the Baltic Dirty Tanker Index (BDTI) can efficiently reflect the freight rates of VLCC along both the routes from the Middle East to United States Gulf (TD_1) and Middle East to Singapore (TD_2). As a result, the BDTI trend along these routes is similar to the VLCC freight trend. According to the research, the West Texas Intermediate Spot Price (WTI) is negatively affected by TD_1. Then, we discovered that a 1% increase in WTI price results in a 0.064 % drop in the freight rate in the TD_1 route.

Moreover, other factors that have a positive impact on WTI oil price include the price of scrap in Bangladesh, OPEC crude oil production, as well as US seaborne crude oil imports and the bunker price in Genoa. The factor, the bunker price Genoa has a big impact on the TD_1 and WTI crude oil price. This data reveals that most of the oil trading between the Middle East and the US mainly passes through the Mediterranean Sea which is a significant bunkering port for VLCCs travelling along this route.

Primarily, the research identified BDTI as a relevant tool to study the crude oil trade along TD_1 and TD_2 and in addition, it shows that the port of Genoa is a choke point for VLCC sailing along the route from the Middle East to the United States. Among the significant variables for WTI crude oil prices, the Bangladesh scrap prices, the OPEC´s crude oil production and the US seaborne crude oil imports are macroeconomic features that characterise the international crude oil market.

Chapter Six – Conclusion

The research undertaken in this study uses the Classical Linear Regression Model to determine what factors affect the freight rate of VLCC and Crude oil. The results indicated that on the different regression performed, there were various factors that affected each other.

The period under review for this research has included the global financial crisis of 2008, the conflict in the Middle East, the United States economic sanctions against Iran and Venezuela, the revolution of Shale oil and the COVID-19 pandemic. These financial and geopolitical activities have not only affected the world economic structure but also the crude oil market.

It is worthy to note that the regression results for both routes coming from the Middle East and going to the United States Gulf or to Singapore have the Baltic Dirty Tanker Index. This shows that the index can significantly express the freight rates of both routes. With a positive BDTI coefficient for (1.057) Middle East to the United States and (1.277) for the Middle East to Singapore confirmed the index as a major contributor to the Freight rate of the VLCC for both routes.

This research has shown that the significant variable that affected both West Texas Intermediate and the Middle East to the United States route is the Bunker Price Genoa. As bunker fuel is a major cost for the ship-owner under the spot voyage agreement, during the high bunker oil prices period, VLCC tanker owners always have more operating expenses, thus reducing revenues. In addition, when the rates are low, and the bunker is high, tanker owners will slowly the steam to minimise the cost of the bunker, and when the rates have improved, they will speed up to benefit from the increased spot rate.

Going by the results from the regression, it is clear that many factors affect the price of crude oil and VLCC. These factors range from global financial crises, geopolitical events, sanctions against oil producing countries, global oil production, and tonnage availability.

However, OPEC Oil production and geopolitical events have an impact on crude oil as they affect the price of crude oil and seaborne transportation. Sanctions in oil-producing countries usually lead to an oversupply of minimal importation of crude oil which is done from those areas.

OPEC and Global oil production can also influence the price of oil. When there is an oversupply of oil in the market and oil production is not minimised, it affects the crude oil and VLCC prices. During this period, tankers are usually employed as floating storage facilities, thus reducing tonnage in the market.

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Appendices

Regression Results for RasTanura_Loop

>> **regression_results_1**

regression_results_1 =

Linear regression model:
RasTanura_Loop ~ 1 + WTI_OilPrice + BunkerPrices_Genoa + BDTI_Index

Estimated Coefficients:

	Estimate	**SE**	**tStat**	**pValue**
(Intercept)	-0.0064402	0.014926	-0.43148	0.66673
WTI_OilPrice	-0.61923	0.19396	-3.1926	0.0017138
BunkerPrices_Genoa	0.59952	0.22269	2.6922	0.0078946
BDTI_Index	1.0014	0.095354	10.502	9.6963e-20

Number of observations: 156, Error degrees of freedom: 152
Root Mean Squared Error: 0.186
R-squared: 0.461, Adjusted R-Squared: 0.451
F-statistic vs. constant model: 43.4, p-value = 2.53e-20

>> **regression_results_3**

regression_results_3 =

Linear regression model:
RasTanura_Loop ~ 1 + WTI_OilPrice + BunkerPrices_Genoa + BDTI_Index + ect_BDTI_Index

Estimated Coefficients:

	Estimate	**SE**	**tStat**	**pValue**
(Intercept)	-0.005541	0.013744	-0.40316	0.6874
WTI_OilPrice	-0.57298	0.1788	-3.2046	0.0016506
BunkerPrices_Genoa	0.5389	0.20536	2.6242	0.0095782
BDTI_Index	1.0573	0.088425	11.957	1.3201e-23
ect_BDTI_Index	-0.30961	0.058215	-5.3184	3.7049e-07

Number of observations: 156, Error degrees of freedom: 151
Root Mean Squared Error: 0.171
R-squared: 0.546, Adjusted R-Squared: 0.534
F-statistic vs. constant model: 45.5, p-value = 5.04e-25

>> **regression_results_5**

regression_results_5 =

Linear regression model:
RasTanura_Loop ~ 1 + WTI_OilPrice + BunkerPrices_Genoa + BDTI_Index + ect_BDTI_Index

Estimated Coefficients:

	Estimate	**SE**	**tStat**	**pValue**
(Intercept)	-0.005541	0.013744	-0.40316	0.6874
WTI_OilPrice	-0.57298	0.1788	-3.2046	0.0016506
BunkerPrices_Genoa	0.5389	0.20536	2.6242	0.0095782
BDTI_Index	1.0573	0.088425	11.957	1.3201e-23
ect_BDTI_Index	-0.30961	0.058215	-5.3184	3.7049e-07

Number of observations: 156, Error degrees of freedom: 151
Root Mean Squared Error: 0.171
R-squared: 0.546, Adjusted R-Squared: 0.534
F-statistic vs. constant model: 45.5, p-value = 5.04e-25
Warning: P is less than the smallest tabulated value, returning 0.001.

>> regression_results_7

regression_results_7 =

Linear regression model:
RasTanura_Loop ~ 1 + BunkerPrices_Genoa + BDTI_Index

Estimated Coefficients:

	Estimate	**SE**	**tStat**	**pValue**
(Intercept)	-0.0046187	0.015356	-0.30077	0.764
BunkerPrices_Genoa	0.053221	0.14673	0.36271	0.71733
BDTI_Index	1.0371	0.097498	10.638	3.9509e-20

Number of observations: 156, Error degrees of freedom: 153
Root Mean Squared Error: 0.192
R-squared: 0.425, Adjusted R-Squared: 0.418
F-statistic vs. constant model: 56.6, p-value = 3.93e-19

>> hac_result
hac_result =
'With ARCH effect but no serial correlation'

>> regression_results_9

regression_results_9 =

Linear regression model:
RasTanura_Loop ~ 1 + BunkerPrices_Genoa + BDTI_Index + dummy143 + dummy145 + dummy138

Estimated Coefficients:

	Estimate	**SE**	**tStat**	**pValue**
(Intercept)	-0.013958	0.01238	-1.1275	0.26134
BunkerPrices_Genoa	0.27099	0.1205	2.249	0.02597
BDTI_Index	0.7741	0.084468	9.1644	3.5341e-16
dummy143	1.2332	0.15976	7.7192	1.5273e-12
dummy145	-0.70453	0.15749	-4.4736	1.5108e-05
dummy138	0.68809	0.16094	4.2755	3.3784e-05

Number of observations: 156, Error degrees of freedom: 150
Root Mean Squared Error: 0.153
R-squared: 0.642, Adjusted R-Squared: 0.63
F-statistic vs. constant model: 53.7, p-value = 9.62e-32

>> RESET_test

RESET_test =
Linear regression model:
resid ~ 1 + y_fit_p2

Estimated Coefficients:

	Estimate	**SE**	**tStat**	**pValue**
(Intercept)	-0.011294	0.017004	-0.66423	0.50754

y_fit_p2	0.4216	0.28605	1.4739	0.14255

Number of observations: 156, Error degrees of freedom: 154
Root Mean Squared Error: 0.19
R-squared: 0.0139, Adjusted R-Squared: 0.00751
F-statistic vs. constant model: 2.17, p-value = 0.143

>> pValue_RESET

pValue_RESET =
0.1426

>> F_stat_RESET

F_stat_RESET =
2.1724

<u>Regression Results for RasTanura_Singapore</u>

>> **regression_results_1**
regression_results_1 =

Linear regression model:
RasTanura_SG ~ 1 + WTI_OilPrice + BunkerPrices_Genoa + BDTI_Index

Estimated Coefficients:

	Estimate	SE	tStat	pValue
(Intercept)	-0.0038839	0.016496	-0.23544	0.81418
WTI_OilPrice	-0.4636	0.21437	-2.1626	0.032134
BunkerPrices_Genoa	0.50163	0.24612	2.0381	0.043271
BDTI_Index	1.1075	0.10539	10.508	9.3301e-20

Number of observations: 156, Error degrees of freedom: 152
Root Mean Squared Error: 0.206
R-squared: 0.446, Adjusted R-Squared: 0.435
F-statistic vs. constant model: 40.7, p-value = 2.28e-19

>> **regression_results_3**

regression_results_3 =

Linear regression model:

RasTanura_SG ~ 1 + BDTI_Index + ect_BDTI_Index
Estimated Coefficients:

	Estimate	SE	tStat	pValue
(Intercept)	-0.00091073	0.013659	-0.066674	0.94693
BDTI_Index	1.2766	0.088183	14.477	1.823e-30
Ect_BDTI_Index	-0.67969	0.078153	-8.6968	4.9904e-15

Number of observations: 156, Error degrees of freedom: 153
Root Mean Squared Error: 0.17
R-squared: 0.617, Adjusted R-Squared: 0.612
F-statistic vs. constant model: 123, p-value = 1.39e-32

>> **regression_results_5**

regression_results_5 =

Linear regression model:
RasTanura_SG ~ 1 + BDTI_Index + ect_BDTI_Index

Estimated Coefficients:

	Estimate	SE	tStat	pValue
(Intercept)	-0.00091073	0.013659	-0.066674	0.94693
BDTI_Index	1.2766	0.088183	14.477	1.823e-30
ect_BDTI_Index	-0.67969	0.078153	-8.6968	4.9904e-15

Number of observations: 156, Error degrees of freedom: 153
Root Mean Squared Error: 0.17
R-squared: 0.617, Adjusted R-Squared: 0.612
F-statistic vs. constant model: 123, p-value = 1.39e-32
Warning: P is greater than the largest tabulated value, returning 0.5.

>> **regression_results_7**

regression_results_7 =

Linear regression model:
RasTanura_SG ~ 1 + BDTI_Index

Estimated Coefficients:

	Estimate	SE	tStat	pValue
(Intercept)	-0.0027255	0.016642	-0.16378	0.87012
BDTI_Index	1.1304	0.10548	10.717	2.2663e-20

Number of observations: 156, Error degrees of freedom: 154
Root Mean Squared Error: 0.208
R-squared: 0.427, Adjusted R-Squared: 0.423
F-statistic vs. constant model: 115, p-value = 2.27e-20
>> hac_result
hac_result =
'With ARCH effect but no serial correlation'

>> regression_results_9

regression_results_9 =

Linear regression model:
RasTanura_SG ~ 1 + BDTI_Index + dummy143

Estimated Coefficients:

	Estimate	SE	tStat	pValue
(Intercept)	-0.0090096	0.015727	-0.57286	0.56758
BDTI_Index	1.0637	0.10037	10.598	5.0364e-20
dummy143	0.90308	0.19821	4.5562	1.0579e-05

Number of observations: 156, Error degrees of freedom: 153
Root Mean Squared Error: 0.195
R-squared: 0.496, Adjusted R-Squared: 0.489
F-statistic vs. constant model: 75.2, p-value = 1.82e-23

>> RESET_test

RESET_test =

Linear regression model:
resid ~ 1 + y_fit_p2

Estimated Coefficients:

	Estimate	SE	tStat	pValue
(Intercept)	-0.0073941	0.018537	-0.39889	0.69053
y_fit_p2	0.23208	0.26017	0.89203	0.37377

Number of observations: 156, Error degrees of freedom: 154
Root Mean Squared Error: 0.207
R-squared: 0.00514, Adjusted R-Squared: -0.00132
F-statistic vs. constant model: 0.796, p-value = 0.374

>> pValue_RESET

pValue_RESET =
0.3738

>> F_stat_RESET

F_stat_RESET =
0.7957

Regression Results for WTI Oil Price

>> regression_results_1

regression_results_1 =

Linear regression model:
WTI_OilPrice ~ [Linear formula with 6 terms in 5 predictors]

Estimated Coefficients:

	Estimate	SE	tStat	pValue
(Intercept)	-0.000239	0.0055809	-0.042839	0.96589
RasTanura_Loop	-0.074899	0.022366	-3.3487	0.0010266
BangladeshScrapPrice	0.17609	0.060357	2.9175	0.0040714
OPEC_CrudeOilProd	0.49475	0.22309	2.2177	0.028078
US_SeaborneCrudeOil_Imp	0.28009	0.067157	4.1707	5.1187e-05
BunkerPrices_Genoa	0.85881	0.056784	15.124	5.6499e-32

Number of observations: 156, Error degrees of freedom: 150
Root Mean Squared Error: 0.0692
R-squared: 0.686, Adjusted R-Squared: 0.675

F-statistic vs. constant model: 65.4, p-value = 5.99e-36

>> **regression_results_3**

regression_results_3 =

Linear regression model:
WTI_OilPrice ~ [Linear formula with 7 terms in 6 predictors]

Estimated Coefficients:

	Estimate	SE	tStat	pValue
(Intercept)	-0.00024785	0.0052369	-0.047326	0.96232
RasTanura_Loop	-0.064025	0.021119	-3.0316	0.00287
BangladeshScrapPrice	0.14628	0.057003	2.5662	0.011269
OPEC_CrudeOilProd	0.4296	0.20982	2.0475	0.042363
US_SeaborneCrudeOil_Imp	0.27185	0.063043	4.3121	2.9282e-05
BunkerPrices_Genoa	0.873	0.053373	16.357	4.4408e-35
ect_BunkerPrices_Genoa	-0.20921	0.045278	-4.6206	8.2195e-06

Number of observations: 156, Error degrees of freedom: 149
Root Mean Squared Error: 0.0649
R-squared: 0.725, Adjusted R-Squared: 0.714
F-statistic vs. constant model: 65.4, p-value = 2.65e-39

>> **regression_results_5**
regression_results_5 =

Linear regression model:
WTI_OilPrice ~ [Linear formula with 7 terms in 6 predictors]

Estimated Coefficients:

	Estimate	SE	tStat	pValue
(Intercept)	-0.0002479	0.0052369	-0.047326	0.96232
RasTanura_Loop	-0.064025	0.021119	-3.0316	0.00287
BangladeshScrapPrice	0.14628	0.057003	2.5662	0.011269

OPEC_CrudeOilProd	0.4296	0.20982	2.0475	0.042363
US_SeaborneCrudeOil_Imp	0.27185	0.063043	4.3121	2.9282e-05
BunkerPrices_Genoa	0.873	0.053373	16.357	4.4408e-35
ect_BunkerPrices_Genoa	-0.20921	0.045278	-4.6206	8.2195e-06

Number of observations: 156, Error degrees of freedom: 149
Root Mean Squared Error: 0.0649
R-squared: 0.725, Adjusted R-Squared: 0.714
F-statistic vs. constant model: 65.4, p-value = 2.65e-39
Warning: P is less than the smallest tabulated value, returning 0.001.
Warning: P is less than the smallest tabulated value, returning 0.001.
Warning: P is less than the smallest tabulated value, returning 0.001.

>> **regression_results_7**

regression_results_7 =

Linear regression model:
WTI_OilPrice ~ 1 + BDTI_Index

Estimated Coefficients:

	Estimate	**SE**	**tStat**	**pValue**
(Intercept)	0.00089985	0.0057558	0.15634	0.87598
BangladeshScrapPrice	0.15918	0.062146	2.5614	0.011405
OPEC_CrudeOilProd	0.53062	0.23025	2.3046	0.022554
US_SeaborneCrudeOil_Imp	0.30061	0.069101	4.3502	2.4915e-05
BunkerPrices_Genoa	0.86764	0.05861	14.804	3.3441e-31

Number of observations: 156, Error degrees of freedom: 151
Root Mean Squared Error: 0.0715
R-squared: 0.662, Adjusted R-Squared: 0.653
F-statistic vs. constant model: 73.9, p-value = 1.38e-34
>> hac_result

hac_result =
'With no ARCH effect and no serial correlation'

>> **regression_results_9**

regression_results_9 =

Linear regression model:
    WTI_OilPrice ~ [Linear formula with 9 terms in 8 predictors]

Estimated Coefficients:

	Estimate	**SE**	**tStat**	**pValue**
(Intercept)	-0.00052173	0.0042594	-0.12249	0.90268
BangladeshScrapPrice	0.16695	0.045374	3.6795	0.00032733
OPEC_CrudeOilProd	-0.060125	0.17829	-0.33722	0.73643
US_SeaborneCrudeOil_Imp	0.061522	0.056132	1.096	0.27486
BunkerPrices_Genoa	0.70387	0.046682	15.078	1.2191e-31
dummy145	0.54163	0.058562	9.2489	2.454e-16
dummy143	-0.31331	0.054488	-5.75	4.9844e-08
dummy144	-0.29248	0.056477	-5.1788	7.2314e-07
dummy8	-0.19812	0.054474	-3.6369	0.00038108

Number of observations: 156, Error degrees of freedom: 147
Root Mean Squared Error: 0.0521
R-squared: 0.825, Adjusted R-Squared: 0.816
F-statistic vs. constant model: 86.9, p-value = 8.01e-52

>> **RESET_test**

RESET_test =

Linear regression model:
    resid ~ 1 + y_fit_p2

Estimated Coefficients:

	Estimate	**SE**	**tStat**	**pValue**
(Intercept)	0.00046611	0.0060939	0.076488	0.93913
y_fit_p2	-0.04807	0.2319	-0.20729	0.83606

Number of observations: 156, Error degrees of freedom: 154
Root Mean Squared Error: 0.0707

R-squared: 0.000279, Adjusted R-Squared: -0.00621
F-statistic vs. constant model: 0.043, p-value = 0.836

>> pValue_RESET

pValue_RESET =
0.8361

>> F_stat_RESET

F_stat_RESET =
0.0430

Model Criterion for RasTanura_Loop Route
Regression _results_1. ModelCriterion

Filed	Value
AIC	-78.0688
AICc	-77.8039
BIC	-65.8694
CAIC	-61.8694

Regression _results_5. ModelCriterion

Filed	Value
AIC	-102.8540
AICc	-102.4540
BIC	-87.6048
CAIC	-82.6048

Model Criterion for RasTanura_Singapore Route

Regression _results_1. ModelCriterion

Filed	Value
AIC	-46.8501
AICc	-46.5852
BIC	-34.6507
CAIC	-30.6507

Regression _results_5. ModelCriterion

Filed	Value
AIC	-106.4417
AICc	-106.2838
BIC	-97.2921

CAIC	-94.2921

Model Criterion for WTI Oil Price

Regression _results_1. ModelCriterion

Filed	Value
AIC	-384.9065
AICc	-384.3427
BIC	-366.6073
CAIC	-360.6073

Regression _results_5. ModelCriterion

Filed	Value
AIC	-403.7960
AICc	-403.0393
BIC	-382.4471
CAIC	-375.4471