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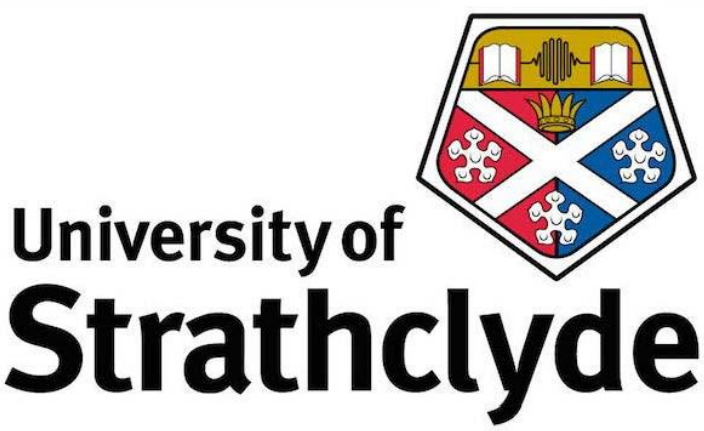

Developing A Decision-Making Methodology for Investing in Newbuild Large Oil Tanker

By

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This thesis has resulted from the author's own efforts. It has been created for the purposes of the PhD award and not been submitted for any previous examination, nor been awarded for any other degree.

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Abbreviation	Meaning
AHP	Analytic Hierarchy Process
ANN	Artificial Neural Network
ANOVA	Analysis of Variance
AoF	Age of Current Fleet
ARCH	Autoregressive Conditional Heteroscedasticity
Aver.	Average
B	Barrel
BDI	Baltic Dry Index
BIMCO	Baltic and International Maritime Council
BLR	Binary Logistic Regression
BP	Back-Propagation
BRS	Barry Rogliano Salles
BWTC	Ballast Water Treatment Convention
CAP	Capital
CG	Conjugate Gradient
COMP	Competition
COVID	Coronavirus Disease
CP	Company Profit
CS	Company Strategy
DCF	Discounted Cash Flow
DEMATEL	DEcision MAking Trial and Evaluation Laboratory
DNB	Norway's Largest Financial Services Group
DWT	Tons Deadweight
EBITDA	Earnings Before Interest, Taxes, Depreciation, and Amortization
EC	Economic Crisis
ECAs	Export Credit Agencies
ECLAC	Economic Commission of Latin America and the Caribbean

EEDI	Energy Efficiency Design Index
EEXI	Energy Efficiency Existing Ship Index
EIA	Energy Information Administration
ERR	Economic Rate of Return
EU	European Union
FAD	Fuzzy Axiomatic Design
FAHP	Fuzzy Analytic Hierarchy Process
FDI	Foreign Direct Investment
FNN	False Nearest Neighbour
FR	Freight Rate
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GE Capital	Financial Services Division of General Electric
Geop	Geopolitical
GIEK	Norwegian Export Credit Agency
GPS	Global Positioning System
GT	Gross Tonnage
Ibid	Refer to a book or article that has already been mentioned
IDRs	Incentive Distribution Rights
IHS	American-British information provide
IMO	The International Maritime Organisation
IMOr	IMO Regulation
IPOs	Initial Public Offerings
IQR	Inter-Quartile Range
IRM	Influence-Relations Map
IRR	Internal Rate of Return
Leve	Leverage
LNG	Liquefied Natural Gas
LR	Logistic Regression
LR1	Long Range Oil Tanker 1

LR2	Long Range Oil Tanker 2
LRA	Logistic Regression Analysis
MATLAB	High-Performance Language Software for Technical Computing
Med	Median
MLPs	Master Limited Partnerships
MR	Medium Range Oil Tanker
n	Number of participants
NAOME	Naval Architecture, Ocean and Marine Engineering
NBOB	New Build Order Book
NBP	New Build Price
NOCF	Number of Current Fleets
NPV	Net Present Value
OP	Oil Price
OPEC	Organisation of the Petroleum Exporting Countries
OPEX	Operating Expense
PhD	Doctor of Philosophy
PIS	Participant Information Sheet
QFD	Quality Function Deployment
R	Regression
RA	Regression Analysis
REH	Rational Expectations Hypothesis
ROE	Return on Equity
Saudi	Kingdom of Saudi Arabia
SC	Secured Cargo
SCG	Scaled Conjugate Gradient
SF	Source of Finance
SPSS	Statistical Package for the Social Sciences
STSA	Swiss Trading and Shipping Association
TC	Time Charter
TCE	Time Charter Equivalent
Tech	Technology

ToO	Time of Order
ToS	Type of Ship (new / second hand)
UK	United Kingdom
ULCC	Ultra Large Crude Carrier
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
US	United State
USA	United State of America
VLCC	Very Large Crude Carrier
w	Weight
WS	Worldscale
WTO	World Trade Organisation
Z	The oil shipping company which was used as case study

Abstract

The world's marine sector is comprised of myriad tangled multinational elements. As part of this industry and as any other large organisations, the huge businesses that deliver oil products around the world are faced with rising levels of difficulty in making appropriate choices in their survival strategy due to the greater number of interrelated variables. Market volatility in the oil industry has increased the desire for both raw and refined goods, which has driven further demand for new vessels capable of transporting such wares to their final destination. This work is primarily concerned with investment decisions, given the uncertainty and difficulty that companies often encounter when attempting to assess the data behind any such choice with regard to the procurement of vessels, and that the key aim is thus to develop a method that can simplify this process. The main purpose of this thesis is to develop decision-making methodology to assist in making the appropriate investment decision when it comes to investing in Newbuild Large Oil Tanker. The aim is reached through using ANN and logistic regression to first predict future oil prices that can impact this decision through ANN; then, to develop an equation that can be used to make the decision.

First, the identified relevant variables are assessed on their own, and together, using the DEcision-MAking Trial and Evaluation Laboratory (DEMATEL). After that, as published studies have already determined good precision using Neural Networks in this field, this work will seek to introduce Artificial Neural Networks (ANN) as a means of advancing our ability to accurately predict the behaviour of the price of oil. It will then seek to further apply the logistic regression technique as a way to create an equation as part of the process of developing a method whereby a given business may accurately gauge the efficacy of a given strategy with regard to the viability of investment into the purchase or construction of new tanker vessels.

1. Introduction

1.1. Chapter Overview

This chapter presents information to introduce the field of study related to this thesis. It presents the field of shipping industry, starting with its importance and then followed with challenges and risks associated with the shipping industry. This chapter also presents the topic of ship investment and making the decision in that regard in the shipping companies. Additionally, the last section in this chapter presents the structure and outline of the thesis.

1.2. Importance of Shipping Industry

The shipping industry is one of the oldest industries in history (Grbic, 2016), and today it became one of the most important businesses to the global economy as it is involved in approximately 90% of the global trade (Antonios, 2016). It was created to enhance international commerce by linking sources of supply and demand for commodities such as raw materials, manufactured goods, and finished products, as well as passenger, automobile, and even livestock transit between ports and nations (Alizadeh and Nomikos, 2009). In fact, ships transport four times the goods that are transported by trucks and six times of those transported by rail (Kleiner, 2007). In addition, this industry is vital to the welfare and development of several countries as it is responsible for an annual addition of $380 billion to the global economy via freight rates alone (Alexandridis *et al.*, 2018). This high contribution is attributed to the high reliability and the low cost associated to this mode of transportation (Frankel, 1989) which indirectly lowers the costs of goods and merchandise (Hummels, Lugovskyy and Skiba, 2009). Also, this increase in seaborne commerce during the previous century has resulted in the rise of the shipping sector and its associated

companies and markets, including shipbuilding, shipbroking, insurance, and maritime finance and investment (Alizadeh and Nomikos, 2009).

Furthermore, economically, the shipping industry has a number of advantages including the ability to transport large capacities of goods at low cost when compared to other means of transportation, the high degree of adjustability and flexibility towards changes in demand, the fact that vessels have long service lives, and that it does not require a lot of investments in infrastructure (Naletina and Perkov, 2017). These advantages highlight the importance of shipping industry; hence, the existence of our modern civilization would not have been possible without shipping industry, according to iRami (2012), since it connects producers and suppliers from all over the world (Naletina and Perkov, 2017). This importance was emphasized by the former UN secretary general, Ban Ki-moon, when he declared that "maritime transport is the backbone of the global trade and the global economy" (United Nations (UN), 2016). This high contribution is expected to continue in the future as the volume of global maritime trade is expected to grow by a compounded annual growth rate of 3.2% over the coming three years according to the United Nations Conference on Trade and Development (UNCTAD) (Christian, Laurent and Cenk, 2018). In addition, with this large volume, the shipping industry contributes indirectly to the world's economy by employing more than a million seafarers in addition to all the indirect labour who benefit from this industry (International Chamber of Shipping, 2019). Furthermore, vessels, regardless of their types, are the least emitters of CO_2 among all the other transportation modes as large vessels emit approximately only 3 grams per tonne-km versus 80 grams per tonne-km for trucks and 435 for planes (STSA, 2019). After discussing the importance of shipping industry, the following section addresses the challenges and risks associated with the shipping industry.

1.3. Challenges and Risks Associated with the Shipping Industry

Despite the importance and the increased contribution of the maritime transport industry to the global economy, the shipping industry faces some challenges and risks in different areas. Due to the economical, technological, and regulatory developments, shipping countries continuously have to run faster, better, and more cost-effective operations (Panayides, 2006). These challenges can be grouped under four main categories; namely: safety and environmental challenges, economic challenges, human resource challenges, and regulatory challenges.

By nature, the shipping industry is one of the most dangerous industries in today's global economy (Hetherington, Flin and Mearns, 2006) as, according to the study conducted by Hansen, Nielsen and Frydenberg (2002), Despite the fact that the shipping industry has a fairly sound safety record, any shipping accident has potentially catastrophic consequences on humans, the economy, and the environment.

The economic challenges, on the other hand could be considered the most important and well publicized challenge that faces the maritime industry is. This category of challenges includes the oversupply and low demand for shipping, especially, when one of the largest economies in the world experience a slow down; such as: China (CrewMirror, 2018). In addition, the shipping business is one of the most volatile businesses as its revenues are highly dependent on the global economic conditions and global trade volumes (Albertijn, Bessler and Drobetz, 2011). Thus, this volatility makes it difficult for operators to forecast their income and plan accordingly, and also makes financing entities more cautious when they are faced with a decision to finance shipping companies (Albertijn, Bessler and Drobetz, 2011).

Regarding the human resource challenges, there has been a global shortage of seafarers, and this shortage is expected to worsen in the future (Nguyen *et al.*, 2014). In 2016, the BIMCO/ICS report

estimated the shortage in officers of about 16,500 officers and that, by 2025, an additional 147,500 officers will be needed (Petersen, 2016). This shortage is a result of the challenges in recruiting and retaining seafarers (Nguyen *et al.*, 2014). The main reason for the challenges in recruiting seafarers is the lack of appropriate knowledge and skills in the market (Cahoon and Haugstetter, 2008). This imbalance between the supply and demand for seafarers results in volatility in the labour market; as well as an increase in the costs for the shipping companies, as a result of the increase in the salaries offered to attract senior and experienced seafarers (Nguyen *et al.*, 2014).

Finally, the fourth and toughest challenge facing the shipping industry is the regulatory challenge. The increased awareness of the environmental impacts of human activities and the need for creating sustainable operations have encouraged the International Maritime Organisation to impose some new environmental regulations on the shipping industry (Shin *et al.*, 2018; Lee, Kwon and Ruan, 2019). These regulations are largely concerned with greenhouse gas emissions and other types of pollutants released by the vessels. Under these regulations, flag states are required to use new engines that are more energy efficient for all their large ships to reduce CO_2 emissions (George *et al.*, 2017). Basically, there are some main environmental regulations that are of concern nowadays to the shipping industry such as: Ballast Water Treatment Convention (BWTC), the Energy Efficiency Design Index (EEDI), Emission Control Areas (Christian, Laurent and Cenk, 2018) and Energy Efficiency Existing Ship Index (EEXI) that forced ship builders and owners to either modify their designs or equip their vessels with additional equipment in order to meet these regulations. For example, to satisfy these regulations, shipping companies might have to implement new technological and operational measures (Ren and Lützen, 2015); such as: speed reduction (Eide *et al.*, 2011), using scrubbers (Aronietis, Sys and Vanelslander, 2014), adding ballast water management system (Christian, Laurent and Cenk, 2018). Yet, implementing these measures have different economic impacts on the shipping companies as they

incur additional costs in order to achieve these sustainability benefits, which presents a major challenge for shipping companies now and in the future (Ren and Lützen, 2015). Therefore, the following section reviews the area of investment decision-making; particularly, ship investment.

1.4. Ship Investment and Decision Making

There are factors within investment decisions that are recognised as worthy of considerable weighting due to the uncertainty, risks and challenges associated with the field. The financial burden associated with the purchase of a new vessel is high. This means that prospective businesses must determine whether new or pre-owned ships are the most appropriate to ensure the survival and progress of their company in such an uncertain market.

The difficult and ever changing nature of the sector ensures that there are substantial dangers associated with any choice made (Lun *et al.,* 2010), wherein a single-misguided step can destroy a company in its entirety, with the flipside being that a well-managed decision can lead to considerable returns for the business. This means that clear comprehension of all aspects of maritime shipping methods is necessary and could help in generating a better decision support system for shipping investors (Lun, Lai and Cheng, 2010). In this regard, such businesses must assess all the different means of investment and management if they are to ensure that they make good decisions. There are three key concerns that must be addressed by prospective entrants to the market, which are entry and exit conditions, ship investment decision and the proper ship management strategy decision.

It is of great importance to note that this work is primarily concerned with investment decisions, given the uncertainty and difficulty that companies often encounter when attempting to assess the data behind any such choice with regard to the procurement of vessels, and that the key aim is thus to develop a method that can simplify this process. The main purpose of this thesis is to develop

decision-making methodology to assist in making the appropriate investment decision when it comes to investing in Newbuild Large Oil Tanker. Through using ANN and logistic regression to first predict future oil prices that can impact this decision through ANN; then, to develop an equation that can be used to make the decision.

1.5. Research Structure

The rest of the thesis is divided and organised into seven chapters:

Chapter 2: The second chapter introduces the motivation and justification for the Research, and It also introduces the list of aim and objectives of this thesis.

Chapter 3: The third chapter in this thesis is the literature review. This chapter presents the relevant literature on investment decision-making in the shipping industry.

Chapter 4: The fourth chapter in this thesis is the methodology. This chapter provide a detailed description of the research philosophy, paradigm, and research design. It also provides a detailed description of instruments and procedure used for collecting the data and analysing the collected data.

Chapter 5: The fifth chapter in this thesis is the data analysis, which provides a detailed analysis and description of the collected data.

Chapter 6: The sixth chapter in this thesis is the case study, this chapter presents the forecast of future oil price and present the created equation for investment decision making.

Chapter 7: The seventh chapter in this thesis is the discussion. It provides the research discussion and contribution through discussing how the aims and the objectives were achieved within this study.

Chapter 8: The eighth and final chapter in this thesis is the conclusion chapter, which provide a summary of the main finding in this research, the research limitations, and the recommendations for future work.

2. Research Aims and Objectives

2.1. Chapter Overview

This chapter will present the motivation behind this research, followed by the research aims and objectives.

2.2. The Motivation Behind this Work

The uncertainty, risks and challenges of the shipping industry are well recognised. As Lun *et al.* (2010) point out, the extreme volatility and challenges of the shipping industry mean that all decisions carry high risk: wherein a single misguided step can destroy a company in its entirety, with the flipside being that a well-managed decision can lead to considerable returns for the business.

Any company in this sector will be required to pay a considerable sum for a new vessel, and thus company owners must make strategic management decisions and decide the appropriateness of a new or pre-owned ship purchase or sale, which must be considered in detail, given that this will allow them to join or leave the maritime market. However, it is argued that their investment decision is based on a number of crucial indicators and parameters that seems to affect investment decision-making when buying a ship. Thus, failing to pay these factors sufficient attention while making a decision whether to sell or purchase may damage the company. For instance, sales at a time of currency fluctuation could significantly damage the financial position of the company. However, the literature reveals the lack of studies targeting the factors affecting investment decision-making when buying a ship.

Moreover, Lun *et al.* (2010) asserted that understanding the way the shipping market and its components work can help shipping investors to generate a decision support system which allows

the investors to make more sound choices in their sales or purchases. For that, this research study will concentrate on developing a thorough understanding of the shipping sector and its components, and exploring the factors affecting investment decision-making when buying a ship, and their degree of importance and the interrelationship between factors as an attempt to develop a method to ease and make better decision support system for shipping investors on the investment decision making for the oil shipping companies in order to invest in a new ship.

2.3. Research Aims and Objectives

This research aims to develop investment decision-making technique for the oil shipping companies to assist the decision-making of ordering newbuild ship with consideration of influential factors and uncertainty:

- Explore the relevant literature and hypotheses to determine the indicators that may have an impact on the decision-making in the oil shipping companies in order to invest in new ships.
- Investigate the relevant factors that influence and affect the oil price.
- Collect the indicators affecting the investment decision making in the oil shipping companies from the literature and experts, then evaluate these indicators in order to be ranked according to their influence. In addition, assess the interrelationship between these indicators to ease the process of the investment decision-making in oil shipping companies.
- Forecast the future of oil price.
- Create an investment decision-making equation whereby the shipping companies can incorporate into their decision-making process in order to make informed and faster decisions about placing newbuild tanker order.

2.4. Chapter Summary

This chapter has explored the motivation behind this research. As well, the research aims and objectives.

3. Literature Review

3.1. Chapter Overview

This chapter will present a literature review for the following area: Oil Markets, Shipping Market, Shipping Finance, Market forecasting, and decision making. All these aspects are reviews in order to provide cohesive background for the research and to reach the following objectives:

- Explore the relevant literature and hypotheses to determine the indicators that may have an impact on the decision-making in the oil shipping companies in order to invest in new ships.
- Investigate the relevant factors that influence and affect the oil price.

It starts by exploring crude oil markets, including its history and the factors influencing oil price, as well as description and discussion oil transportation and oil tankers along with the factors affecting the tanker market. It is then followed by detailed reviews on the shipping markets, shipping financing, and oil market forecast. The review on shipping markets includes its growth, its cycle, the different types of shipping markets. This review is followed by a section about the different methods used to value ships. Then, the review on shipping finance includes exploring the main sources of finance in shipping companies and a review on the different shipping financing practices from different parts around the world. The review on market forecast includes its forecasting methods, and the factors impacting these forecasts. Then, the focus is shifted to one of the most important decisions in the shipping market that is investment decision-making when placing a new order for a newbuild ship, along with the investigation of the decision criteria used in reaching this decision and the different tools that were developed in the literature to assist ship

owners with reaching the decision. The last three sections introduce the key finding from the literature, gaps in the investment decision making in the oil shipping companies.

3.2. Oil Market

Oil is an exceedingly important global commodity as both a source of energy and the raw material for many commonplace and domestic items. The top five oil producing countries are United State, Saudi Arabia, Russia, Canada and China (U.S EIA, 2020). According to the U.S. Energy Information Administration (2016), global oil producers are characterized as OPEC countries (accounting for 40% of global crude oil production and exports) or non-OPEC countries (accounting for 60% of global crude oil production and exports). Thus, reacting to the laws of supply and demand, the OPEC countries' oil production levels have a significant bearing on global oil prices. Since the collapse of the oil price in 2014, however, the market remains in distress. Figure 3-1 below demonstrates the average annual crude oil price (Statista, 2020).

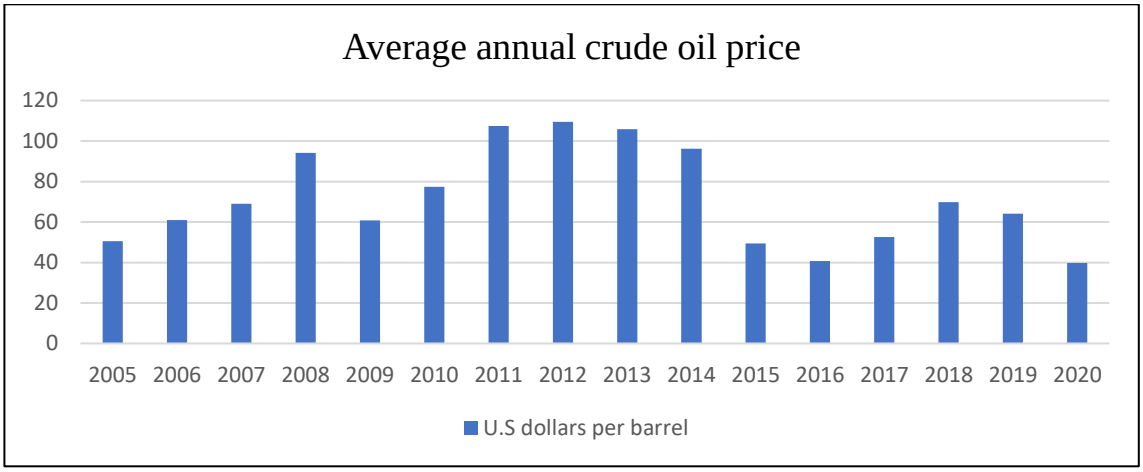

Figure 3-1 Average Annual Crude Oil Price by (Statista, 2020)

A global knock-on effect of the 2014 oil price was due to the oversupply of crude oil. This phenomenon led to many oil fields seeing their marginal profits decrease significantly, and some faced bankruptcy, particularly those offshore in the North Sea. Alert to the danger, in 2016, OPEC members took a series of measures, including a freeze on all oil production, to stabilise prices and attempt to return them to their pre-crisis level. However, according to (The Guardian, 2016), 25% of the North Sea oil platforms face being scrapped for two reasons. The first problem is that the platforms are ageing and require maintenance; secondly, such maintenance is costly and unaffordable due to the pertaining low commodity price.

(IHS Market, 2014) states that a combination of OPEC's capacity/level of production, and, in particular, a number of geopolitical events and oil shocks, have impacted the price of crude oil, and in turn, have reflected on the level of supply and demand, significantly ratcheting up the price. The next section explores the different geological events and oil shocks through exploring the history of the oil market.

3.2.1. Oil Market History

The international market of crude oil is a very competitive and established market characterized by a large number of producers and high demand (Piccirillo, 2015). However, the history of the oil markets is full of volatility and shock events that shaped the world's economy and global trade throughout history. The journey of the oil markets in history can be divided into five main periods starting from the year 1800 till our present time.

The first period of the crude oil market can be defined as the early crude industry period between 1800 and 1869 (IG Trading, 2019). In the first half of the 19th century, crude oil has almost no value (Piccirillo, 2015). However, This discovery of kerosene from oil led to a rapid expansion in the oil market and by1865, the price of a barrel of crude oil reached $6.59 (IG Trading, 2019). The

second period starts from the year 1870, the birth of the modern oil industry began, thanks mainly to the efforts of one man: John D. Rockefeller (IG Trading, 2019). By the end of the 19th century, several events led to the expansion of the oil market; most notably, the launch of the first commercial car in Germany in 1896 (IG Trading, 2019) and the discovery of the Spindletop oil field in Texas in 1901 (Piccirillo, 2015). During this period, till the year 1913, the big seven oil companies: Texaco, Shell, British Petroleum, Chevron, Exxon, Mobil, and Royal Dutch, were created (IG Trading, 2019).

The third major period in the oil markets' history is from 1914 to 1949 i.e. during the two World Wars. During this period, wars drove prices up tremendously and major discoveries were made in different countries all over the world; such as: Venezuela (1922), Iraq (1928), Kuwait and Saudi Arabia (1938) (IG Trading, 2019). Then, the great depression took place, which drove the prices of oil down again. Since the mid of the 20th century, oil prices became the main focus of the global economy. Controlling the oil reserves had increasingly more strategic importance and governments realized this importance and acted accordingly (Piccirillo, 2015). This importance, coupled with the acceleration of the industrial revolution in the USA, created a huge demand for oil that the supply was not initially able to match (Holodny, 2016). Consequently, the big oil companies started working in the interests of their origin countries i.e. oil consumers, rather than the countries that granted them exploration rights. Subsequently, these actions transferred the control over oil production and pricing from the big oil companies and the oil-consuming countries to these oil-producing countries, and the dynamics of the whole market changed completely.

The last period, starting from 2003 till our present time, prices continued to fluctuate up and down in response to major political and economic events such as the US invasion of Iraq, the global financial crisis in 2007, the Arab Spring in 2011, and the shale oil boom in the US (IG Trading, 2019). In summary, Figure 3-2 below shows the major movements of the global oil prices over

the entire history of the oil markets (Pankratyeva, 2019). The next section introduces the factors that affect the oil price.

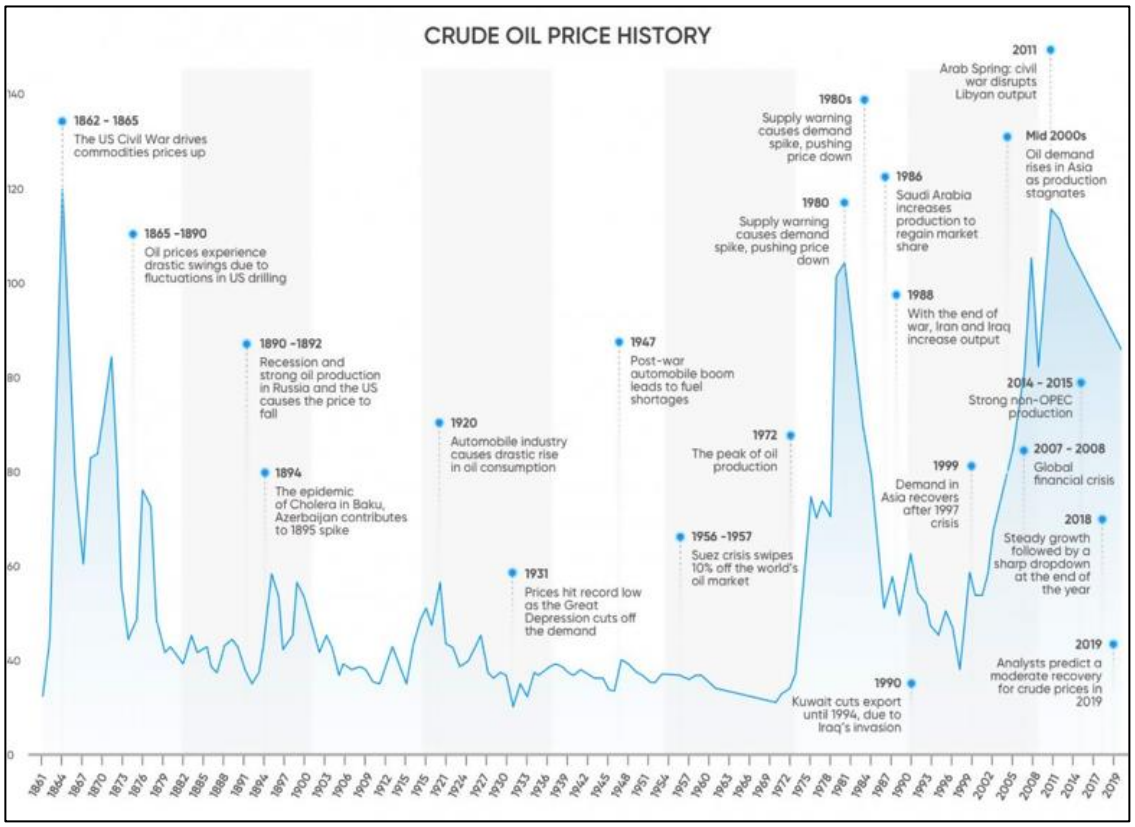

Figure 3-2 Oil Price History (Pankratyeva, 2019)

3.2.2. Factors Impacting Oil Prices

From the above historical background, it is evident that there are some factors that have major impacts on oil prices, whether positively or negatively. These factors can be divided into either external factors; such as: political, economical, and meteorological, or technical factors; such as: technology, major players, and price volatility (Braginskii, 2009). With regards to the external factor, perhaps the factor with the biggest and most sudden impact is the political one while the

meteorological factor is the one with the least impact; yet, these two factors are difficult to predict (Braginskii, 2009). At the same time, although the economic factor also has a strong impact, this impact is often gradual and the economic conditions can be fairly forecasted, which mitigates this impact to an extent (Braginskii, 2009). On the other hand, the most influential technical factor is the technological one. Technological breakthroughs in oil exploration and production can lead to the reduction of oil production, refining, and transportation costs; hence, leading to a decline in the crude oil prices (Braginskii, 2009). Some examples of these technological advancements that lowered the price of crude oil are GPS survey, multidimentional geophysics, and horizontal and directional drilling (Braginskii, 2009). Another recent and more evident impact of a technological breakthrough is the shale oil production in the US. This technological breakthrough increased the supply of oil and reduced the US imports which put downward pressure on the global oil prices and led to its decline in 2014 (Kilian, 2016). In addition, supply and demand play an important role in determining future oil prices. For instance, the production levels of OPEC's countries significantly impact the global oil prices; moreover, the spare capacities that these countries possess have also an impact on the oil prices (Fattouh, 2007; Lojanica, 2015). In terms of demand, Dvir and Rogoff (2009) examined crude oil price's data from 1861 to 2008 and found that the price of oil showed high volatility whenever there was rapid industrialization in a major world economy i.e. an increase in demand. Similarly, Alquist and Kilian (2010) employed a two-country, multi-period general equilibrium model to simulate the crude oil spot and futures markets and found that when precautionary demand increases, this coincides with an immediate increase in the real spot price of oil.

Another factor that can have an impact on oil prices is the timing of economic information. According to Elder, Miao and Ramchander (2013), there is evidence of the existence of a substantial association exists between high-frequency price surges in oil and the time of economic

news. After introducing the history and factors affecting oil price, the next section presents oil transportation, including the different type of oil tankers.

3.2.3. Oil Transportation and Tankers

Throughout its lifecycle, the oil needs to be transported on two main occasions: from the oil wells to the refineries and from the refineries to the consumers; these two processes are usually referred to as midstream (Mahmood, 2018). Moreover, oil is often transported through a network of four main transportation modes, which are: pipelines, rail, tanker ships, and trucks (Wetzel, 2018). As (Mahmood, 2018) comments, the most appropriate method will depend on the geographical location of both ends of the process and will also be dependent on the cost of the chosen transportation method and the required speed of delivery. By far, the largest volume of oil is transported through pipelines, which contributes to 70% of crude oil transportation in the US, followed by tankers with 23%; however, in terms of safety, tankers are the safest mode of oil transportation (Conca, 2019). Yet, globally this spread between pipelines and tankers gets narrower, reaching almost 50/50 split for crude oil transportation (Vidmar and Perkovič, 2018).

Maritime oil transportation started at the end of the nineteenth century with a continuous increase in the transported volume ever since (Hennig *et al.*, 2012). Marine transport is mostly done through purpose-built ships called tankers, which are designed to transport liquids and are classified according to their deadweight tonnage (dwt) (Maritime Connector, 2007; Planète Énergies, 2015). In 2018, the global tanker fleet amounted to 561 million dwt which constitutes 29.2% of the world shipping fleet (UNCTAD, 2018). In addition, there are different types of tankers based on their maximum dwt and the route they serve. (see Table 3-1).

Table 3-1 Geometrical Features of Oil Tankers

Type	DWT	DRAFT	Length (m)
LR1	50000 - 80000	14	220
Panamax	60000 – 80000	13.7	228
Aframax	80000 – 120000	14.8	244
LR2	80000 - 120000	15	245
Suezmax	120000 – 200000	17	274
Very Large Crude Carrier (VLCC)	200000 – 320000	21	333
Ultra Large Crude Carrier (ULCC)	320000 - 550000	24.5	380

With the regards to the oil tanker market itself, one of the main features of this market is its seasonality which is mainly a result of the supply and demand for oil. According to (Drobetz, Schilling and Tegtmeier, 2010), the demand for tanker shipping stems from the demand for oil. An example of how oil demand impacts the freight rates for the oil tankers is that these rates tend to be higher during the first and fourth quarters of the calendar year as 90% of the global population lives in the northern hemisphere and more oil is needed during the winter season in that region (Euronav, 2018). Nonetheless, the degree of this seasonality has been diminishing in recent years as demand increased from countries in other regions, such as: Asia and Africa (Euronav, 2018). In addition, the tanker market passes through a typical cycle that starts with oversupply, and this will drive owners to get rid of old ships, which will rebalance the market. In this balanced market, owners will earn more money, so they will be encouraged to order new vessels and the market gets oversupplied again (Euronav, 2018). As for the oil prices, some researchers argue that since oil prices increase when demand increases, this will benefit the tanker industry according to the above rationale; hence, increase the shipping rates (Drobetz, Schilling and Tegtmeier, 2010). On the other hand, when researchers include oil prices as an expense in their shipping rates' models, the impact will be expected to be the opposite i.e., when oil prices increase, the profits of the oil

shipping companies decrease (El-Masry, Olugbode and Pointon, 2010). For instance, (Grammenos and Arkoulis, 2002; Hammoudeh and Li, 2005) showed that the link between oil prices and the profits of oil transportation businesses is inverse.

Although the growth in the number of the tanker vessels contracted recovered from the low levels of 2011, 3% increase between 2015 and 2014 (Hübner, 2016), according to the (Danish Ship Finance, 2018), the outlook for the crude tanker market is negative. In the report published in November 2018, the crude oil tanker market was characterized by oversupply, with the average age of a vessel at 19 years, which drives the freight rates down. This has led to a slowdown in the number of tankers contracted in the first nine months of 2018 to reach only 15.7 million dwt, which is less than the 17.5 million dwt contracted during the first nine months of 2017 (Danish Ship Finance, 2018). A similar trend was witnessed for the deliveries of oil tankers as they declined by 7 million dwt in the first nine months of 2018. At the same time, newbuilding prices increased by 11% in 2018, while secondhand prices remained constant (Danish Ship Finance, 2018). All these factors led to an uncertain future of the crude tanker market with an additional downward risk for the secondhand market. The following section explores the factors influencing the tanker market.

3.2.3.1. Factors Impacting Tanker Market

The tanker market can be reconfigured by events impacting oil production. For example, an oil embargo imposed by OPEC in 1973 in opposition to the US's involvement in the Arab-Israeli war, triggered an oil crisis which also detrimentally affected as the demand for oil transportation plummeted, resulting in many vessels being laid up or scrapped, thus saving the companies from rocketing operating costs. As Brooks (2014) reports, many ship owners felt they had little option but to scrap newly commissioned ships since the operating costs were unsustainable. A further

example of reshaping the oil tanker industry occurred in late 2014 when oil tanker owners responded positively to the rapid fall in oil prices by increasing capacity, which leads, as Peter Sand (2017) reports, to a significant recovery in the tanker market following the 2008 market crash. Ship owners have been quick to take advantage of this bonanza to make significant profits, with many traders stockpiling oil until it can be sold at a much inflated price at some future date. Indeed, as Lewis (2005) confirms, the term 'Contango' is now applied to oil tankers that are lying idle off main ports just waiting for the opportune moment when they can sell their oil at the optimum price to meet demand as a gap in supply opens up.

Since refineries rely on oil as feedstock in order to produce petroleum products as worldwide demand has increased in line with the increased level of production. As de Almeida and Silva (2009) explains, the profit margin also rises when the price of oil is relatively low. Thus, geopolitical and/or economic events have reshaped the global oil tanker industry since its early days as it reacted to the characteristic volatility and cyclicality that dominate both this industry and the shipping industry in general. As 75% of world trade is transported through the shipping industry, according to Drobetz, Schilling and Tegtmeier (2010), there is huge global demand for oil. Oil shipping companies use tankers of enormous size in order to deliver the maximum amount of oil in a single journey, carrying crude or refined oil all over the world to satisfy demand. Drobetz *et al.*, (2010) suggest that shipping is the sole form of transportation that facilitates the international trade in food, manufactured goods and oil, while Albertijn *et al.*, (2011) and Drobetz *et al.*, (2013) state that almost 90% of global trade is now achieved through shipping. Therefore, ordering a new oil tanker is a significant financial undertaking. Table 3-2 below illustrates the value of oil tankers from new to 20 years old (Compass Maritime, 2020).

Table 3-2 Oil Tanker Value (Compass Maritime, 2020)

Tanker Ship Class	Number of New Build Contract	New Build Prompt Delivery	5 Years	10 Years	20 Years
		Prices are in US$ Millions			
VLCC	88	90	64	45	22
SUEZMAX	58	60	44	32	11
AFRAMAX	47	47	35	25	10
PANAMAX-LR1	40	40	28	18	7
MR TANKER	34	34	25	17	6

The oil transportation and tanker market are considered as parts of the shipping market introduced in the next section.

3.3. Shipping Market

3.3.1. Shipping Market Growth

The shipping market mainly consists of the transportation of goods and cargo. This market witnessed tremendous growth due to the growth in the global trade that was fueled by the economic liberalization efforts under GATT and the WTO (STSA, 2019). As a result of these efforts, two new main global players entered the global trade markets: China and Mexico, and with them came increased trade volumes with the industrialized nations (STSA, 2019). In addition, the revolution in information technology and communication increased global mobility and accessibility which facilitated global trade and increased the volumes of goods transported through the seas (STSA,

2019). Due to this growth, the global shipping market witnessed an increase in its capacity in all three types of cargos: oil, main bulk, and other dry bulk over the years. This increase accelerated in 2017 as 42 million tons were added to the global tonnage, which is equivalent to 3.3% growth over 2016, resulting from an upturn in new deliveries and a slowdown in the demolition activities (UNCTAD, 2018).

3.3.2. Shipping Market Cycle

One of the main features of the shipping market is the shipping cycle, which is an economic concept that explains how the shipping market reacts to changes in the supply and demand dynamics (Akers, 2017). In brief, according to the Economic Commission of Latin America and the Caribbean (2017), "this cycle is a combination of price incentives and the typical inelasticity of supply within this market". Furthermore, the shipping cycle results from the lack of synchronization between ship production and its dynamic demand (ECLAC, 2017). While cycles are generally caused by an imbalance between supply and demand for ocean-going transportation that results in freight rate fluctuations, each cycle also has unique characteristics. Research (Chrzanowski, 1985; Stopford, 2009; Albertijn, Bessler and Drobetz, 2011; IHS Market, 2014; Abdul Rahman *et al.*, 2015) suggests that by their behaviour in response to fluctuations in freight rates, ship owners distort the supply side of the market. Conversely, the seaborne/ seaborne/ocean-going trade (demand side) is subject to fluctuations as a consequence of changes in the global economy and geopolitical events and shocks. Ship owners believe that the maritime industry's volatility and cyclicality are the results of exogenous and unpredictable variables (such as changes in the global economy; geopolitical events) that cause the demand to fluctuate, which in turn affects the market. Table 3-3 below illustrates the primary factors that Stopford (2009) suggests affect supply and demand.

Table 3-3 Factors Affect Supply and Demand (Stopford, 2009)

Demand	**Supply**
Seaborne Trade	Fleet Productivity
Average Haul	Freight Rates
The World Economy	World Fleet
Random Shocks	Newbuilding Activity
Transport Costs	Scrapping Activity

In regard to the factors affecting ship demands, several researchers suggested that the world economy is the most significant determinant of the demand side. As living standards rise in tandem with the growth of the global economy, seaborne trade increases as consumers demand more products to enhance their lifestyle. Historically, the stability of trade is liable to disruption from random events, including geopolitical turmoil and natural disasters, which occur relatively frequently. A global economic crisis or an extreme fluctuation in the price of oil (positive or negative) has an influence on demand for seaborne commerce; low oil prices stimulate global economic development, whilst high oil prices have the reverse effect. Thus, the demand for seaborne trade rises as oil prices drop. Moreover, Stopford (2009) reports that the demand for ships (ton-miles) is calculated as the volume of seaborne trade (tons) multiplied by the average haul (miles). Another factor is the average haul that denotes the average distance of the active sea routes by which a specific cargo is imported/exported. Unexpected and random events - e.g. wars; closure of the Suez and/or Panama Canals - result in the distance to transport the cargo being increased as the ship takes diversionary action. Navigational errors are an additional cause of an increase in average haul because they add to the distance, increasing demand as the supply dwindles. Furthermore, ocean-going transportation, which is considered another affecting factor, was prohibitively expensive, but the situation has increased noticeably over the last hundred years

as developments in the maritime industry lowered sea-going cargo transportation costs. Researchers (Chrzanowski, 1985; Stopford, 2009; Albertijn *et al.*, 2011; IHS Market, 2014; Abdul Rahman *et al.*, 2015) confirm that technological developments have resulted in larger, more efficient ships, which in turn, equate to comparatively negligible seaborne transportation costs.

In regard to the factors affecting ship supply, fleet productivity is identified by Stopford (2009). He reports that the supply side is also calculated through an equation - in this case, world fleet multiplied by the fleet productivity equals ton-miles. The behaviour and marketing decisions of ship owners in response to freight rate fluctuations determine the calculation of the world fleet. According to Stopford (2009), fleet productivity is a measure of the active merchant fleet and is subject to a number of variables, such as the days that a ship is loaded while at sea, its speed and deadweight utilisation. It is also affected by the time spent in port unloading since this down time means that the ship is unproductive during this period. Conversely, the days when a ship is loaded at sea, and any increase in speed can all improve productivity. Moreover, the common practice of 'Contango', a term coined by Lewis (2005), also affects the supply side since tankers are used as holding/storage vessels rather than plying their trade to and from ports. Traders store cheap oil in tankers moored off-shore until the price of oil rises significantly and they can sell for a handsome profit. Effectively, these tankers are outside the market, but once the decision to sell has been made, the excessive tonnage of oil released onto the market has a depressive effect on the freight rates. Thus, the supply of shipping services is determined by the size and structure of the fleet on active service, the average time of operation and the productivity.

Moreover, Chrzanowski (1985) comments regarding another two-affecting factors that are newbuilding and scrapping activity, that any perceived shortage in transportation capacity will press older vessels into use because they will still be profitable until the market stabilises and the entire operational fleet is seaborne. Shortage in transportation capacity also means that ships will

operate at a higher than optimal speed, leading to high running costs, but ship owners calculate that these will be more than accounted for by the efficiency in time saved and the higher freight rates they can charge. Conversely, if an excess of tonnage floods the market, driving down the freight rates, it will no longer be cost-effective to run the older, less efficient vessels in the fleet, which will be withdrawn from service or scrapped. In turn, the supply side will contract to reflect the excess tonnage in the market, a move that eventually restores equilibrium until the next fluctuation. As the literature shows (Chrzanowski, 1985; Stopford, 2009; Albertijn *et al.*, 2011; Abdul Rahman *et al.*, 2015), once equilibrium has been restored, maritime transportation companies will revert to operating their ships at the optimum, fuel-efficient speed.

Furthermore, the intensity of shipping cycles is maintained by delays in balancing supply and demand to restore equilibrium. Stopford (2009) proposes that there are three types of shipping cycle, namely those that are long, short, and seasonal. Long cycles are distinguished by their extended time horizon (20 to 50 years), meaning that they are often problematic to detect (Stopford, 2009). Long cycles are characterized by long-term technological developments and significant global political and societal events. The maritime industry's long cycles tend towards the shorter time horizon of 20 years, since newly-commissioned vessels have a service life expectancy of between 20 to 25 years, after which period they are likely to be scrapped as they cease to be cost-effective. Moreover, the most common shipping cycles are the short (or business) cycles which are characterised by their detectability. As Stopford (2009) notes, short cycles are variable and subject to investors' ordering behaviour whereby anticipation of a future boom market following a slight recovery can trigger a longer recession. Thus, as the author (ibid.) states, the time horizon can differ between 3 to 12 years, depending on the owners' behavioural decisions. Finally, as the name suggests, seasonal cycles are initiated by freight fluctuations in response to seasonal demands in any given year.

Furthermore, it important to know that a lot can happen in each shipping cycle. According to Cufley (1972), as quoted in Stopford (1997), three main events occur during one shipping cycle:

1) shortage of ships starts to develop.

2) the consequent high freight rates encourage owners to over order new ships.

3) these new orders flood the market, and the market collapses.

Consequently, the shipping cycle is characterized by four main phases trough, recovery, peak/plateau and collapse (Stopford, 1997, 2009) that are shaped by the fluctuations in the supply of the vessels (Karakitsos *et al.*, 2014) and typically lasts three to four years, with two years down and two up (Goulielmos, 2009). Phase one is the trough phase, which is the lowest point in a shipping cycle when the market bottoms out, leading to an oversupply of ships. In other words, it is when the supply exceeds the demand and ships begin to become idle at the ports. This drives ships to remain at sea longer by reducing their speed to cut on the fuel costs; hence, freight rates decrease and shipping companies will experience negative cash flows (Akers, 2017). These negative cash flows prompt ship owners to sell or demolish their old ships to cut their costs. At this stage, phase two begins. This is the recovery phase at which both supply and demand start to reach equilibrium since the extra tonnage was removed from the market and now demand is almost equal to the supply (Akers, 2017; ECLAC, 2017). At this stage, freight prices start to move up again and orders for new ships start to be made. However, this stage is highly volatile; albeit, cashflows start to increase at a steady rate (Akers, 2017).

Phase three is called the peak phase as the freight rates reach their maximum point (Scarsi, 2007). At this point, supply and demand are almost equal, or even the demand becomes higher; hence, almost all of the shipping fleet is in operation and the shipping companies realize quite high cashflows (ECLAC, 2017). Finally, phase four of the cycle is the collapse phase as the high freight rates fuel a slowdown in global trade and initiate a recession; thus, the demand will decrease and

the supply will outstrip it again (ECLAC, 2017). At the beginning of this phase, shipping companies will still experience high cashflows, but these will diminish rapidly as ships will start to sit idle at ports (Scarsi, 2007; Akers, 2017) and the cycle is repeated again. As a result of this complex cycle, shipping cycles often force weak shipping companies out of business which only leaves the strong and efficient ones in play (Stopford, 1997).

3.3.3. Types of Shipping Market

The maritime industry recognizes four discrete shipping markets, namely: freight, new-builds; sale and purchase; and demolition/scrapping markets, as reported by Stopford (2009). Freight (or charter) rate denotes the income that derives from a vessel's operation. In common with all markets, freight rates respond to competition and the interdependent supply and demand situation for maritime transportation. Stopford (2009) points out that the level of freight rates has little effect on sea transport services, which are inelastic, but does affect the volume of seaborne trade. Thus, the four shipping markets are interactive, triggering changes to the supply side.

3.3.3.1. Freight Market

The freight market is the market in which ships are hired for the purpose of transportation through the assistance of a broker (Kemplon Engineering, 2016). It describes transactions between buyers (charterers) and sellers (ship owners) to transport freight at an agreed rate, a point at which the ship is said to be 'fixed' according to Stopford (2009). To be effective, the freight market requires the services of a third player, namely a shipbroker, whose role is to act as an intermediary to connect buyer and seller. A shipbroker plays a pivotal role in seeking out available vessel capacity for cargo transportation; once achieved, the broker conducts negotiations between the two parties on a consultative basis, until the agreement to 'fix' a vessel has been achieved. At this point, all

parties sign a Charter Party, which sets out in detail all the relevant terms and clauses of the agreement. According to Stopford (2009), the freight market has two different types of transactions:

1) the freight contract when transportation is bought at a fixed price per ton of cargo.

2) the time charter when the ship is hired on a daily basis.

The freight contract is the first category whereby a fixed price for transportation per ton of cargo is agreed between the parties. The time charter contract is the second category which determines the rate to be paid for every day that the period of vessel hire is exceeded (Stopford, 2009). In respect of crude tankers, there are four discrete types of contracts covering the two transactional categories. These are: Voyage (or charter); Trip Charter; Time Charter (TC); and Bare Boat Charter contracts.

3.3.3.2. New-Build Market

The second shipping market that will be discussed is the newbuilding market. This is the market in which new ships are ordered (Stopford, 2009). Through this market, new ships enter into the shipping industry, which increases the supply and sends cash out of the market (UKEssays, 2018). Nevertheless, this market does not increase the supply immediately as new ships need around two to four years to be built after they have been ordered; albeit, market players can accurately account for these new ships in their future forecasts (Kemplon Engineering, 2016). Mainly, there are two main reasons for ordering new ships: the first is to extend the size of the existing fleet; the second reason is to replace an existing vessel with one that is more cost-efficient, comes equipped with advanced technology, and can meet the increasingly stringent maritime regulatory requirements. There is a long lead time between placing an order and taking delivery - a period of between one and two years is not exceptional. Freight rates, ship-building costs, the age of the existing fleet

and international regulations are all factors that affect ship-building activity. While the amount of orders and freight rates have a positive association, the link between shipbuilding activity and shipbuilding costs has a negative correlation. Moreover, ship-building activity is also affected by ship owners' ordering of new vessels reflects their optimism that the level of future freight rates will remain high as demand outstrips supply. Thus, they believe that seaborne trade will continue to expand, and the additional capacity promised by new vessels will allow them to take advantage of increased revenues, thereby stabilising the market. Therefore, the unpredictability of ship-building activity is largely due to ship-owners' erratic decision-making, behaviours and unrealistic expectations. Investors' attitudes and anticipation of price levels remaining high (market sentiment) results in increased ship-building activity to the point where there is over-supply, freight rates are low and the market becomes depressed. In fact, given the projected lifespan of a new vessel as 25 years, market depression can last for a considerable time. When owners are forced to scrap vessels due to age redundancy or oversupply of fleet capacity (Demolition Market), supply and demand begin to move towards equilibrium. Thus, the new-build market is the prime factor governing the shipping market, leading to freight rate fluctuations.

In addition, the prices in the new build market can be extremely volatile, inelastic with respect to demand, and even reach lower than the second-hand market (Stopford, 1997; Adland and Jia, 2015). Several factors have contributed to such complex dynamics in this market; including government subsidies, the presence of strong labour unions, and the rigidity of the organisational structures of most of the shipbuilding companies (Adland and Jia, 2015). Furthermore, the leading country in the shipbuilding industry is South Korea with 34% of the global market share, followed by China with 33% and Japan with 17% of the global market share (Market Watch, 2019). The price for building new ships moves in tandem with ship-building activity: the more new vessels are ordered, the higher the prices rise. When the freight market begins to slow down, ship owners

react to the depressed market by becoming cautious about ordering new vessels; as the demand for new ships falls, the price of ship building also drops. In contrast, as (McConville and Leggate, 1999; Tsolakis, Cridland and Haralambides, 2003; Dikos, 2004; Stopford, 2009) point out, ship building prices reach great heights under a booming market.

3.3.3.3. Sale and Purchase or Second-Hand Market

The shipping companies' highest generation of revenue is largely through the tanker freight market when seaborne transportation is at its peak and owners seek to expand their fleet by commissioning new vessels (ship building market) or purchasing them second-hand in the Sale and Purchase (S & P) market. As Stopford (2009) argues, tens of millions of dollars regularly flow through the S & P market. For example, in 2006, 1,500 second-hand merchant vessels were sold for a total of $36 billion, a considerable sum. Potential buyers hire S & P ship brokers to lead the negotiations and complete the sales transaction through to the signed contract stage. Moreover, the decision on whether to commission a new vessel or buy one second-hand rests largely on whether the one to four-year time frame required for a new build meets the potential owner's needs for revenue generation. The purchase of a second-hand tanker takes much less time and, when the oil tanker market is thriving, owners may prefer to satisfy the demand for oil transport services relatively quickly by buying from the S & P market with shorter delivery times in order to rapidly increase the volume of oil they can supply (Goulielmos, 2008). Strandenes (2002) notes that the S & P market is considered to be an auxiliary market since the vessels for sale are already included in the total number and capacity of the existing fleet. Therefore, providing that no new ships enter the market and/or no ships are scrapped, the S & P market has no effect on the freight market. Strandenes (2002) argues that the existence of the second-hand market facilitates owners' ability to restructure their fleet, and/or exit the market by being responsive to fluctuations in demand.

The price of second-hand vessels is primarily affected by freight rates, with the age of the ship, inflation and market expectations as secondary considerations. The S & P market is extremely volatile due to prices moving in tandem with freight rates. Market expectations are also influential since when investors believe that freight rates are likely to rise, the demand for second-hand vessels increases, as does their price. In a thriving market, when second-hand vessels are at a premium, prices demanded can equal the cost of a new-build vessel (although the delivery time will be shorter). Conversely, as Adland, Jia and Strandenes (2006) point out, the price of second-hand ships plummets when the market is in recession and may ultimately become scrap value. For the S & P market overall, individual sales set a benchmark for the type and size of a vessel sold against which the price can be negotiated.

3.3.3.4. Demolition Market

The demolition market deals with old and obsolete vessels and is the final type of shipping market to be described. It is a market in which owners sell their ships to scrap yards (Stopford, 2009). This market is the opposite of the newbuild market as it reduces the supply and infuses cash into the market (UKEssays, 2018). This market tends to flourish during recessions as owners want to discard the old ships they own as they become a liability during these tough times. Strandenes (2002) comments that this market, together with the new-build market, reflects the available vessel capacity to service the existing demand for sea transportation and services. The decision to scrap a vessel may be taken when it is no longer able to meet the stringent regulatory requirements, or would cost too much to ensure compliance, or where the running costs exceed freight rates so that owners would operate at a loss. The owners look to gain a financial return from the scrap value of the ship to offset their operating losses in a recessive market or to realise their capital by putting ships at the end of their useful life into obsolescence.

In a booming market, however, even ships of 30 years old may not be scrapped since owners consider that the cost of deploying them is more than offset by the revenue likely to be generated by high freight rates. Thus, a relationship exists between the second-hand and the demolition markets, since ships that constitute the former are ultimately scrapped in the latter. Additionally, there is a thriving trade in ship scrappage, particularly for ship-breaking yards in the Far East, India, Pakistan, China and Bangladesh. Brokers specialising in the demolition market conduct negotiations and determine the selling price, similar to ship-brokers for new-build vessels. Moreover, the prices in this market depend on many factors; which are: the demand on the scrap metal, lightweight tonnage, and the supply of ships for scrapping; yet prices in this market are subject to negotiations as there are no strict mechanisms for these transactions (Kemplon Engineering, 2016). Additionally, the price of scrap rises in tandem with the rise in the demand for steel (Knapp, Kumar and Remijn, 2008), and is also affected by the number and availability of ships to be scrapped. As Knapp, Kumar and Remijn (2008) report, the lower the number of vessels needing scrapping, the higher the scrap price will be; in the reverse situation, prices decrease.

3.3.4. Ship Evaluation and Costs in the Shipping Market

One of the key aspects of the shipping market is the presence of high-value, sophisticated, and capital-intensive assets i.e. the ships (Albertijn, Bessler and Drobetz, 2011). These assets are critical to the success of shipping operations (Engelen, Meersman and Voorde, 2006); hence, as with all other markets, pricing and evaluating these assets accurately becomes an important contributor to the overall market's efficiency (Kavussanos *et al.*, 2002). However, accurately evaluating the value of ships is not an easy task as it cannot simply depend on the supply and demand analysis since the ship is an asset with a long economic life (Beenstock, 1985).

Consequently, several attempts in the literature were made to develop models that can perform the task of evaluating the ships accurately using a variety of techniques.

In general, there are two main valuation methods on which the price estimation models are based; these methods are (Albertijn, Drobetz and Johns, 2016):

1) the market approaches.

2) the discounted cash flow (DCF) approach, which is two of the most common valuation methods in the fields of corporate investment and finance (Bendall and Stent, 2003).

3.3.4.1. Costs Associated with the Shipping Industry

The shipping sector is characterised by two distinct categories of costs:

1) Fixed costs of the vessels.

2) The running or operational costs.

Regarding the former, these costs are basically the cost of acquiring the vessel. Regarding the running or operational costs, the following sub-section will shed more light on the nature of these costs, their composition, and methods of determination. In general, the running costs incurred by the shipping company are variable costs that depend on the age and state of the vessel, as well as, its utilization rate, and can be divided into two broad categories: the daily running costs and the voyage operational costs (Maroulis, 2004). The detailed breakdown of each of these cost categories are presented in Table 3-4 below (Maroulis, 2004).

Table 3-4 Daily Running Costs and the Voyage Operational Costs (Maroulis, 2004)

Daily Running Costs	**Voyage Operational Costs**
Crew Wages	Fuel Costs
Insurance for Hull & Machinery	Port Use
Repairs and Maintenance	Pilot Fees
Engine and Deck Spare Parts	
Protection and Indemnity Insurance	
Provisions; such as: food	
Engine Deck and Cabin Stores and Consumables	
Lubricating Oils and Chemicals	
Communications	
Management Fees	

In order to be able to estimate these costs accurately, it is essential that all costs are categorized correctly. Moreover, another new category of costs that have been added to the operational costs of the shipping companies is the one resulting from the tougher environmental regulations that have been put into place (Lloyd's List Intelligence, 2018).

Another category of operating costs that is calculated on an annual basis is the ship's depreciation cost (Počuča, 2006).

3.4. Shipping Financing

The decision to finance shipping companies is one of the most complex decisions faced by creditors due to the high volatility and cyclicality of this business, the changes in its operating cashflows, and the changes in the values of the assets themselves (Albertijn, Bessler and Drobetz, 2011). This nature, coupled with the financial crisis in 2007, has led to the extreme reluctance of banks to finance this industry and the number of shipping banks has fallen sharply (Albertijn, Bessler and Drobetz, 2011; Thomopoulos, 2016). Nevertheless, as previously highlighted, the

shipping industry is a capital-intensive industry, either through newbuild or acquisition of second-hand vessels, which requires external financing in order to sustain and grow its operations (Giannakoulis, 2016).

Traditionally, shipping companies had three main sources of finance:

1) equity financing, which may take the form of retained profits or stock issues to public or private companies.

2) mezzanine financing is concerned with hybrid such as warrants and convertible securities, preference shares, and subordinated loans.

3) debt financing is concerned with bank loans, export financing, bonds, subsidies, shipyard financing, private placements, and state debt (Maroulis, 2004; Laurent and Cenk, 2019).

In addition, debt finance in general, remain the most important source of financing for the shipping companies, with over $63 billion of bank debt issued to the shipping companies in 2014 alone (Giannakoulis, 2016) and covers more than 80% of the financing needs of the shipping companies (Drobetz *et al.*, 2013). The reason behind this popularity of bank loans is that this form of financing is the least expensive one (Maroulis, 2004). At the same time, banks find the shipping market attractive as they are able to increase their returns on these low margin loans by refinancing them before their maturities (Giannakoulis, 2016). However, this dependency is less severe than it used to be in the past as, nowadays, capital markets became more open to the idea of providing the needed financing to the shipping companies (Giannakoulis, 2016), and, as of September 2018, a total of $4.48 billion of capital was raised by the shipping industry from the capital markets (Laurent and Cenk, 2019). The reason for the attractiveness of the shipping industry to these markets is the continuous growth in the volume of global trade, which are associated with high returns (Giannakoulis, 2016). Hence, in the following sub-sections, the most widely used of these types of financing and their different instruments will be reviewed in detail.

3.4.1. Equity Financing

For shipping firms, equity markets and private investors provide a variety of funding options; these include, but not limited to: private placement, initial public offerings, master limited partnerships (MLPs), and preferred stock; Figure 3-3 shows the different options of equity financing available for the shipping companies, based on whether this company is public or private (Pribor and Lind, 2016).

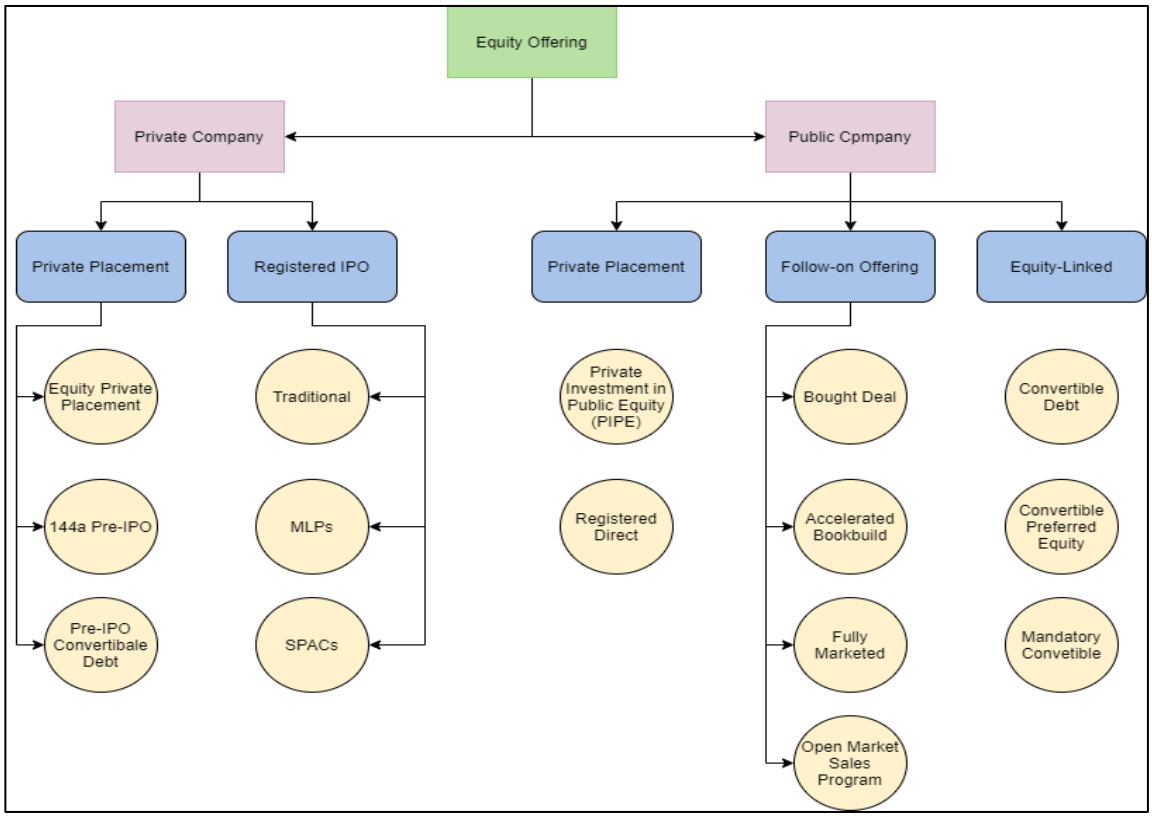

Figure 3-3 Different Options of Equity Financing Available for the Shipping Companies (Pribor and Lind, 2016)

In the following sub-sections, details of the commonly-used equity financing instruments by the shipping industry will be provided.

3.4.1.1. Initial Public Offerings (IPOs)

Shipping companies can raise capital through selling shares and become listed in one of the major stock exchanges; such as: New York, Oslo, Hong Kong, and Singapore (Giannakoulis, 2016). Through this instrument, public and private entities can purchase ownership into the shipping company through a regulated capital market; nevertheless, this process takes a considerable amount of time and requires a lot of coordination between different parties. Generally speaking, the IPO process consists of four main stages (Pribor and Lind, 2016):

1- Company preparation stage: During this stage, the company analysis and selects the most suitable capital structure for its operations. In addition, the company should prepare its historical audited financial statements, presentations for investors and regulators, and reports with the operational performance, risks associated, and other business-related features of the company. At the same time, during this stage, the shipping company has to select the stock exchange in which it will be listed, review its corporate governance structure, and hire an investment banker.

2- Drafting, diligence and initial filing: At this stage, the final structure and timing of the deal are to be determined by the company, together with its advisors. In addition, during this stage, the preliminary prospectus should be drafted and filed with the relevant regulatory authorities, after which the third stage starts.

3- Regulatory review and decision: During this stage, the relevant regulatory body will start reviewing the company's documents and offer terms in order to either accept, reject, or recommend some amendments to these documents. During this stage, the company itself will have no obligations towards the IPO process, in fact, it should not make any comments regarding this process till the regulatory body reaches its decision.

4- Marketing, pricing and aftermarket: After the approval of the regulatory body, the final stage of the IPO process starts. During this stage, the company's management will start to market its offering by conducting roadshow to potential investors in the major financial centres around the world. After receiving the feedback from these marketing efforts, the final offering price will then be determined.

Furthermore, in order for a shipping company's IPO to be a success, the timing of this IPO has to be chosen carefully. This timing will greatly depend on some economic and market conditions; such as: current and forecasted freight rates, trade volumes, and the global macro-economic fundamentals (Pribor and Lind, 2016).

3.4.1.2. Master limited partnerships (MLPs)

Master Limited Partnerships (MLPs) are companies with a special structure, under the US federal law, which enjoy some tax benefits (Giannakoulis, 2016). These companies have to be in the businesses related to the energy, natural resources, or transportation sectors; hence, shipping companies qualify as MLPs (Giannakoulis, 2016). This favourable tax position reduces the costs of raising debts by these companies, which allows them to offer extra high yields (Pribor and Lind, 2016). A typical MLP structure is depicted in Figure 3-4. As can be seen from this figure, the MLPs have three classes of shares: public investors own the publicly traded common units, while the general partner (the owner) who holds the subordinated units and 2% of the company. In addition, the general partner is entitled to incentive distribution rights (IDRs) that guarantees him higher share of the distributions when a certain distribution target is met (Giannakoulis, 2016).

In the shipping industry, the first MLP was created in May 2005 by Teekay LNG Partners; and, since that date, the number of shipping MLPs expanded to include bulk companies, as well as the

oil and gas ones; and, in total, these companies have raised over $7 billion in equity in the US (Giannakoulis, 2016).

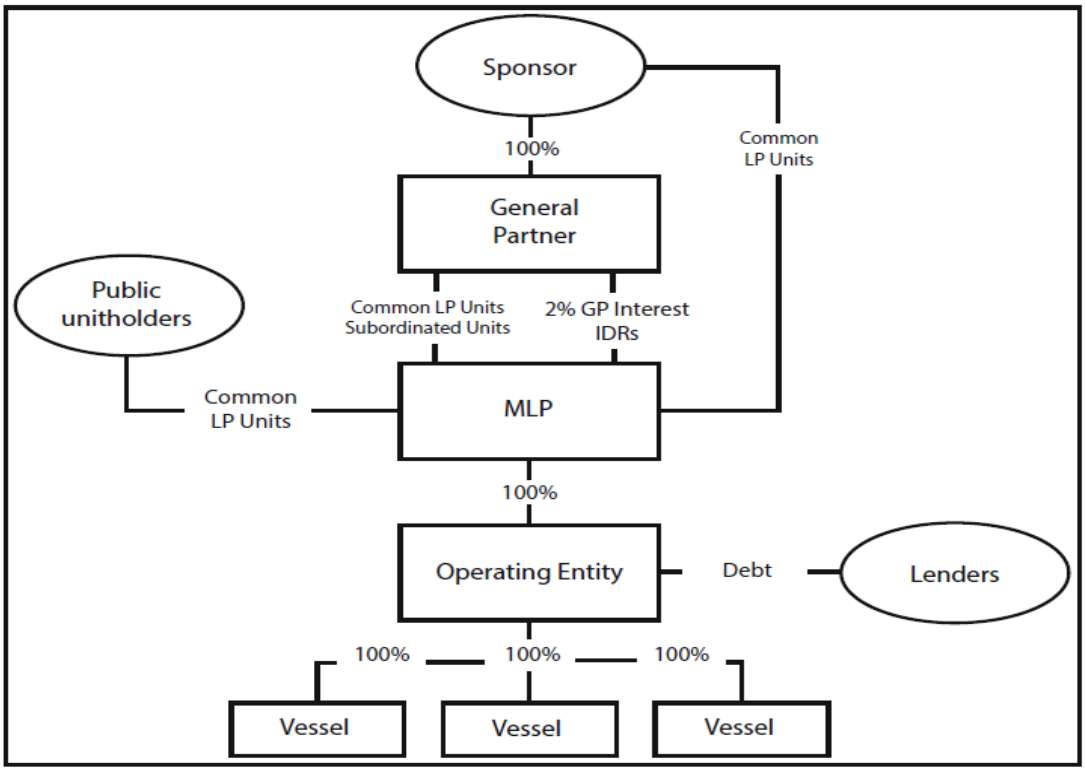

Figure 3-4 Typical Structure of MLP (Giannakoulis, 2016)

These above two financing instruments allow the shipping company to become public which, in itself, has some advantages and disadvantages as detailed in Table 3-5 below:

Table 3-5 Advantages and Disadvantages of Being a Public Company

	Advantages	**Disadvantages**
1	Higher company valuation	Extensive listing process
2	Funding opportunities	Associated with extra costs
3	Increased liquidity	Market pressure
4	Public credibility	Risk of takeover or loss of control
5	Better economics for raising capital	Increased scrutiny of management
6	Ability to use stocks for acquisitions	

3.4.1.3. Private Equity

The interest in the shipping companies from private equity and hedge funds have increased over the past decade. These types of funds have creative investment strategies that combine active trading with short- and long-term investments as well as debt financing (Pribor and Lind, 2016).Hence, concerning the shipping industry, the economic crisis of 2007 saw many of these companies lose a lot of value and became undervalued with a lot of debt. This provided an opportunity for private equity firms who look to profit from the companies when they eventually bounce back; in addition, the volatility inherit in the shipping industry provides a golden opportunity for these types of firms to make gains during these cycles (Antonios, 2016). Typically, these firms enter into the shipping market through a joint venture agreement with the owner and use a number of exit strategies to exit the market; such as: the sale of their share, IPO, or merger with another company (Pribor and Lind, 2016).

3.4.2. Mezzanine Financing

Mezzanine financing is a type of financing that can take the form of either debt or equity and is particularly useful when the company does not want to raise more capital and has no more borrowing capacity (Bean, 2008; Rounan, 2013). Although mezzanine financing has many forms,

all these forms offer a risk/return portfolio in between debt and equity (Silbernagel and Vaitkunas, 2012). In other words, mezzanine financing has a higher cost than debt, but lower than equity; while it comes after debt in the priority of repayment but higher than equity (Silbernagel and Vaitkunas, 2012).

Mezzanine finance instruments come in a variety of forms, including preferred stock, convertible bonds, and mezzanine debt. Preferred stocks refer to preference shares that are issued with a preferred coupon which has a priority over common equity dividends and treated on the company's balance sheet as equity (Alexopoulos and Stratis, 2016). Regarding convertible bonds, these are debt instruments convertible to a certain number of shares of common stock (Alexopoulos and Stratis, 2016). Nevertheless, in the shipping industry, mezzanine debt is the most frequent kind of mezzanine financing. This is often referred to as subordinated debt that has higher interest cost and treated as a liability on the company's balance sheet (Alexopoulos and Stratis, 2016). This form of financing can be used by shipowners when their companies are expanding to avoid the dilution of their positions through raising equity. Also, mezzanine financing is a beneficial instrument during low markets as it unlocks the cash trapped in equity (Alexopoulos and Stratis, 2016).

Accordingly, mezzanine financing has a number of advantages and disadvantages (Alexopoulos and Stratis, 2016). Regarding the former, 1) it provides liquidity without raising capital; 2) it is a very flexible financing tool; and 3) it does not dilute the shipowners' control over their companies. On the other hand, mezzanine financing does have a number of drawbacks including: 1) puts strain on the cash flows, 2) has a higher incremental cost which impacts the company's profitability; and 3) its complex structure requires complex paperwork and legal work.

3.4.3. Debt Financing

By definition, any kind of financing that involves repayment together with its associated interest, after a specific period of time is referred to as debt finance (Cushing, 2016). The three most common types of debt financing are mortgage loans, corporate loans, and corporate bonds. Each of these types of debt financing will be explained in detail in the following sub-sections.

3.4.3.1. Mortgage-Based Loans

In this type of financing, the owner will borrow money from the commercial bank. Due to the attractiveness of the shipping industry, most major banks have created specialized shipping financing departments to focus on this category of financing (Maroulis, 2004; Paleokrassas, 2016). Traditionally, bank loans were the biggest source of financing for the shipping companies (Stopford, 2009) as these loans reached $92 billion in 2007; however, due to the financial crisis and the problems faced by the shipping banks, the total amount of these loans shrunk to reach $45 billion in 2017 (Laurent and Cenk, 2019). In this type of financing, the bank usually finances 60-80% of the vessel's value and use the ship itself as collateral to secure against any default from the owner (Giannakoulis, 2016). This, by default, means that the vessel has to be in the owner's possession and delivered by the shipyard in order for the owner to write the mortgage to the bank and have access to this type of financing. In addition, the ship has to be registered in a legally acceptable jurisdiction in order for the bank to have direct access to the ship in case of default and isolate it from any other liabilities incurred by the owner (Giannakoulis, 2016). Furthermore, there are a number of terms that are usually negotiated between the lender and the borrower to ensure a smooth transaction; these terms are (Giannakoulis, 2016):

1- Financing amount: This amount depends on whether the vessel is new or second-hand, its age (in case of a second-hand), the freight rates forecast, the credit rating of the borrower,

and the available securities and corporate guarantees.

2- Tenor: This is the duration over which the loan will be repaid, and it ranges from 5 to 10 years.

3- Repayment interval: Commercial loans are typically repaid on quarterly or semi-annual instalments that are equal in amount. This repayment profile also depends on the age of the vessel and its remaining useful life. Another important factor that impacts the determination of the loan repayment schedule is the cash break-even rate of the mortgaged vessel, as this value will determine its ability to cover its operating expenses and fulfil its loan repayment obligations.

4- Interest Rate: This rate depends on the credit rating of the borrower as well as the quality of the mortgaged vessel and usually ranges between 200-300 bps above LIBOR and can go up to 400 bps in tough economic conditions. When negotiating the interest rates, the owners might add an interest rate cap that protects them against increasing interest rates; on the other hand, the lenders can add an interest rate floor to protect them against sharp decreases in interest rates (Cushing, 2016).

5- Fees: These are the administrative fees entitled to the entity that arranges the loan, and it is usually around 1% of the total loan value.

6- Other Securities: In addition to the mortgage on the vessel, the bank might ask for additional securities from the owner.

7- Financial covenants: The most common type of financial covenants is a term that refers to a clause in a loan agreement that requires the market value of the mortgaged vessel to always exceed the outstanding loan amount by at least 140%. Additionally, additional types of financial covenants include a borrower's minimum liquidity need or a limit on their overall debt.

8- Non-Financial Covenants: These include the required insurance coverages for the vessel and the company, the manager of the vessel, and the completion of satisfactory technical check-ups.

In addition, in some cases, when the amount of the needed financing is large or when the market is viewed as risky, banks might arrange for a syndication loan in which a number of banks finance the same asset in order to hedge against the risk of the borrower's default (Antonios, 2016; Paleokrassas, 2016). In these types of loans, each bank's lending obligation is separate from the other banks, while the leading bank will be responsible for the administration work of the loan on behalf of the entire syndicate (Syriopoulos, 2007). Another type of bank loans is secured loans which are loans that are guaranteed against the expected stream of income to be generated by the company (Syriopoulos, 2007). The main advantage of this type of loans is that it has lower costs; however, its execution is a bit more sophisticated (Syriopoulos, 2007). Furthermore, in the case of newbuilds, the loan is usually made in the same form of milestone payments made to the shipyard throughout the vessel's construction (Paleokrassas, 2016).

Moreover, providing loan facilities to shipping companies poses risks to the banks themselves due to the high volatility of this market. Hence, some research studies attempted to develop a list of factors through which bank managers can assess the quality of the shipping loan applications. For instance, Gavalas and Syriopoulos (2015) developed a multi-criteria assessment model for this purpose that contain 24 factors that belong to four main categories; namely: leverage indicators (3), managerial indicators (10), market indicators (7), and financial indicators (4). Another study that attempted to examine these factors was the one conducted by Lee and Pak (2018) through a survey that was distributed online to 41 managers at 23 banks from 11 countries. Through this study, the researchers used the AHP method to determine the most influential indicators on the decision of the bank managers and found that indicators representing corporate recourse and asset

cash flows are more important than those indicators for the asset's value. In addition, for the corporate recourse indicators, the most important indicator of all was the financial strength followed by the company's track record; while, for the asset cash flow indicators, charterer's credit came out to be the most important indicator.

3.4.3.2. Corporate Loans

These loans are typically warranted to large and established shipping companies with a high credit rating (Giannakoulis, 2016). These loans are typically unsecured and offer flexibility to the shipping companies as they usually take the form of revolving credit lines from which the company can withdraw funds when needed. The main items of this type of loans, such as: repayment, interest, and tenor, depend on the balance sheet of the lender; while, the most common types of covenants include corporate leverage ratio and the interest coverage ratio (Giannakoulis, 2016).

3.4.3.3. Corporate Bonds

Corporate bonds are a type of debt financing that are issued through the capital markets and are typically long term with a specific maturity date, typically after three to eight years (Cushing, 2016; Karatzas, 2016; Laurent and Cenk, 2019). The first bond issued by a shipping company took place in 1992 by Sea Containers Ltd., and from that time, the number of issuances is on the rise (Grammenos, Nomikos and Papapostolou, 2008). These instruments are somehow similar to the loans, as they involve a lender and borrower and the money has to be repaid; however, there are some fundamental differences between the two instruments (Karatzas, 2016). Moreover, this type of financing is usually utilized by large and well-established shipping companies as they are more expensive when compared to mortgage-based loans (Giannakoulis, 2016). Most of the shipping companies have a below an investment grade rating, obtained from a credit rating agency, since

these companies have high levels of gearing with assets that are old when compared to other industries (Leggate, 2000), hence, the bonds they issue have to be high yield ones with a high interest rate (Laurent and Cenk, 2019), typically between 7-9% (Karatzas, 2016). Moreover, according to Grammenos and Arkoulis (2003), credit rating, financial leverage, and the shipping market are the main determinants of the bond spreads; hence, the high yield of the shipping bonds. However, Kavussanos and Tsouknidis (2014) added two more factors to the list of important bonds' spread determinants of the shipping companies, which are: the liquidity of the bond issue and freight earnings; while Karatzas (2016) added the stock market's volatility and bond market's cyclicality to these determinant factors. Nonetheless, the apparent advantage of corporate bonds to the shipping companies is that this instrument is more flexible than loans as they are only repaid once at the maturity date (Leggate, 2000; Giannakoulis, 2016); yet, in some cases, the bond issuer might repay the bond early through a call option (Cushing, 2016). Furthermore, Bonds are exchanged on a centralised exchange or market and are regarded as liquid instruments that may be purchased and sold.

Moreover, bonds are classified into three distinct categories depending on their maturity dates. (Karatzas, 2016):

1- Bills: These are public debt securities with maturities of up to one year.
2- Notes: These are short-term government debt instruments having a maturity of one to five years.
3- Bonds: These are long-term government debt securities of more than five years.

Although issuing bonds has some advantages, their presence on the balance sheets of the shipping companies might add additional risk to these companies. For instance, during the tough phase of the shipping cycle, it is extremely difficult to change the terms of the bonds, especially when compared to mortgage-based loans. In addition, due to its repayment schedule's nature, bonds

might increase the companies' leverage to risky levels as the value of the companies' assets depreciate over the years (Giannakoulis, 2016). These risks might ultimately lead to the bankruptcy of the shipping companies or entail the involvement of the government to bail-out these companies in cases of default on the coupon payments, as were the cases with OSG and General Maritime, which were forced into a Chapter 11 restructuring when they failed to refinance maturing bonds (Giannakoulis, 2016). Moreover, when small shipping companies try to access the public debt market, they have to offer physical collateral to guarantee the repayment of the bond on its maturity date, similar to loans; and this collateral, in most cases, is the vessel itself (Karatzas, 2016).

Finally, when deciding to issue a bond, the shipping company has to hire an underwriter, typically an investment bank, who acts as a consultant to the borrower, provides access to investors, and prepares the bond prospectus (Karatzas, 2016). This latest document has to be filed with the corresponding regulators in case of the public offering; nonetheless, this obligation is waived in case of a private offering (Karatzas, 2016).

3.4.4. Other Financing Instruments

In addition to the above three main categories of financing, there are other financial options available to the shipping companies that offer some advantages over the traditional financing methods. In the following sub-sections, the most popular of these instruments will be highlighted.

3.4.4.1. Export Credit Agencies

Export Credit Agencies (ECAs) are, in most cases, government controlled entities whose main role is to provide support to the countries main exports, in terms of good and services, by providing different financial products and services; such as: guaranteeing the repayment of a loan, insuring

against non-payment of a credit facility or default of an exporter, and even provide direct loans (Alexopoulos and Stratis, 2016; Laurent and Cenk, 2019). Historically, ECAs have provided a lot of support to the shipping industry, especially after the financial crisis in 2008 (Norton Rose Fulbright, 2017), and, according to a report by (Young *et al.*, 2018), in 2017, a total of 44 ECA financing deals were procured globally, amounting for $18.5 billion, with North America contributing around 70% of these deals. Another major form of support provided by the ECAs to the shipping companies is insuring the repayment of loans taken by these companies from commercial banks against a fee charged to the borrower (Alexopoulos and Stratis, 2016).

As with all other financing methods, ECA ship financing has its own set of advantages and disadvantages which are summarised in Table 3-6 below.

Table 3-6 Advantages and Disadvantages of ECA Ship Financing

	Advantages	**Disadvantages**
1	Provide support for fleet expansion and modernization	Have a maximum repayment period of 12 years
2	Provide financial support when certain credit limits are reached that prevents the owner from getting bank loans	The financing decision via ECAs usually takes more time than through other channels
3	Diversify the financing portfolio	When ECAs guarantees repayment, this process will require a lot of documentation and the involvement of lawyers, which increases the cost of borrowing
4	Reduce the company's overall WACC	

3.4.4.2. Leasing

Leasing is a method of financing that has some similarities with debt financing as it utilizes ships as mortgages (Li, 2006). Leasing in the shipping industry is an old practice that takes the form of either operating or financial lease and, in 2016, amounted to a total of $1.8 billion (Li, 2006; Laurent and Cenk, 2019). Operating lease separates the ownership of the ship from its operations as an entity hires the ship for the short- or medium-term as bareboat or time charter, and at the end of the lease agreement, this entity returns the ship to the owner (Koukoutsi, 2015; Laurent and Cenk, 2019). On the other hand, financial leasing is used in the long-term in which the lessor owns the ship, while all the operating responsibilities are with the lessee and the ship, practically, becomes part of his assets (Stopford, 2009; Laurent and Cenk, 2019). Furthermore, in some instances, the leasing agreement comes with an obligation or an option to buy the vessel at the end of the leasing agreement (Giannakoulis, 2016).

A typical shipping leasing structure is shown in Figure 3-5. From this figure, it can be seen that leasing agreements have pretty sophisticated structures. At first, the lessor has to raise the required funds to purchase the ship through a combination of equity and debt financing, then lease this ship to the lessee under the terms of the leasing contract. According to these terms, the lessee operates the ship and make the lease payments to the lessor. As a result of this complex structure and the involvement of both equity and debt financing, the leasing agreements usually have higher cashflow servicing requirements as they need to cover the lessor's both debt and equity obligations (Alexopoulos and Stratis, 2016).

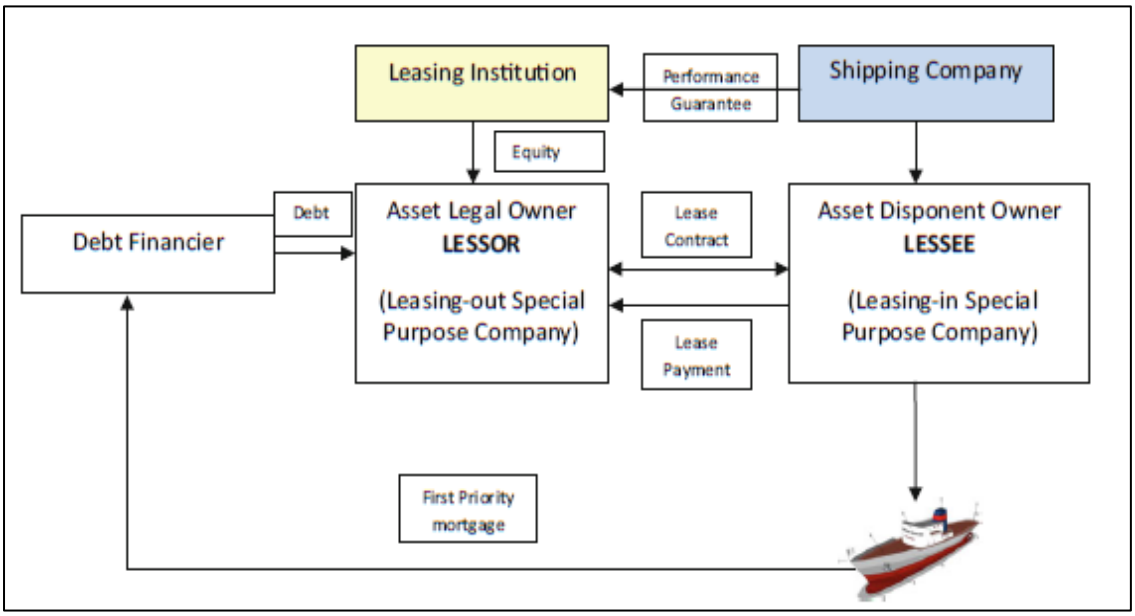

Figure 3-5 Typical Shipping Leasing Structure (Alexopoulos and Stratis, 2016)

One of the main advantages of leasing is that it allows companies to operate vessels and profit from these operations without the need to invest large sums of capital (Li, 2006; Koukoutsi, 2015; Giannakoulis, 2016). In addition, owners can raise up to 100% of the asset's value through leasing which cannot be achieved through debt financing, and they also provide a liquidity instrument in depressed freight markets (Syriopoulos, 2007; Alexopoulos and Stratis, 2016). Furthermore, leasing agreements offer tax benefits to the lessor (Li, 2006). With leasing, the tax liability on capital allowance is deferred and, sometimes, it is possible to gain tax allowance in two different countries at the same time. Moreover, the leasing agreement can help the shipping company to preserve its working capital as they will not need to make any payments before delivering the ship. Finally, risks are reasonably shared among the parties involved in the leasing agreement; hence, reducing the risk exposure of the shipping companies (Li, 2006).

On the other hand, the risk of default with leasing is higher than with debt financing as the leverage levels are higher (Alexopoulos and Stratis, 2016). Moreover, the complex leasing structure described above exposes the leasing company to high risk when there are any changes to the rules

or regulations (Li, 2006). Furthermore, with operating lease agreements, the lessee has to record the lease payments as operating expenses which hurts the EBITDA of the company (Alexopoulos and Stratis, 2016). Another drawback of leasing a ship is that the lessee cannot make any modifications to the ship while in operation; thus, they have no control over the quality of the ship, in addition to the operating restrictions that might be imposed by the lessor (Li, 2006; Alexopoulos and Stratis, 2016).

3.4.5. Shipping Financing Practices

Due to the complex and sophisticated nature of the shipping market and the availability of different financing instruments, the financial practices of different companies differ greatly. Hence, in order to explore these practices around the world, a review of the most recent practices in the top maritime countries will be conducted.

3.4.5.1. China

China is one of the biggest shipping and shipbuilding countries, with the construction of 33.1% of the global number of newbuild ships over the period from 2007 to 2017 (Laurent and Cenk, 2019). During the past 20 years, China has been the major influencer in the entire maritime and shipping industry; hence, its role in the shipping financing sector is continuously becoming more and more important (Laurent and Cenk, 2019). Chinese lending and financing to the shipping industry have been on the upward trend since the financial crisis in 2008, reaching $20 billion in 2017, an increase of 33% over 2016 (Paris and Chiu, 2017). In addition, China continued to expand its financing power in the shipping industry by establishing a shipping leasing fund at the beginning of 2018 (Marantidou, 2018). Hence, when it comes to examining the shipping financing practices

in China, a differentiation between the practices of the Chinese shipping companies and the Chinese financial institutions has to be set.

When it comes to Chinese financial institutions, the most popular method of financing for the shipping industry is the financial leasing method (Paris and Chiu, 2017). Since 2013, Chinese leasing companies have accounted for orders of around 12.2 million GT through the operating lease model (Laurent and Cenk, 2019). Moreover, as of December 2017, China's three biggest leasing firms owned more than 800 vessels with a total value of $23.6 billion, and all these companies experienced exponential growth in their portfolios and valuation since 2009 (Paris and Chiu, 2017). Another form of financing that is also popular in China is the ECAs (Laurent and Cenk, 2019). China's biggest ECA, CEXIM, issued more than $15.1 billion in shipping loans during the two years of 2016 and 2017. This contributed to the country's building of 688 boats and offshore projects (Lloyd's List Intelligence, 2018).

3.4.5.2. Norway

Norway is one of the traditionally big shipping and shipbuilding markets in the world, with a long history in the industry (Laurent and Cenk, 2019). In this market, ECAs are one of the most popular methods of financing through the Export Credit Norway (Eksportkreditt Norge), which provides loans and the Norwegian Export Credit Agency (GIEK), which issues guarantees (Laurent and Cenk, 2019). Recently in 2018, a new shipping loan scheme was put into place under which Eksportkreditt Norge is permitted to finance Norwegian enterprises seeking to acquire ships built at Norwegian yards for use in international commerce and the offshore sector; This initiative is anticipated to result in an increase in the amount of funding granted by ECAs. (Laurent and Cenk, 2019). Moreover, in Norway, both the bank loans and corporate bonds are popular with shipping

companies as the issuance of the latter increased by 600% in 2017 over 2016 and, in the former category, DNB is the fourth largest shipping lender in the world (Laurent and Cenk, 2019).

3.4.5.3. The European Union and the United States

The two most common sources of financing in the EU are commercial banks and ECAs. Almost each of the EU's member countries has its own ECA entities that historically provided financing for the shipping industry, while the European banks are among the biggest in the world in terms of shipping financing; albeit, the amount of loans guaranteed to the shipping companies after the financial crisis fell considerably (Laurent and Cenk, 2019). Consequently, in an attempt to determine the financing practices of the Italian shipping companies, Laura Del Gaudio (2018) examined the balance sheets of 500 of these companies over the period between 2007 and 2015. According to the study of this data, bank loans are the most common type of funding for Italian businesses in both the short and medium-term. On the other hand, other kinds of financing, such as shareholders' loans, private equity, and corporate bonds, are not popular among Italian maritime businesses, as seen by their balance sheets. Meanwhile, in the United States, bank loans, corporate bonds, and IPOs are popular means of shipping finance (Laurent and Cenk, 2019). The US has the highest number of publicly traded shipping companies as this number reached 50 companies in 2017 as, during 2016 and 2017, the number of IPOs of the shipping companies saw significant growth (Laurent and Cenk, 2019).

3.5. Market Forecasting

A decision-making system is only as good as the quality of the forecasting that informs it. In response to cues from the pertaining supply and demand situation, all market players will need to make future business decisions; thus, accurate forecasting is essential to enhance the decision-making process. If the forecasting is inaccurate, the decision-making will be inefficient, at best.

Financial forecasters access a variety of methods to better inform their estimates (Siriram, 2016), through either qualitative or quantitative forecasting (Siriram, 2016).

3.5.1. Forecasting Method

The nature of prediction has been widely studied, yielding a variety of general recommendations about how accuracy can be improved. Wang *et al.* (2012) categorise two of the more eminent methods being statistical and soft computing techniques. Khashei and Bijari (2010), and Khan (1999), report that the use of artificial neural networks (ANNs) is a soft computing technique that has gained traction for its accuracy in forecasting models in a range of areas, including the financially-related fields of economics, finance and foreign exchange, together with engineering, business and social studies. Several specific characteristics of ANNs make them a technique of choice for industrial practitioners and researchers alike, namely that they are data-driven and self-adaptive and require limited prior assumptions to be made (Khashei and Bijari, 2010). Furthermore, they have proven to be reliable predictors of generalised observations based on the original data and can act as universal approximates that is capable of accurately approximating a continuous function. Last but not least, as Khashei and Bijari (2010) report, ANNs are very efficient in solving non-linear problems, especially those encountered in the real world, in stark contrast to many standard time-series prediction approaches. One such technique is ARIMA, which, as Zhang *et al.*, (1998) and Khashei *et al.*, (2009) state, presupposes that the series are formed by linear processes, and hence may be inapplicable to non-linear situations encountered in practice. Fullér (1995) and Khan (1999) propose that, as many applications are non-linear and concerned with unpredictable behaviour that is subject to change, there is a pressing need for a technique that will solve highly non-linear, time-variant problems such as stock markets. Research (Chen *et al.*, 2005; Jain and Kumar, 2007; Khashei and Bijari, 2010) suggests that ANNs have

been proved to generate competitive results to various traditional time-series models, such as ARIMA. Gutierrez *et al.,* (2008) recommend that ANNs can be usefully applied to demand forecasting, particularly to forecast lumpy demand. This study (Gutierrez *et al.,* 2008) We used the ANN approach to estimate irregular demand and compared its performance to that of three classic forecasting methods (single exponential smoothing; Croston's method; the Syntetos-Boylan approximation), finding that ANN significantly outperformed the more traditional comparators.

Artificial neural networks (ANNs) are now ubiquitous across a wide range of domains, including finance, medicine, engineering, chemistry, geology and physics. Furthermore, many studies have investigated the use of ANNs (Anderson and Rosenfeld, 1988; Eberhart and Dobbins, 1990; Nelson and Illingworth, 1991; Priddy and Keller, 2005; Yegnanarayana, 2009).

3.5.2. Oil Market Forecasting

Oil-producing countries are critically reliant on accurate oil market projections. Figure 3-6 below illustrates OPEC's Demand and Supply Balance for crude oil. The forecast based on this graph suggests that there is a strong likelihood that the demand for crude oil and associated products will increase from 2018. Thus, oil manufacturing and exporting countries will seek to satisfy the rising demand for crude oil and associated products by increasing the market supply. However, as the graph shows, the aim is to limit the supply to below the level of demand so that the crude oil price does not experience a fall. If the supply is allowed to exceed demand, oil prices would potentially plummet.

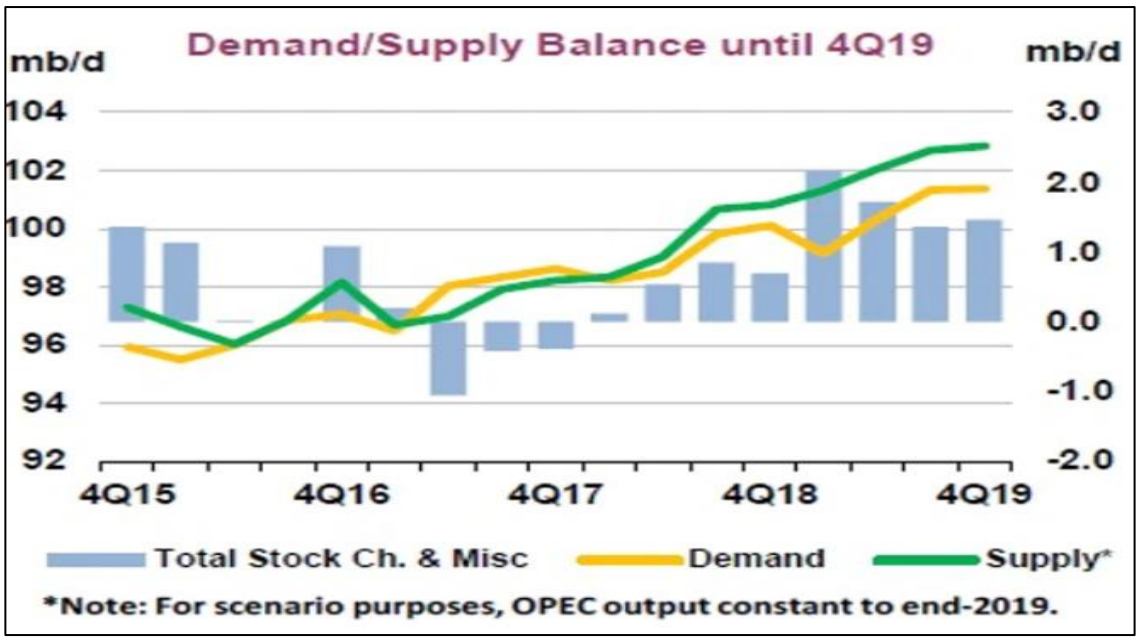

Figure 3-6 OPEC's Demand and Supply Balance for Crude Oil (IEA, 2019)

3.5.2.1. Factors Affecting Oil Market Forecasting

Numerous research studies have been conducted to examine the plethora of elements that impact the industry pf market forecasting in respect of crude oil and associated products. In particular, one study focused on examining the factors responsible for forecasting oil prices, the outcome of which proposed that the forces of supply and demand are the major factors that exert influence on the oil prices and the market as a whole. From the perspective of oil-producing and exporting countries, ship owners and financial institutions, it is critical to be able to rely on accurate and precise forecasts for supply and demand in the oil market so that necessary business adjustments can be made. The study found that forecasting oil prices is largely dependent on two discrete factors, categorised as fundamental and non-fundamental. Fundamental factors are those specifically associated with the oil industry, its innate problems and the supply and demand of oil and its related products, all of which influence the forecasting of the oil market's projected performance over a given period. By contrast, non-fundamental factors are mainly external to the

oil-producing industry but nevertheless are significant in the influence they wield over the oil market and the performance of oil prices.

A further strong influence on forecasting the performance of oil prices and the oil market in general concerns the determination of whether or not oil-producing and exporting countries continue to hold the capability and capacity for the storage of oil and its related products, which in turn significantly influences oil prices in the market. Cunningham (2017) points out that oil-producing and exporting countries must maintain a delicate balancing act in producing sufficient oil to satisfy the aggregate demands of the international market without creating a surplus, which would drive oil prices down and have a significant negative effect on the country's income and economic stability.

However, the main factors which affect forecasting the oil price are: Oil supply and demand, economic crisis, geopolitical event, the strength of the US dollar and the world GDP.

3.6. Decision Making

There is an obvious inter-relationship between three major shipping investment decisions (see Figure 3-7) (Bulut *et al.*, 2013), the first of which relates to the entry-exit decision as part of the business cycle. For the shipping industry, the decision about when to enter or exit the market is critical in terms of ship allocation and the optimum timing of investment acquisition. As Bulut, Duru and Yoshida (2013) confirm, a number of indicators characterise the investment climate in the shipping industry. Furthermore, the optimised market entry makes a significant positive contribution to the aggregate financial performance of a shipping asset, according to the researchers (ibid).

The second significant shipping investment option is whether to acquire a new vessel, a used vessel, or to rent an existing vessel for a certain duration. Given the continued growth of the global

economy, shipping capacity remains an important means of global transportation. In determining the ship's characteristics, investors need to consider the optimum size of the ship, a critical decision that has concomitant effects on the number of employees and profit margins. In reality, however, as Duru, Bulut and Yoshida (2012) explain, ship charterers are usually large-scale maritime industry players, or those acting as their intermediaries (e.g. brokers), and investors in the maritime industry usually prefer to buy a new-build vessel or purchase an existing ship through the S & P market.

A major shipping investment decision facing owners concerns the most appropriate method of ship management. The owner can either self-manage the fleet or outsource the ship's management to a third party. Where an investor is experienced in the shipping business, he may prefer to manage the fleet through senior managers already employed by his company, thus retaining control in-house. However, if he is an entrepreneur, outsourcing the ship management to an external company may be the preferred option. Bulut *et al.*, (2012) suggest that either option is feasible, depending on the size of the fleet and the investor's experience and expertise in the shipping industry.

Asset management ranks highly in the necessary processes to be addressed in the management of shipping. As Bulut *et al.*, (2012) states, a ship/vessel is a valuable asset, and asset management refers to the long-term planning that must be put in place in order to maximise profits and ensure the continued growth of the company. One of the management's critical shipping investment decisions concerns market entry - effectively the sale and purchase of vessels - in order to minimise financial losses and maximise potential profit. Ship management also encompasses the process that occurs between the sale and purchase of a vessel with the aim of maximising long term competitiveness in the maritime service industry. The decision on the optimum time to switch markets (market switching decision) between period and spot markets is a critical aspect since it

is also associated with risks (employment; opportunity) and potential loss of business reputation. Research into ship management has revealed a particularly complex business environment for which the current lack of appropriate data poses a significant problem.

Thus, the most critical aspect of the shipping industry focuses on the timing of the investment decisions and the rationale applied to the decision-making process.

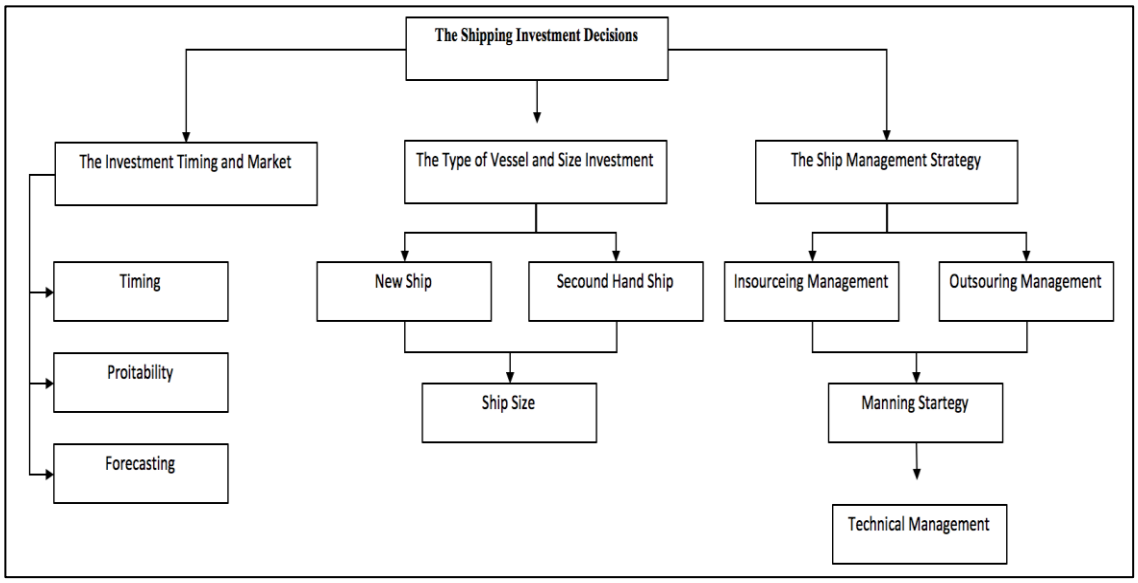

Figure 3-7 Critical Aspect of the Shipping Industry Focus (Bulut *et al.*, 2013).

3.6.1. Factors Affecting Decision Making

The way in which people make decisions and the influences that impact on them has been the subject of much research. In terms of the shipping industry, decisions makers must take a number of complex factors into account, including the factors whish been discussed in the literature review such as the oil market, the oil price, the shipping market, and supply and demand, etc. The influence of these factors impinges on the final decision and variation in any factor will result in a different outcome. Orasanu and Connolly (1993) discuss how resolutions are formed, describing them as intentionally activated decisions that are decided by a certain combination of

circumstances that result in the making of a given choice. Thus, all investors will inhabit an individual set of circumstances, including their socio-economic and cultural backgrounds, demographic factors, level of education, gender and age and ethnicity. As the relevance and variability of these factors are individual for each person, uniformity in decision-making is not possible. The key factors that exert influence on the decision-making process of investors comprise both internal and external factors. Internal factors comprise psychological and demographic influences, and exogenous (external) factors include social, cultural, political, environmental and ethical characteristics. Thus, there is a whole range of factors that collectively impact investors' decision-making process (see Figure 3-8) (composed by the author from different sources).

A number of empirical studies have demonstrated that the behaviour of investors is influenced and impacted by these factors. Numerous studies have demonstrated that cognitive and emotional influences, overconfidence, self-attribution, representativeness, herding, anchoring, cognitive dissonance, regret aversion, gambler's fallacy, mental accounting, hindsight bias, greed, and fear all influence investors' decision-making processes (Barberis and Thaler, 2003; Sharma, 2006; Walter and Moritz Weber, 2006; Hira, Loibl and Schenk, 2007; Nofsinger, 2007; Grinblatt, Keloharju and Ikäheimo, 2008; Biais and Weber, 2009; Kiyilar and Acar, 2009; Shive, 2010; Aregbeyen and Mbadiugha, 2011). Furthermore, other studies have indicated that factors such as age, education, economic level, family size, and gender all influence the decision-making process (Beugelsdijk and Frijns, 2010; Kourtidis *et al.*, 2011; Ozorio *et al.*, 2013; Lee and Selart, 2014).

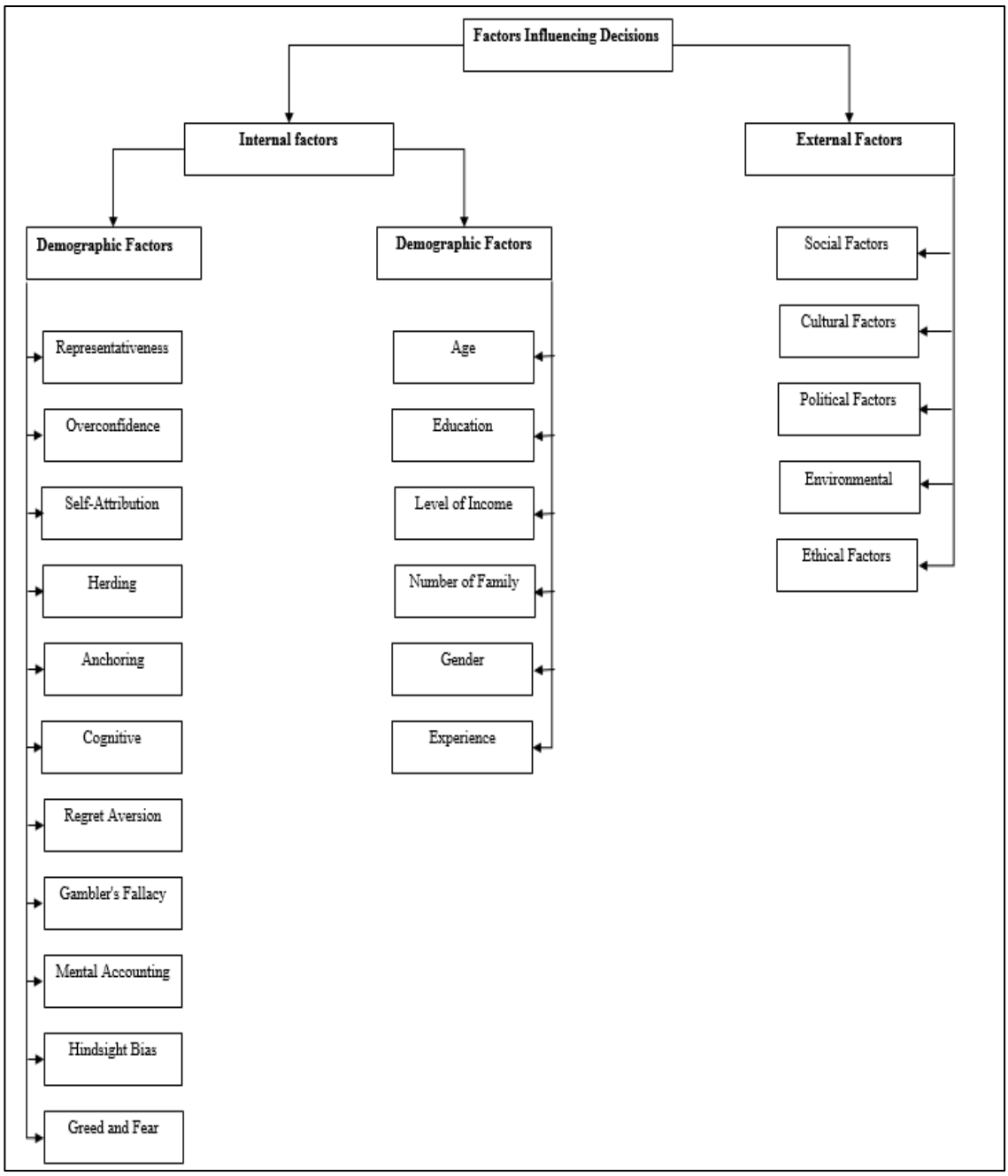

Figure 3-8 Factors Impact Investment Behaviour (composed by the author from different sources)

3.6.2. Decision Criteria for Investing in New Vessels

In order to be able to reach the most beneficial decision regarding the investment in new vessels, shipowners will need to assess and compare these two decisions against each other using the most relevant and important decision criteria. Consequently, a number of research studies attempted to identify these criteria and group them into different categories.

One of the first attempts in the literature to model the different criteria that can influence the shipowners' decision to replace their old vessels with new ones is the model developed by Miyashita in 1982. In this study, the researcher studied the factors that impact the investment decision in the bulk carrier industry through theoretical development. Consequently, the researcher was able to extract the seven most influential factors in the shipowners' investment decision; these factors are:

1) the service sales volume per unit of transport capacity.

2) growth rate of service sales volume.

3) average size of ships.

4) freight rate / new building ship price ratio.

5) interest rate of shipbuilding.

6) broken-up ship volume/total existing ship volume ratio.

7) volume of old ships suitable for scrap/total existing ship volume ratio.

Through the assessment of these factors, the researcher argued that shipowners would be able to decide whether it is the right time for them to replace their old ships with newer ones or not.

Another attempt to define the criteria that the shipowners should consider when faced with the decision to expand the capacity of their fleets and invest in new vessels was made by Berg Andreassen (1990). In this study, the researcher argued that the demand for the capacity, the

supply, and the forecasted profits are the three main criteria that should be examined by the non-liner shipowners when deciding whether or not to expand their fleets. In addition, it was shown that the assessment of these criteria and the corresponding decisions could vary according to the shipowners' behaviour towards risk and the shipping market conditions. Moreover, Marlow (1991) identified six criteria from the literature of both shipping and economics, by which the investment decision in the shipping industry should be evaluated. The first of these criteria is the current levels of ship capacity utilization which is basically the difference between demand and supply, the second criterion is the total size of the world fleet measured in terms of deadweight. Moreover, the third criterion suggested by Marlow (1991) is the change in the volume of global trade, while the fourth criterion is the presence of any governmental investment incentive packages and the fifth one is the current credit arrangements that the shipowner have in place. Lastly, the sixth criterion is the future market expectations in terms of both risk and returns. Another study on the main criteria affecting the investment decision in the shipping industry that was conducted in the late 1990s is the one by Revenko and Lapkina (1997). The researchers argued that the main criteria that govern the investment decision in the shipping industry, whether it is a newbuild or second-hand ship, should include:

1) the technical and operating state of the ship.

2) the value of the ship.

3) the age and the expected useful life of the ship.

4) the current operating costs of similar types of ships.

5) the availability of financing, whether it's self-financing or credit facilities.

6) the forecasted operating income of the new ship for a specific period of time.

7) the forecasted cost of a similar type of ship in the coming few years.

Merikas *et al.*, (2008) identified the criteria that will help shipowners to decide whether to buy a newbuild tanker or a second-hand one. The researchers argued that, ultimately, the price of the second-hand tanker relative to that of the newbuild would be the decisive factor; however, they argued that there are a number of criteria that impact this ratio.

Through a study of the relevant literature, the researchers reached the conclusion that there are six main criteria that impact the ratio between the second-hand tanker' price and the price of the newbuild; these criteria are:

1) The average time charter rate for one year contract.

2) Number of completed transactions in the sale and purchase market.

3) Cost per gross tonnage.

4) Volatility of the freight rate.

5) Price of crude oil.

6) Libor.

In addition, Rousos and Lee (2012) identified eight different criteria that are important for the shipowners to evaluate before deciding which type of vessel will they invest in. However, before defining these criteria, the researchers identified three main categories under which the important criteria will fall which are: financial, risk, and special preferences categories. Consequently, in order to evaluate the financial category of each vessel type, the decision-makers need to evaluate three main criteria; namely: NPV, IRR, and the small capital needs. Similarly, for the risk category, the freight rate stability and the second-hand price stability are the two main criteria that need to be evaluated in order to assess the risks associated with each vessel type. Lastly, in order to evaluate the special preference category, the shipowner needs to assess the environmental impacts of each vessel type, as well as, the degree of third party involvement and the level of sector experience.

Furthermore, Xu and Yip (2012) used panel data analysis to determine the variables that have the most important role in formulating the ship investment decision. In this research, to analyse the relationships, eight distinct hypotheses were established between eight different variables and the ship investment decision regardless of the type of the ship; these variables are: fleet size, existing orderbook, international trade volume, freight rate, newbuilding ship price, second-hand ship price, FDI in transportation, and share of transport service in total export services. Furthermore, these hypotheses were tested using nine different econometric models. Through these models, it was concluded that fleet size and existing orderbook are negatively related to the investment decision; international trade volume, freight rate, and share of transport service in total export services are positively related to the shipping investment decision; while newbuilding ship price, second-hand ship price, and FDI in transportation have no statistically significant impacts on the shipping investment decision. In conclusion, according to this study, shipowners should decide to invest in new ships when there is a large volume of international trade, the freight rates are high, there is a high share of transport service in total export services, the fleet size is small, and the existing orderbook is not large.

Bulut *et al.*, (2013) determined five main variables that are significant to the dry cargo shipping investment decision. However, the method used in this research was different from the previous studies explored in this review. First, the researchers modelled the shipping investment decision as the decision to enter the market through buying newbuild or second-hand ships. Second, to determine the most significant variables, the researchers argued that in order to enter any new market, investors assume that this entrance will be profitable for them; hence, the researchers modelled this decision as the value of ROE realized from entering the shipping market. Consequently, through statistical analysis, it was found that the price of the newbuild ship is the most important criterion in deciding whether to invest in the shipping industry or not. Moreover,

four other variables were also found to have an impact on this decision, albeit to a lesser extent; these variables are the current time charter rate, the second-hand ships' prices, the existing volume of the orderbook, and the current contracting volume.

More recently, Rau and Spinler (2016) introduced the competition in the shipping industry as a variable that affects the investment decision in the container shipping market, in addition to the traditional factors that were previously determined in the literature, such as: fuel-efficiency, lead time, and cost. The researchers modelled this new variable using the number of players in the market and also included the intensity of the competition, which was depicted as the volatility in the fleets' utilization. In addition, Clintworth *et al.*, (2017) identified financial and non-financial criteria that are most important when evaluating a shipping investment decision i.e. the decision to expand the fleet. Through the output from a questionnaire that was sent to a select group of senior engineers and economists with expertise valuing shipping projects, the researchers were able to identify eight different criteria, four financial and four non-financial, to assess the success of the decision to expand the fleet. Regarding the first category of criteria, the project's NPV, IRR, Economic Rate of Return (ERR), and its cost are the four criteria used; while regarding the non-financial category, the four criteria that were used were: employment (including temporary and full-time employment opportunities created), environment (including climate change considerations), technological fit, and priority eligibility.

Moreover, Park *et al.*, (2018) attempted to identify the important decision criteria that will enable shipowners to reach the right decision regarding the acquisition of a second-hand ship, regardless of the type of vessel. The researchers conducted interviews with the shipping company managers and reviewed the relevant literature and came up with 12 criteria (as shown in Table 3-7) grouped under three main categories; which are: business criteria, market environment criteria, and policy criteria.

Table 3-7 Criteria for the Decision to Acquire Second-hand Ships

	Business Criteria	**Market Environment Criteria**	**Policy Criteria**
1	Financial status and funding	International situation changes	Shipping tax benefit
2	Strengthening market Influence	Fleet and throughput fluctuations	Investment assistance to policy-oriented financial institutions
3	Ship types and size	Market fluctuations	Domestic and international ship rules changes
4	Old-age ship replacement fleet management	Changes in the price of oil and freight rates	Ship registry

Another type of decision that might influence the investment decisions of the shipowners is the decision of whether to demolish the ships that they currently own as if they decided to go ahead and demolish the ships they own, and they can raise capital to make new investments (Park *et al.*, 2018). Consequently, Knapp, Kumar and Remijn (2008) tried to identify the main criteria that will influence the shipowners in their decisions to scrap their old ships, regardless of the type of ship. Through the use of historical data, of 51,112 ships over 100 GT and 748,621 scrapping events over a period of 29 years, and statistical analysis, it was found that the ships' age and tonnage, and the current scrap prices are the main criteria that are positively related to the decision to scrap the ships i.e. when any of these variables increase, the owner's preference should be to scrap the ship. On the other hand, the only variable that will favour the decision to keep the ship operational is its earnings i.e. if its earnings are high, then the owner should not scrap the ship. The following section discusses the impact of COVID-2019 as an unexpected trigger for economic crises and global heath and its impact.

3.6.2.1. The Impact of COVID-19 on Shipping

The pandemic of Covid-19 had a significant influence on maritime transport and shipping. As the need for shipping and goods transport are derived demands, in that they are governed by economic direction and international trade, the pandemic has had a considerable effect on them. In essence, the reduction in both production and consumption of many sectors has reduced the need for goods to be transported, with the oil shipping sector feeling this impact in particular. The closure of borders and the imposition of severe travel restrictions on March 19, 2020 (IMO; Van Tatenhove, 2021) was enacted around the world as a means of tackling viral spread. The effects of this were felt both because ships could no longer dock in many ports and because since many value chains reduced their output in response, there was little need for maritime transport services, which further reduced shipping demand, port traffic, and turnover (UNESCAP, 2020). The shipping industry has thus had to take unexpected actions as a means of ensuring that businesses remain afloat through the duration of the pandemic (Van Tatenhove, 2021). Over the year 2020, EU ports reported a reduced number in ship calls in its territories, and despite UNCTAD's prediction of a 4.8% growth in marine trade in the coming year, the sector must still adapt to these novel circumstances arising from the pandemic itself, with certain steps, such as reducing the number of ship calls, or cancelling them altogether, already having been taken.

3.6.3. Decision-Making Method

The importance of timely and accurate predictions that can determine future trends (hypothetical future conditions) from a complex stream of variable information is paramount for modern organisations operating in today's global economy and consequently comes at a high cost. According to Grover (2012), strategic leaders must be ready to respond to unforeseen events and circumstances in order to make well informed decisions based on information that is near real-

time, taking into consideration the interaction and inter-dependency of much of the information that affects all aspects of the business's operation. Moreover, after determining the most influential criteria that can impact the investment decisions in the shipping industry, the tools that were developed to assist in reaching this decision should be explored.

Decision-making support techniques have been the subject of much research. Examples of these techniques are Bayesian networks, AHP method, and other techniques that were based on econometric models.

3.6.3.1. Bayesian Networks

Regarding the first type of technique that was used to assist in decision-making and one of the most used probabilistic or statistical methods are Bayesian Networks, first developed in the 1970s at Stanford University (McCabe *et al.*, 1998). They are sometimes referred to by the following terms: Bayesian Belief Networks; Belief Networks; Causal Probabilistic Networks; Causal Nets; Graphical Probability Networks; and Probabilistic Cause-Effect models. According to Neapolitan (1990), Bayesian networks (or similar collective terms) are an emerging modelling approach based on artificial intelligence and probabilistic reasoning that is proving useful to ameliorate problems that are complex or based on uncertainties by providing a supportive decision-making framework. The initiator of the concept of Bayesian Networks (Pearl, published in 1988) has since been followed by other authors, including Neapolitan (1990); Jensen (1996) and Castillo *et al.*, (1997), respectively. In many fields, such as industry, medicine and finance, there is little choice but to make decisions without complete and/or reliable information to hand. The advantage of Bayesian networks is their ability to deal with uncertainty based on a theoretical framework that utilises probability calculus and an underlying graphical structure. They have proved useful in many disciplines, including finance and medical diagnosis (Bielza *et al.*, 1999; Holmes and Jain, 2008)

and particularly in the context of decision-making, such as venture capital financing (Kemmerer *et al.*, 2001), auditing (Gillett and Srivastava, 2000) and software design (Horvitz *et al.*, 1998).

3.6.3.2. AHP Method

Regarding the second type of technique that was used to support the decision-making process that is the AHP method, Celik *et al.*, (2009) attempted to develop a tool to assist in the oil tanker investment decision; specifically speaking, Suezmax, Aframax and VLCCs. This model is based on the Quality Function Deployment (QFD) principles, which originated in the heavy industry field and solved via the Fuzzy Analytic Hierarchy Process (FAHP) and Fuzzy Axiomatic Design (FAD) algorithms. The unique perspective of QFD is that it incorporates customer satisfaction in investment planning, and this idea was previously adopted in other industries (Celik *et al.*, 2009). In addition, Rousos and Lee (2012) developed an AHP model based on pairwise comparisons for owners to determine which type of vessel to buy. The researchers compared the alternatives against each other using the criteria mentioned in the previous section. However, due to the differences in the nature of each criterion, three different comparisons' categories were used, namely: model input comparisons, quantitative comparisons, and qualitative comparisons. For the model input comparisons, four different inputs are compared together, namely: NPV, IRR, capital needs, and experiences. Three of these inputs should be maximized, while the capital needs should be minimized for each alternative. The second level of comparisons is the quantitative comparison between the freight rates and the second-hand prices of the different alternatives. For these comparisons, the researchers used quantifiable comparisons that have been previously used in the literature. Finally, regarding the qualitative comparisons, this was done for two criteria, degree of third-party involvement and the environmental impact, which were assessed a priori.

The second study that adopted the AHP method is the one conducted by Clintworth *et al.*, (2017). In this study, the researchers used both the fuzzy AHP and cost-benefit analysis tools to arrive at the right decision regarding the investment in the shipping industry. This tool provides a cost-benefit analysis output from the criteria entered into the fuzzy AHP hierarchy. The fuzzy AHP has the ability to classify values that are subjective; hence, the researchers used fuzzy triangular numbers defined by three real numbers and expert opinions to derive the criteria preference vector. Using the following matrix (3.1).

$$\widetilde{A^k} = \begin{bmatrix} \widetilde{d_{11}^k} & \cdots & \widetilde{d_{1n}^k} \\ \widetilde{d_{21}^k} & \cdots & \widetilde{d_{2n}^k} \\ \widetilde{d_{n1}^k} & \cdots & \widetilde{d_{nn}^k} \end{bmatrix} \tag{3.1}$$

where, $\widetilde{d_{12}^k}$ Represents the first decision maker's preference of the first criterion over the second criterion.

The third and last study that adopted the AHP method was the one by Park *et al.*, (2018). This study also adopted the fuzzy AHP method to determine the relative weights of each criterion through the calculation of the best non-fuzzy performance (BNP) value and consequently, the criteria with the larger BNP value are the ones that have a greater effect than the other criteria. Finally, the fuzzy comparison matrix for each major criteria is calculated and the fuzzy weighted evaluation matrix is obtained equation (3.2).

$$BNP\ value = \frac{[(u-l) + (m-l)]}{3} + l \tag{3.2}$$

where m, l & u are the dimensions of the fuzzy number.

3.6.3.3. Derivation of Econometric Models

Besides AHP and Bayesian network that were used to assist in decision-making, the majority of the investment decision making tools for the shipping industry that was found in the literature were based on the derivation of econometric models using a number of different techniques. For example, Balliauw (2017) used a real option model that involves a discrete-time Markov process to help in reaching the right decision regarding buying and selling a container ship for shipowners who charter out their ships. The model has two unknown variables that will trigger the buying and selling decision, which are: the minimum threshold of the profit for a certain period that is required to enter the market and the exit threshold, while the market characteristics, the cost of entrance, and the recovery cost in the case of selling are known. Moreover, another model that was developed to derive the shipping investment decision is the one developed by Dikos and Thomakos (2012). Similar to the above model, this model also utilized the real option hypothesis with aggregate data. The researchers developed two different models; the first is an ordered heterogeneity model in which the investment data is discrete, and the second is a Poisson heterogeneity model. These models were applied to a tanker ship.

One of the earliest shipping investment decision tools that was based on econometric models was the one developed by Goss in 1987. In this study, separate modules were developed that can be combined in a number of different ways to assess the decision to invest in a new build ship under different macroeconomic conditions. In total, three modules were developed which are: 1) a module that depicts the relationship between capital cost, net cash flow, internal rate of return and the ship's economic life; 2) a module that shows the impacts of shipbuilding loans on the investment decision in different circumstances, and when inflation was or was not included; and 3) a module that shows the effects of some tax regimes; such as: tax allowances given for depreciation of the asset and for the interest payments on the shipbuilding loans.

Following this early model, Berg Andreassen (1990) developed a stochastic model for the investment decision that accounts for the risk preference of the shipowner. This econometric model was developed based on the assumptions that the shipowners will want to maximize their profits and that reaching equilibrium is the target of every shipowner. This model was verified against Zannetos's investment hypothesis and proved its robustness and accuracy. In 1997 Revenko and Lapkina developed a model to analyse the different investment alternatives available for the shipowner when deciding to buy a new ship. This model is based on calculating the future resale value of each alternative which depends on the NPV of the income generated from each alternative, the time charter rate, the fixed cost rate, and the expected rate of growth.

In addition, Merikas *et al.*, (2008) developed a model to calculate the relative ratio of the price of the second-hand ship and the newbuild, and the movement of this ratio, after determining the most critical factors that impact these prices.

Moreover, (Pires *et al.*, (2012) used Monte Carlo simulation of auto-correlated series of time-charter rates and prices of newbuild and second-hand ships to model the investment decision in Suezmax tanker ship. A unique dimension was incorporated in this model, which is the possibility of project abandonment by the ship-owners. Through this model, it is found that the value of the investment is extremely sensitive to the ship-owners' flexibility regarding the possibility of abandonment. Another attempt to develop a model that can assist ship-owners in their investment decision is the model developed by Bulut *et al.*, (2013). As explained previously, this model was based on predicting the ROE of the different investment alternatives; therefore, the researchers calculated this value based on its relationship with the decision criteria.

Another important model to assist in the shipping investment decision is the one developed by Rau and Spinler (2016). This model was developed for the container carriers based on the real

option hypothesis while taking into consideration the endogenous price function and price formation in the second-hand vessel market and the target of a fuel-efficient investment. In this study, two types of models were developed; continuous-time model and discrete-time model. In the former model, infinitely divisible output and endogenous price function were assumed; while for the latter model, constant values were assumed for the different parameters and the model was solved using Dynamic Programming.

Another stream of models that approached the investment decision in the shipping industry from another perspective started to develop since the second half of the 2000s. These models were concerned with developing models that will help shipowners in determining the optimal time to invest in new ships, rather than whether to invest or not. The first of these models was developed by Alizadeh and Nomikos (2007). In this study, the researchers demonstrated that pricing and profits have a long-run cointegrating connection through the use of the capital gain theory. Then, the researchers used this relationship as an indicator of investment or divestment timing decisions for three different sizes of dry bulk vessels; namely: Handymax, Panamax, and capsize, through conducting unit root tests. Furthermore, Gkochari (2015) was another example of these types of models in the dry bulk capesize sector. In her study, to achieve this objective, the researcher used a dataset of the capsize market development from 2000 to 2013 and developed a stochastic dynamic equilibrium model. The model was based on the real options theory approach to irresistible investment opportunity under uncertainty in a perfectly-competitive market. When applying the model, it was able to correctly identify the first trigger between 2003 and 2004 when capsize earnings increased sharply.

Finally, the latest model that was reviewed in this study was the one developed by Kyriakou *et al.*, (2017). Again, the real option approach was used, and the model was calibrated using the Baltic Option Assessments and its robustness was checked using the weekly mean absolute percentage

error and the root mean square percentage error. Most recently, Feng *et al.,* (2019) attempted to model the investment decision of oil tankers from the perspective of the total costs associated with this decision. In this study, a unique cost category was included in the model, which was the maintenance cost of oil spill; in addition to the tanker freight demand. Since the oil spill cost is treated as a risk, the researchers used the real option theory as it has the capability of solving problems including risks and uncertainty.

3.7. Key Findings from The Literature Review

Key findings from the critical review performed in chapter 3 can be listed below:

1- There has been an increase in the price of new tanker construction and a growth in the global tanker fleet.
2- The oil markets are full of volatility and shock events, and oil prices became the main focus of the global economy.
3- The oil price, which is affected by the oil demand and supply, is the main driver for the tanker market as the demand for tankers is related to the demand for oil (the freight rate and oil price have an inverse relationship).
4- The presence of high-value, sophisticated, and capital-intensive assets is one of the significant features in the shipping market.
5- The oil price and the freight rate are negatively proportionate.
6- The demand for tankers is related to the demand for oil (the freight rate and the oil price has an Inverse relationship)
7- The most critical aspect of the shipping industry focuses on the timing of the investment decisions, and the rationale applied to the decision-making process.
8- Factors affecting the investment decision making (see Table 3-8).

9- Factors affecting the forecasting of oil prices (see Table 3-9).

Table 3-8 Factors Affecting the Investment Decision Making

Freight rate	Company leverages	Source of finance	Ship Second-hand prices	Cost of operation
New build order book	Geopolitical	Market competition	Bunker prices	Currency exchange price
Secured cargo	Company profit	Number of current fleets	Oil market	Trip destination
Time of order	Oil price	Age of current fleet	Crude oil production	Global economy
Type of ship (new / second hand)	New build price	Demand for oil transportation	Fleet productivity	Shipping market
Company capital	Economic crisis	Shop scrap prices	Seaborne trade	

Table 3-9 Factors Affecting the Forecasting of Oil Prices

Oil supply	Oil demand	Economic crisis	Geopolitical event
strength of the US dollar	world GDP	The oil price history	

3.8. Gaps in the Investment Decision Making in the Oil Shipping Companies

It is globally recognised that there are considerable uncertainty, risk and challenges within the shipping sector. The purchasing of new vessels requires extended focus, comprehension, and perception if most appropriate choices are to be made in the shortest period due, since the rapidly changing nature of the sector and the challenges within the sector ensures that any such choice comes with high risk (Lun *et al.*, 2010).

Consideration of previously published materials reveals general consensus that any such investment decision is reliant on a number of factors and variables. Similarly, ship investment decision is based on crucial factors that influence the investment decision-making when buying a ship. Yet, there is a lack of studies targeting the factors affecting investment decision-making when buying a ship. Henceforth, this research aims to explore the factors affecting investment decision–making when buying a ship as an attempt to comprehend and determine the means by which this market operates to be able to better guide investors in their decision-making processes (Lun *et al.*, 2010).

Another highlight of the literature review was the revelation that models for decision-making need for board or committee approval that means that decisions are slowed down. Therefore, the focus of this thesis is to have a thorough knowledge of how the shipping industry and its components operate, and exploring the factors affecting investment decision-making when buying a ship and their degree of importance and the interrelationship between factors as an attempt to develop a technique to ease and make better decision support system for shipping investors on the investment decision making for the oil shipping companies in order to invest in a new ship (see Figure 3-9).

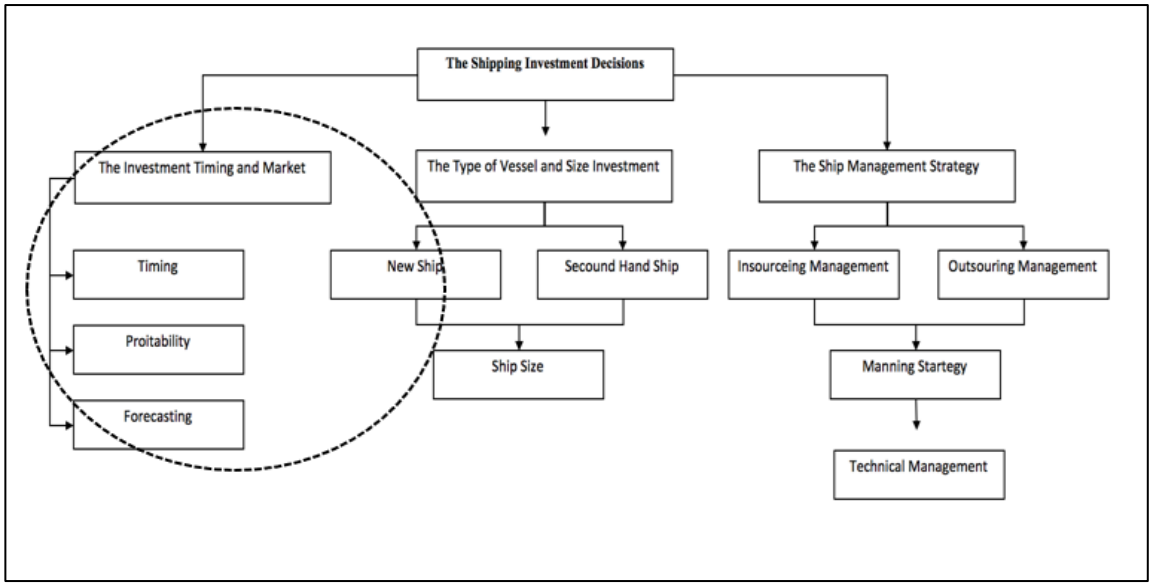

Figure 3-9 Focus of the Research

3.9. Conclusion

This chapter explored and presented the relevant literature as an attempt to introduce a solid background for the research, the gap of this research, and to reach the research objectives. The review covers many areas related to the oil market, shipping market, shipping finance, oil price forecasting and decision-making. It started with a description of oil markets, its history, and the factors impacting the oil market, oil transportation and tanker, including the factors affecting the tanker industry. Then a comprehensive description of the shipping market and its development, cycle, and types. This is followed by a section exploring oil price forecasting methods and the factors impacting forecasting. After that, the next section aimed to review shipping financing along with the main sources of finance. The following section in this chapter investigated the new investment decision, the criteria used in reaching this decision, and different tools assisting in reaching the decision. Then, the last sections aimed to recap the key findings in the study and states the gaps in the field.

4. Research Methodology

4.1. Introduction

The goal of this chapter is to provide and justify the study design, methodology, and an example of the data collection and analytic methods used in this research. This chapter will also provide details of the followed procedures to obtain the approval to collect the data for this research, as well as providing some details and justifications for selecting the participant's sample.

In brief, Figure 4-1provide a summary of the process of this research with the aim of developing decision-making methodology for investment in newbuild large oil tanker. This research begins by exploring the related literature with the aim of identifying the factors affecting investment decision making and collecting the market historical data related to shipping industry. The identified factors were used in the preparation of the interviews that led to the identification of more factors. The identified factors from the literature and the interviews went through different stages of evaluation in order to finalize the list of the factors affecting investment decision making that was used in preparation for the third questionnaire in this study where the importance of factors and the interrelationship among them where determent through DEMATEL and then identified the most important factors which was then used in the case study. In addition, some financial data were also collected through the interviews which were used later on in the case study. Moreover, the collected historical data from the literature used to forecast oil price thorough and predict the future oil price. Lastly, the identified crucial factor, market historical data, and financial data form the Shipping were all used in the case study in order to create an equation to assist making investment decision.

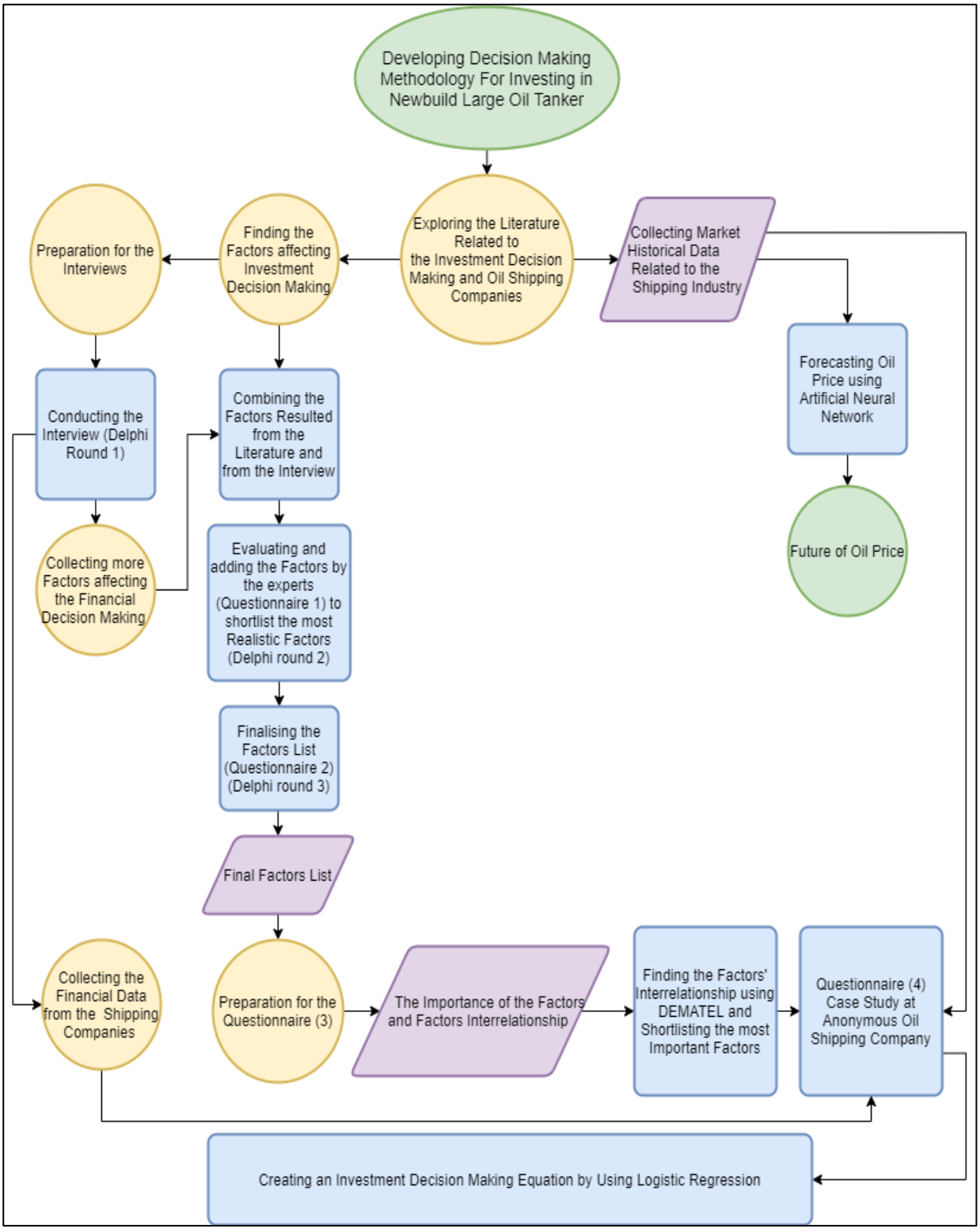

Figure 4-1 Research Methodologies

4.2. Research Approach

All-Academic studies are guided by schools of thought that determine the approach taken, including, philosophy, strategy, and data collection (Creswell, 2009). Any researcher must first determine and justify their preferred research paradigm that will provide the foundation for their study since in turn, this will reveal the extent of the methodologies available for them to use (Easterby-Smith, Thorpe and Jackson, 2015; Gibson and Brown, 2009).

Wahyuni (2012) defines a research paradigm as a series of basic suppositions or creeds that explain to the hold how reality functions and upon which they place their overall perception of the world around them, which in turn determines how they choose to explore a given topic. The key schools of thought in this regard are known as positivism, Critical realism, interpretivism, Postmodernism, and pragmatism (Table 4-1) (Saunders, Lewis and Thornhill, 2019; p. 144). Each of these paradigms is tri-dimensions, containing within each one, an ontology, which reflects the observer's stance on existence, epistemology, which is their perspective of the nature of satisfactory understanding, and axiology—their opinions of research morals and ethics (Saunders, Lewis and Thornhill, 2012; 2019; Easterby-Smith, Thorpe and Jackson, 2015). In this work, the position of pragmatism is taken since it allows for the concurrent interpretation of the observed phenomena, which is felt both to be most in line with the investigator's philosophy, and also to provide the most thorough interpretation of the results presented (Saunders, Lewis and Thornhill, 2012; 2019).

Table 4-1 Comparison between the four research philosophies Adapted from (Saunders, Lewis and Thornhill, 2019; p.144)

Research Philosophy	**Ontology:** nature of reality or being	**Epistemology:** what constitutes acceptable knowledge	**Axiology:** role of values	**Data collection techniques most often used**
Positivism	Real, external, independent One true reality (universalism) Granular (things) Ordered	Scientific method Observable and measurable facts. Law-like generalisations Numbers. Causal explanation and prediction as a contribution	Value-free research Researcher is detached, neutral and independent of what is researched. Researcher maintains an objective stance	Typically deductive, highly structured, large samples, measurement, typically quantitative methods of analysis, but a range of data can be analysed
Critical Realism	Stratified/layered (the empirical, the actual and the real). External, independent Intransient. Objective structures Causal mechanisms	Epistemological relativism Knowledge historically situated and transient Facts are social constructions Historical causal explanation as a contribution	Value-laden research Researcher acknowledges bias by world views, cultural experience and upbringing Researcher tries to minimise bias and errors Researcher is as objective as possible	Retroductive, in-depth historically situated analysis of pre-existing structures and emerging agency. Range of methods and data types to fit the subject matter
Interpretivist	Complex, rich. Socially constructed through culture and language. Multiple meanings, interpretations, realities Flux of processes, experiences, practices	Theories and concepts too simplistic. Focus on narratives, stories, perceptions and interpretations. New understandings and worldviews as a contribution	Value-bound research Researchers are part of what is researched, subjective Researcher interpretations key to contribution Researcher reflexive	Typically inductive. Small samples, in-depth investigations, qualitative methods of analysis, but a range of data can be interpreted

Postmodernism	Nominal. Complex, rich. Socially constructed through power relations, Some meanings, interpretations, realities are dominated and silenced by others. Flux of processes, experiences, practices	What counts as 'truth' and 'knowledge' is decided by dominant ideologies. Focus on absences, silences and oppressed/ repressed meanings, interpretations and voices Exposure of power relations and challenge of dominant views as a contribution	Value-constituted research. Researcher and research embedded in power relations. Some research narratives are repressed and silenced at the expense of others Researcher radically reflexive	Typically deconstructive – reading texts and realities against themselves In-depth investigations of anomalies, silences and absences. Range of data types, typically qualitative methods of analysis
Pragmatism	Complex, rich, external 'Reality' is the practical consequences of ideas Flux of processes, experiences and practices	The Practical meaning of knowledge in specific contexts. 'True' theories and knowledge are those that enable successful action Focus on problems, practices and relevance Problem solving and informed future practice as a contribution	Value-driven research. Research initiated and sustained by researcher's doubts and beliefs Researcher reflexive	Following research problem and research question. Range of methods: mixed, multiple, qualitative, quantitative, action research. Emphasis on practical solutions and outcomes

4.3. Research Design

The Mixed method approach is taken herein, whereby the data for analysis, discussion, and later addressing of the research objectives, is collected through mixing quantitative and qualitative information gathering techniques, can be perhaps best viewed as a pragmatic approach to exploring the identified knowledge gap (Fraenkel, Wallen and Hyun, 2012; Creswell and Plano Clark, 2011, cited in Creswell, 2011), the Pragmatic approach aims to provide thorough understanding of the research problem that is more than what can be achieved (Creswell, 2012; Bryman, 2014). The justification for these combinatorial tactics are such that the benefits of both methods can thus be accessed readily, with each technique able to supplement and expand information gleaned from the other, and in doing so address their respective limitations (Johnson and Onwuegbuzie, 2004; Creswell, 2009, 2012; Bryman, 2014), meaning that the conclusions drawn from the work will have a better foundation, and hence be less prone to bias, inaccuracy, or lack of rigour (Creswell, 2009, 2012; Fraenkel, Wallen and Hyun, 2012).

The specific style of mix method employed in this study is known as an exploratory sequential design, which Creswell (2011) perhaps describes best as a process wherein qualitative investigation (e.g. interviews) is performed to explore phenomena of interest, determine the relationship, whereupon quantitative tools can be built (e.g. questionnaires) and then applied as a means of generalizing the results. To illustrate, this design is often employed when instruments, variables, and measurements are unknown or unavailable for the population being studied. (Creswell, 2011). In this research, the qualitative investigation phase resulted in comprehensive, generalizable findings through the second quantitative phase that was built on the initial qualitative findings. To illustrate, the quantitative data results were utilised to expand the qualitative findings via the development of a survey or the testing of a typology or classification based on the

qualitative findings. According to Creswell (2011), in the exploratory sequential design, rather of approaching a subject with a predetermined set of variables, the researcher might first examine perspectives by listening to participants. Denzin's 1978 highlights triangulation, which is described as the multiple using techniques to explore a single issue, as a key reason for the use of mixed methods. It can be divided into 4 types – data, investigator, theory, and methodological triangulation. As this work utilises more than one technique to answer the research aims, it can be considered as an example of methodological triangulation. In particular, this study can be referred to as an example of between-methods triangulations by using both quantitative and qualitative methods (Denzin, 1978).

4.4. The Target Population of this Study and Sampling Methods

An appropriate decision has to be made in selecting the participants. The current research study used a purposive or judgmental sampling technique. It is a technique of non-probability sampling in which sample persons are chosen based on their expertise (Rubin and Babbie, 2016). The research attempted to get participation from experts in the maritime business, including shipping companies' financial managers, directors of shipping companies and university professors. The decision to target is deliberate and intended to widen the scope of data collected by the research. Moreover, the purposive or judgmental sampling technique will help to gather detailed and appropriate information regarding the research problem. The reason behind the selection of purposive or judgmental sampling technique for the current research study is that those will be interviewed that have a deep understanding and knowledge about the indicators that may affect financial decision making in oil shipping companies. However, recruiting the participants in this research was difficult as most companies do not agree to disclose he data yet there was a signed agreement between the researcher and company Z to share their data. Among the experts in the

company, 28 participants from the company Z agreed to participate and take part in the study. Additionally, 8 out of 9 members only 8 members gave their consent to take part in the study.

This section addresses the target participants and the sampling strategies in this research and the following section will address the process of recruiting the participants and the ethical consideration issues in this research.

4.5. The Data Collection Instrument and Process

4.5.1. Data Collection Instrument

This work combines both primary and secondary sources of data. Neuman's (2005) work differentiates between these two sources, arguing that while the former is collected explicitly for the work in hand through either qualitative or quantitative means, the latter can be gathered from a much wider range of sources, which could include published material contained with books, journal articles, or digital media such as online information repositories, and are best used to provide the foundation and context on which this work is based. The primary data collection in this thesis which took place between 17/6/2018 and 25/9/2018, through several methods have been chosen for the data collection stages of this work, and collectively they should provide an in-depth understanding of what is required to address the knowledge gap. In essence, this can be considered as a mixed-methods study, whereby semi-structured interviews offer the chance to obtain subjective, qualitative data, which is then followed by the use of a total of four questionnaires that can provide more objective, quantitative results. The following section will provide a more in-depth discussion of these techniques.

4.5.1.1. Interviews

Interviews formed the initial means of data collection, as they are considered to be a useful tool that can be applied in a variety of situations to gather knowledge to address a gap in collective understanding. Although surveys are also a useful tool, their intentionally limited construction limits participatory freedom, the limits determined by the researcher, with no opportunity for clarification or expansion offered, and thus the interview method can be used to address these shortcomings. Interviews are defined as a dialogue wherein the affected parties exchange their opinions on a given theme (Kvale, 1996). The technique allows for the development of personal bonds between the interviewer, and interviewee, which can reveal more useful information than other techniques (Wimmer and Dominick, 1997). In essence, it provides a greater opportunity to ensure data validity and precision in data collection through an interview, which can only output a more detailed comprehension of participants' views.

Of the three styles of interview listed by Burns (2010) — structured, unstructured and semi-structured—this work opted to use the latter, since they provide the interviewer with a more open form of control, whereby they can which the researcher can add to, omit and change according to the responses they receive from the interviewee, meaning that although a similar minimum level of data should be acquired, the order in which it arrived is less prescriptive, and thus the researcher may choose to dwell longer on elements of particular interest to a given candidate.

The interview structure with questions are related to certain themes, whereby key areas were determined beforehand, not emerging from the interview (Gillham, 2000; Kvale and Brinkmann, 2008).

The overall structure of the interview meant that there was a total of 31 questions regarding the nature of investment decision making regarding the ordering of oil tankers. These questions cover the entirety of the business, and thus the data collected will cover a broad spread. The questions

posed are listed in detail in appendix A. Although they were scripted in advance, the style of acceptable response was not predefined so that the participants would retain the freedom to independently offer their own interpretation, since the principal objective of this part of the study was to advance the collective knowledge surrounding the strategic choices made in relation to oil tanker investment and the factors affecting this investment. For clarity, it is worth noting that the language of choice for the interviews was English, and the allocated time around 45 minutes.

4.5.1.2. Questionnaire

The questionnaire was the second type of instruments used to collect the primary data for this research. It has been defined by (Dörnyei, 2003) any written instrument in which respondents reply to a series of questions or assertions by writing their responses or picking from a pool of pre-prepared responses. Four questionnaires were designed especially for this study (See Appendix B, C, D and E) and were distributed through the Email or Qualtrics link (Qualtrics, 2018) since it is considered as the official web at the University of Strathclyde.

The first questionnaire, which was included in the Delphi methods, consists of 2 sections. In the first section, the participants were asked to evaluate the importance of twenty-nine factors affecting the process of investment decision-making when buying a new ship, collected from the literature and on their responses in the interviews, through 5-point Likert-scale. It also includes a section where they can add comments or explain their ranking. The second section included an open-ended question where the experts are given the opportunity to suggest any additional factors. Moreover, similar to the first questionnaire, in the second questionnaire, the participants were asked to evaluate the importance of thirty-two factors, the same factors in the first questionnaire in addition to three factors, twenty-nine factors affecting the process of investment decision-making when buying a new ship. Furthermore, the third questionnaire in this study consists of

three sections. In the first section, experts were asked two questions regarding the process of financial decision-making. The second section asked the participants to evaluate and rank the importance of nineteen factors affecting the process of investment decision-making when buying a ship through 5-point Likert-scale. The nineteen factors were the finalized list of factors that reach a consensus from the second questionnaire in the third round of the Delphi method. Finally, the third section aims to examine the influence of each factor on all nineteen factors by evaluating the degree of interdependencies among the factors.

Moreover, the fourth and last questionnaire in this study, which is used in the case study, consists of one section. It aims to explore and investigate the decision of the board members of the company (Z) whether to buy a ship or not in the previous years. To clarify, each board member of the company (Z) were asked, in the questionnaire, to give his decision to buy a ship or not starting from 1980 till 2020, based on the different market scenario for the twelve factors affecting the decision in the company (Z) in each year, which were selected according to their importance based on results of the third questionnaire.

4.5.2. Data Collection Process

A summary of the data collection process in this research is shown in Figure 4-2 below.

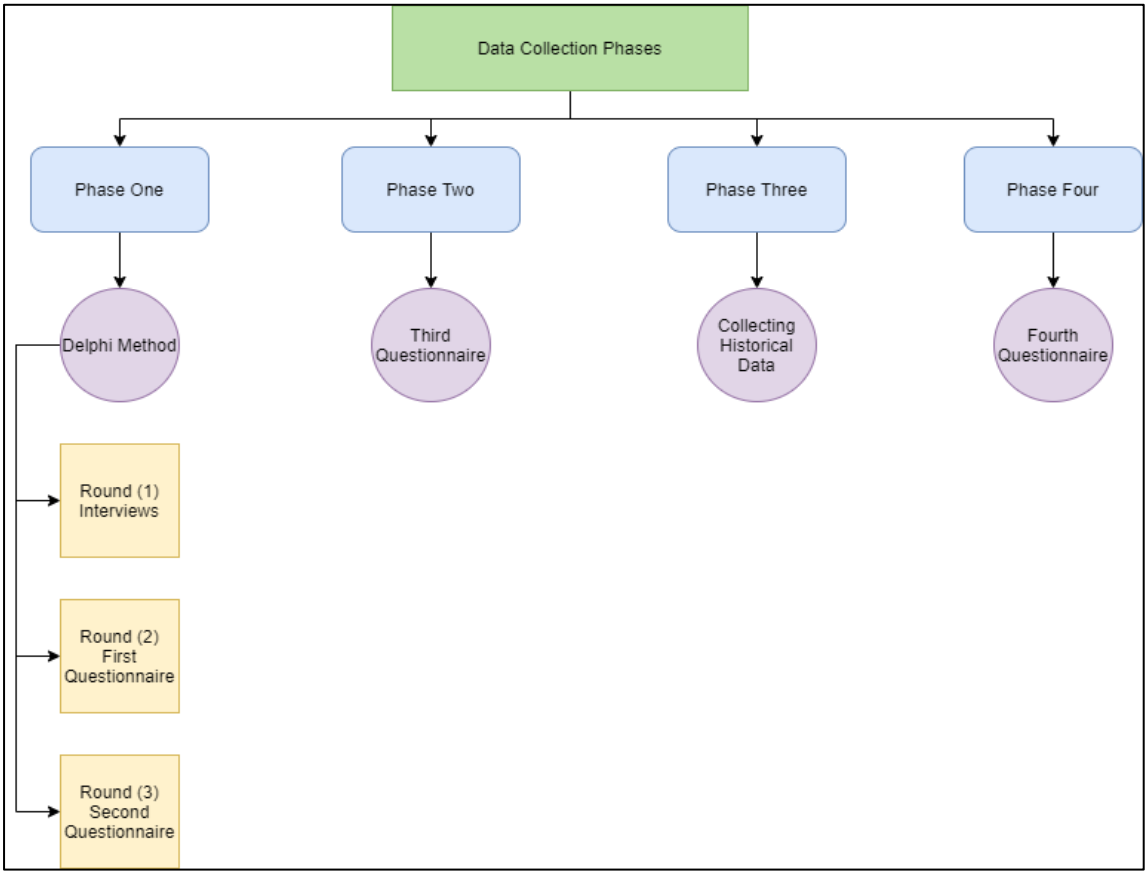

Figure 4-2 Data Collection Process

4.5.2.1. First Phase (Delphi Method)

The Delphi method is chosen in this thesis as an attempt to collect a highly reliable consensus of opinion of a group of experts as stated by Dalkey and Helmer (1963). The Delphi method is recognised as means of gathering variables that impact decision-making. In this sense, it is a predictive technique that can offer approximations regarding probability or likelihood and outcome of future events. It is primarily utilised in financial and economic settings, though

instances of its implementation in health and education can be found in the literature. It mainly involves the collection of a range of opinions collected from experts. The nature of the method requires a minimum of two rounds of surveys, but most publications utilised two or three rounds. Dalkey and Helmer's (1963) work describes the basic functionality of the Delphi method. The progression of repeated rounds of voting in the process ensures that agreement between individuals upon a given topic can be found, even when no tangible evidence has yet been reached about the topic. The repetitive nature of the technique, whereby the investigator must seek out opinions from the same participants again and again, is intentional since it forces experts to review their response and compare them with their peers. It thus requires a certain degree of anonymity so that internal biases held by one participant cannot affect the others and affords each respondent the opportunity to answer freely and truthfully. A key element of the Delphi structure is the use of controlled feedback, wherein the investigator collates and passes relevant summary data between members of the panel as a means of ensuring anonymity. The Delphi approach aids in developing questions that may be used to statistically and quantitatively analyse and quantify expert replies (Landeta, 2006). In summary, a Delphi method is recognisable by the presence of four key elements—anonymity, repetition accompanied by controlled feedback, statistical group response, and expert consultation (Goodman, 1987; Landeta, 2006).

A concise summary of the Delphi method is that round entails a series of open-ended questions that are asked to a panel of qualified individuals. The qualitative data that this generates is then coded through categorisation and identification of commonalities between them. This set of themes is then used as the basis for a further series of survey questions for the same panel. Later rounds aim to increase the level of specificity extracted from the participants, such as by encouraging quantification using rankings or other numerical assignments for ease of objective consideration. This research adopted the modified Delphi method as it allowed for expert

interaction through face-to-face meeting, which was not a component of the original Delphi method. This interaction allowed the participants to provide further information and present arguments in order to justify their viewpoints. The work of Avella (2016) provide a discussion of the advantages and disadvantages of the Delphi method that were summarized and presented in the Table 4-2 below.

Table 4-2 Delphi Method Advantages and Disadvantages

Advantages	Disadvantages
Consensus building in environments of uncertainty	Researcher bias
Flexibility and simplicity in ways of data gathering	The researcher's biases are imposed on the respondents
exchange expertise and generate new ideas relevant to the panel's goal	The anonymity of participants may persuade them to be less than completely motivated.
Freedom of expression	
Cost effectiveness	
Ease of communications	
The panel's composition does not have to stay consistent.	
Lack of geographical limitation	

A common criticism of this technique is that there is no way to ensure that data is trustworthy (Williams and Webb, 1994; Walker and Selfe, 1996), with the latter authors reporting that the method returned different results when a panel were presented with comparable problems for analysis. This is in contrast to the work of Ono and Wedemeyer (1994), who report stability in their conclusions over a 16 year period of research. Other critics of the Delphi method (Goodman, 1987) highlight the validity of the content itself as a cause for concern since the survey development is immune from interference from the investigators, in comparison, if the participants

have sufficient expertise in the study's subject area to serve as panellists, content validity may be assumed (Goodman, 1987) . It is therefore recommended that, when assessing the validity of the method itself, it may be more appropriate to consider criteria such as transferability, credibility, and applicability of results rather than placing reliance on psychometric criteria.

In this study, the data collected through Delphi technique was undertaken in three distinct rounds, as seen in Figure 4-3. In every round, participants are requested to offer their thoughts and feelings on the survey topics, and in the latter stages to review their previous responses and amend them if they deem it necessary, which is a mechanism designed to drive consensus amongst the views of the survey panel. Therefore, the first round is likely to be the most problematic (Green *et al.*, 1999). The first round comprises a total of 28 interviewees, who are geographically speaking, come from either Europe, or the Middle East, and from a relevance perspective, are all involved in investment decision making. The research sponsor undertook the first contact with each candidate, through vocal or written means of communication, in order to ensure that the objectives of this work were thoroughly understood and that the nature of their role in participation was clear. This round was starts with semi-structured interviews, which were chosen as a means to give a more open forum to generate ideas and issues from the perspective of participants. According to the literature (Procter and Hunt, 1994; Keeney, Hasson and McKenna, 2001), semi-structured interviews are flawed in the sense that they can generate a large number of factors that have the potential to overwhelm candidates in the future and could discourage them from participating. Accordingly, researchers often give pre-existing data (Keeney, Hasson and McKenna, 2001) which might effectively manage the time spent obtaining replies (Duffield, 1993; Jenkins and Smith, 1994).

This strategy may influence responses or narrow the range of accessible alternatives. However, pre-existing data might be used to effectively manage the amount of time spent obtaining

responses (Duffield, 1993; Jenkins and Smith, 1994). Post interviews, the collected data was combined with that from the literature review in the previous chapter and used to design the first questionnaire that was provided to the panel in round two via the Qualtrics link (Qualtrics, 2018). Round two consists of a questionnaire, the first questionnaire in this study, that was constructed based on the 28 participants' responses. In the first questionnaire, experts were asked to rank the importance of each factor through a Likert-scale. Experts were also given the opportunity to provide comments and suggest additional items that may not have been included when developing the initial list of factors collected from the literature and the face-to-face interviews. Following the receipt of second-round findings, further rounds will consist of designed questions that include input from round two. Walker and Selfe (1996) state that the analysed data from each round must be distributed to panel members, since the data might motivate panel members to remain active in the research. This procedure collects expert opinions effectively and exposes them to controlled feedback (Buck et al., 1993). The only form of communication amongst experts while providing comments to panellists and is regarded as critical (Murphy et al., 1998). The third round included the addition of the additional elements obtained in round two to the second questionnaire.

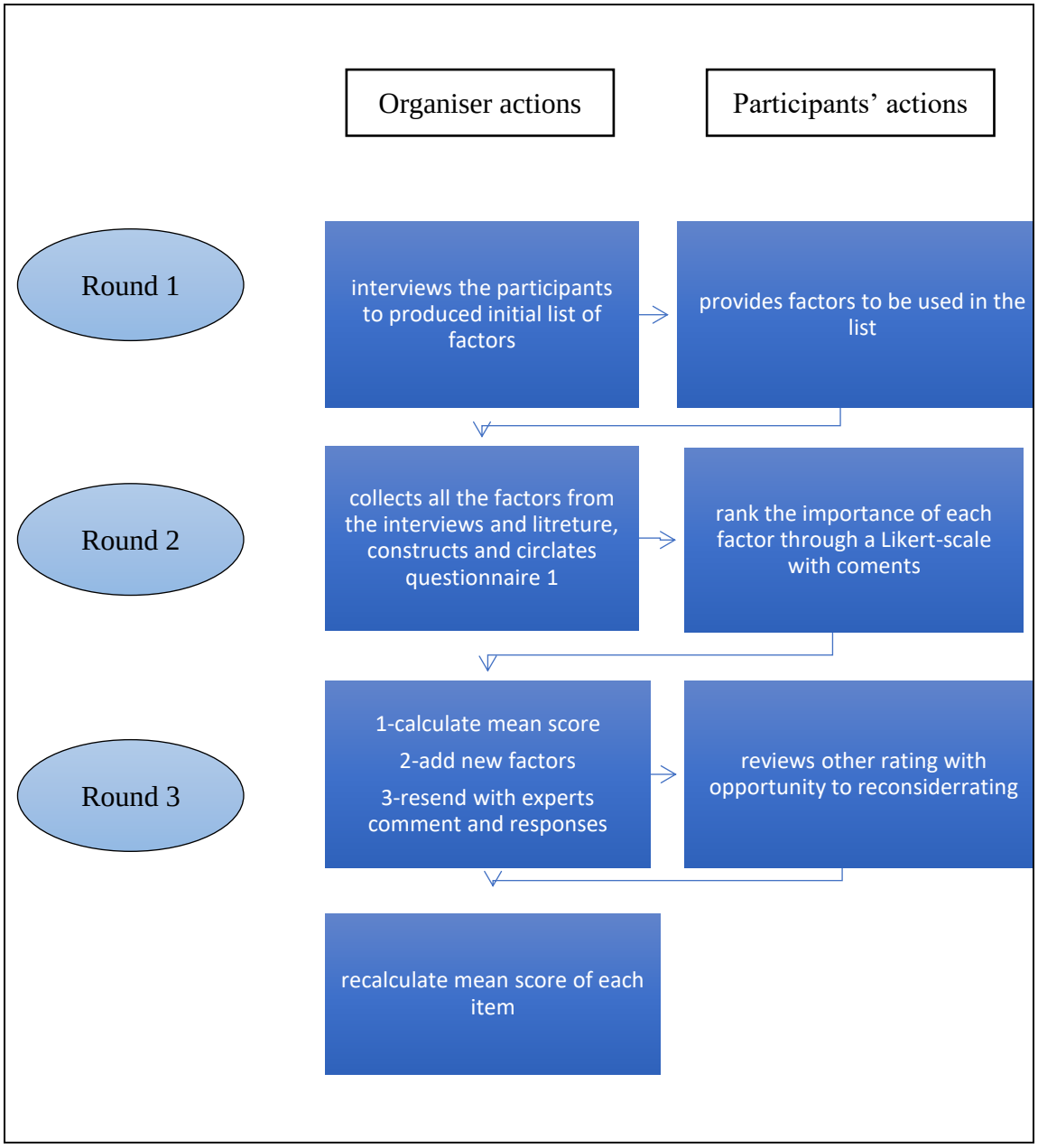

Figure 4-3 Rounds for the Research Delphi Method

4.5.2.2. Second Phase

The second phase of data collection starts after the Delphi method. The questionnaire in the second phase, which is the third questionnaire in this study, was constructed based on the responses of the experts and the finalized list of factors affecting investment decision-making when buying a new ship that was reached from the third round in the Delphi method. Qualtrics was used to distribute the third questionnaire online (Qualtrics, 2018) to make the survey accessible to participants through their personal devices. It consists of three sections; the first section includes two questions regarding the process of investment decision-making. The second section asked the participants to evaluate and rank the importance of nineteen factors affecting the process of investment decision-making when buying a new ship through 5-point Likert-scale. Finally, the third and last section aim to examine the influence of each factor on the others through evaluating the degree of interdependencies among the factors.

4.5.2.3. Third Phase

The third phase of data collection includes the collection of some historical data related to the factors affecting future oil prices for the period from 1980 to 2020. These factors are: Oil price, oil supply, oil demand, economic crisis, geopolitical, strength of the US dollar, and world GDP. The information and data about these factors were collected both from the secondary data resources including papers, books, and journal articles, and from the company (Z). The aim of collecting these data is to forecast for future oil prices for the period from 2020 till 2030.

4.5.2.4. Fourth Phase

The fourth phase of data collection in this study aims to create an equation as the final step in the process of developing a technique for the new ship investment decision-making. This stage begins

by using the fourth questionnaire in this study, which aims to investigate the investment decision of the board members of the company (Z) when buying a ship according to the different market scenarios for the twelve factors affecting the decision making in each previous years from 1980 to 2020. The twelve factors are: freight rate, new build price, oil price, production of the country, guaranteed cargo, new build order book, IMO regulation, economic crisis, company fleet, age of company fleet 20 years or over, the interest rate for vessel investment, and company profit. The questionnaire was distributed to all nine members of the board of the company (Z); however, only 8 members gave their consent to take part in the study. The main purpose of this questionnaire is to collect as many decisions in order to create an equation as a part of the process of developing the investment decision making technique that goes with the company and board member visions.

4.5.3. The Data Analysis Method and Process

After the activation of the survey link and the collection of the responses from the participants, the analysis of the questionnaires returned will be performed using the following techniques that can be divided into four steps (see Figure 4-4).

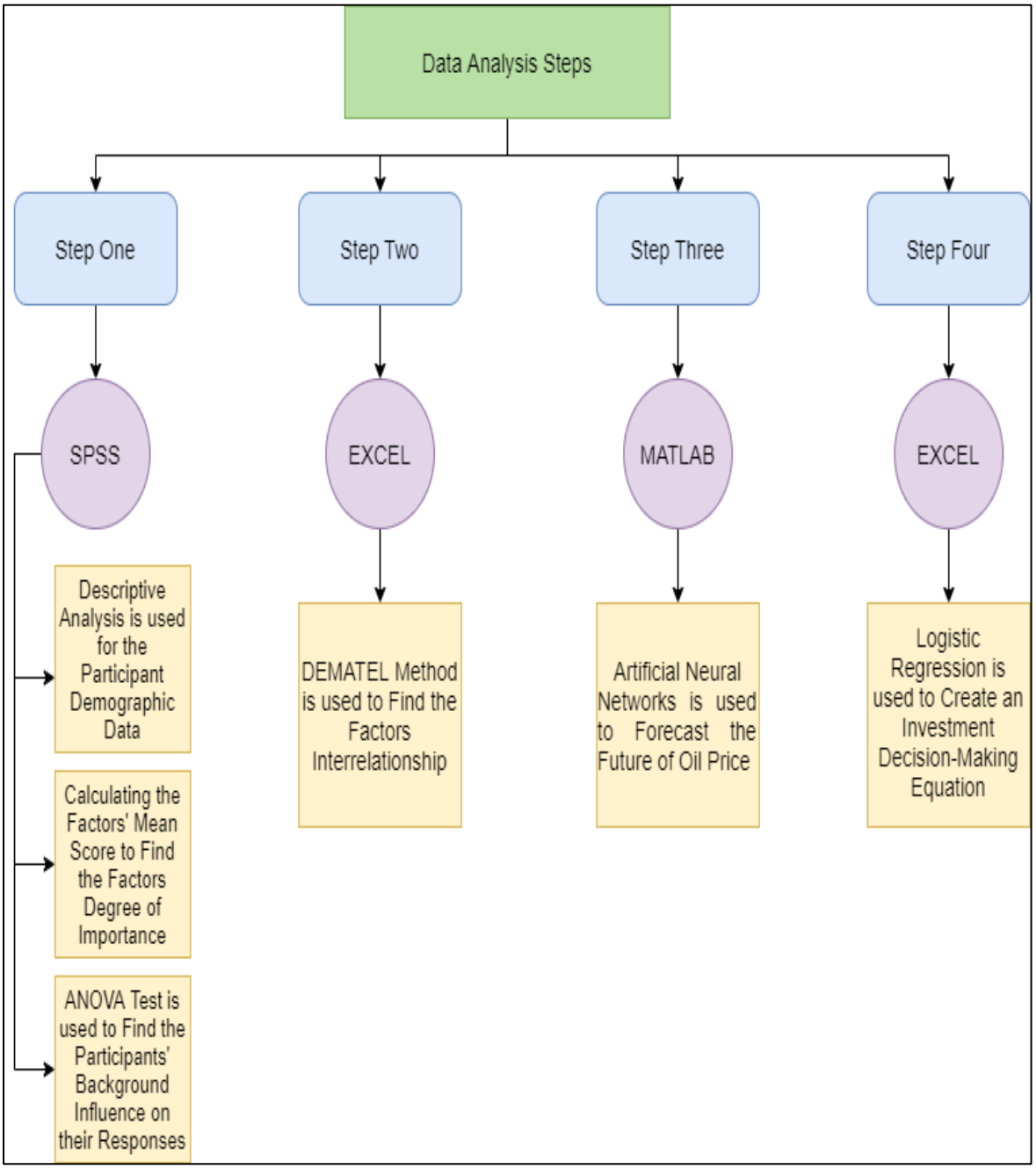

Figure 4-4 Data Analysis Steps

4.5.3.1. Step One

The first step of analysis includes the descriptive analysis for the demography of the participants, calculation of the mean for each statement within the questionnaire and each factor via SPSS 26.0 software (IBM, 2019), and the ANOVA analysis. The interpretation technique for the mean score is shown in Table 4-3 below.

Table 4-3 Mean Score Interpretation

The interpretation	Colour code and mean score in percentage
Factors affecting the decision making with Low rate	<39.9 %
Factors affecting the decision making with Low Medium rate	40% - 74.99%
Factors affecting the decision making with High Medium rate	75% - 89.99%
Factors affecting the decision making with High rate	>90%

As Table 4-3 above shows, the statement and the dimension that is labelled by the dark and light green colour code is representing an agreement on the factors that has a huge impact on decision making. The amber colour is reflecting the factors affecting the decision making with a low medium rate. The red colour code is reflecting the agreement regarding the factors that has a low impact on the decision making.

Then, the Analysis of variance (ANOVA) is conducted to find the influence of the participants' demography on their responses. ANOVA test is a statistical technique that is usually used to compare the mean of the involved samples; to illustrates, ANOVA tests the influence of one or more factors through comparing the means of these factors. There are two types of ANOVA tests one-way or two-way, that mainly depends on the number of independent variables and the number of levels. To clarify, the one-way test has one independent variable with two levels, and the two-way test has two independent variables and yet it can have multiple levels. Through using the

ANOVA test, the chance factor is removed from the analysis that leads to the validation of results. The ANOVA test is usually conducted in the SPSS tool (Post-Hoc Multiple comparisons). This test aims to compare the P-value for the dependent variable concerning the independent variables. In this research, the one-way ANOVA test is used to find the P-value for each dependent (the factors affecting decision-making) in relation to the independent variable (the demography of the participant), including their academic background, and working experience. It is important to note that it is required for the independent variable to have three or more groups to calculate a reliable P-value. He stated that when P-value < 0.05, then the result indicates a noteworthy statistical difference among different groups answers within the questionnaire (Laerd Statistics, 2018).

4.5.3.2. Step Two (Decision-Making Trial and Evaluation Laboratory)

The following step in the analysis includes the use of decision-making trial and evaluation laboratory (DEMATEL) through Excel (Microsoft Office, 2013) that is the technique used to ascertain the degree of interdependence between the variables. This system was originally designed by The Battelle Memorial Institute of Geneva to solve complex and interconnected challenges encountered in a Science and Human Affairs Program (Gabus and Fontela, 1973; Li, 2009; Lin and Tzeng, 2009). It is used to determine the weight assigned to each recognised interdependent element that influences the decision to purchase a new ship. This technique may also be used in combination with a mixed-methods strategy for weighing and discovering interdependencies, and it is reasonably simple to use due to the relatively small sample size required for data analysis (Büyüközkan and Çifçi, 2012). The ability to provide graphical representations of solutions to these problems, combined with the clear variable separation and categorisation as either cause or effect groups, allows investigators to more thoroughly comprehend the relationships among these variables (Li, 2009). The final output from DEMATEL

is the creation of an influence-relations map (IRM), which clearly displays all relations between the variables identified within the system under consideration. Lin and Tzeng (2009) summarise DEMATEL in four parts:

Step 1: Calculate the Average Matrix of an Initial Direct-relation Matrix.

Step 2: Calculating the normalized initial direct-relation matrix (D).

Step 3: Calculate the total relation matrix (T).

Step 4: Set up a threshold value to obtain the influence-relations map (IRM).

4.5.3.3. Step Three (Artificial Neural Network)

Artificial Neural Network (ANN), particularly Scaled Conjugate Gradient Backpropagation algorithm (SCG/ trainscg) is used in MATLAB version 2016b (MathWorks, 2016) to predict and forecast future oil prices for the period from 2020 till 2030 (for a brief description of the different algorithms see Table 4-4). Artificial Neural Networks (ANN) have been applied to predict the price of crude oil over the next decade using previous data, though many other technologies have also been able to forecast more immediate dangers across a range of industries. Of these tools, the most commonly encountered remains Artificial Neural Networks (ANNs) due to their sturdy trustworthiness and their notable ability to reflect nonlinear interactions between the variables in convoluted networks with a range of inbound and outbound data.

ANNs is widely recognised in a different range of fields, that it is ideal for unlocking complicated challenges. They are considered a particularly useful form of Artificial intelligence for tackling nonlinearity, since they remain capable of forecasting future results due to the initial training that they receive (Al-Zubaidi, Ghani and Che Haron, 2011). In contrast to traditional techniques, ANNs are better at both forecasting and optimising manufacturing strategies (Graupe, 2013). It has been demonstrated that they are adept at recognising and categorising patterns. Drawing inspiration

from biological studies of the human brain from the perspective of nonlinear drivers, in terms of their ability to learn and make assumptions based on prior experiences, With their extra characteristics like as adaptive learning, real-time operation, self-organization, thinking and reasoning, judgement and remembering, and fault tolerance, ANNs are effectively our digital analogues (Widrow, Rumelhart and Lehr, 1994; Ravi Kumar and Ravi, 2007; Graupe, 2013). Some of the advantages of employing neural networks for predictions are stated by (Tu, 1996) such as;

- ANN models require less formal statistical training is required to construct neural network
- Automatic detection of complicated nonlinear interactions between independent and dependent variables is possible using neural network models.
- Models based on neural networks are capable of detecting all conceivable interactions between predictor variables.
- Multiple alternative training methods may be used to construct neural networks.

Table 4-4 Training algorithm for ANN (Powell, 1977; Scales, 1985; Møller, 1993)

Training Algorithm	Training Function	Description
Gradient Descent	GD/ traingd	Gradient descent back-propagation
	GDM/ traingdm	Gradient descent with momentum back-propagation
	RP/ trainrp	Resilient back-propagation (Rprop)
	SCG/ trainscg	Scaled conjugate gradient back-propagation
Conjugate Gradient	CGP/ traincgp	Conjugate Gradient back-propagation with Polak-Rieber Updates
	CGF/ traincgf	Fletcher-Powell conjugate gradient back-propagation
Quasi-Newton	BFG/ traincfg	BFGS quasi-Newton back-propagation
	LM/ trainlm	Levenberg-Marquardt back-propagation

4.5.3.3.1. ANN Principles:

Although the terminology used to describe a system of inputs is similar to that used to describe an actual neuron, the complicated nature of a true neuron is worlds apart from its digital analogues (synapses), which are compounded by weights (the intensity of the corresponding signals) and then calculated by a mathematical function that defines the neuron's activity; another function (potentially identity) then computes the artificial neuron's output. In effect, an ANN's structure works together to utilise all nodes for data evaluation. A neuron in possession of a higher weighting will, in effect, possess a stronger input. The extent of the computation it undertakes is dependent on this weight due to the multiplicative nature of this stage, meaning that changes in the weight will adapt the system to function correctly for a range of inputs. While this is acceptable for small networks, ANNs consist of a great number of neurons, each of which must be weighted, and thus automation in the form of weighting algorithms must be used to determine the appropriate weighting to solve a specific problem in a process known in the literature as either training or learning (Haykin, 1999).

Despite the existence of a vast range of different network designs, they contain many commonalities:

1- A set of nodes:

Nodes are considered the building block of an ANN, the simplest ones take an input and produce an output, but the internal structure may range from the simplest summation, to in effect, being an entire network itself.

2- Connections between nodes:

These facilitate the transfer of data between nodes, and are capable of providing unidirectional (information flows in one sense) or bidirectional (information flows in both senses).

The manner in which nodes interact via these connects determines the overall behaviour of the system, but this cannot be predicted by considered smaller subsets of the constituent parts. In truth, it is recognised that often, this behaviour far surpasses the capabilities expected from consideration of the summation of each individual element's capacity. This phenomenon is known as emergence and serves to highlight the extent of ANN's power (Haykin, 1999).

The nature of ANNs is such that they use many simplistic structures in an interwoven fashion in a manner not dissimilar to the cerebral cortex to provide a significantly more complex tool than anticipated. There are many different designs present in the literature, with estimates from the early 1990s surpassing 50 (Simpson, 1990; Maren, 1991; Pham, 1994). Many designs have been targeted towards addressing specific problems, such as perceptual challenges, data modelling or approximating functions, with the most common architectures encountered typically feed-forward designs such as Back-Propagation, or recurrent networks (Basheer and Hajmeer, 2000).

There are three key reasons why Back-Propagation (BP) has been utilised in this work:

1- Capability to acquire knowledge about a mapping from one data space to another via examples.
2- Capability to acquire knowledge about a mapping from one data space to another via examples
3- The ease with which the training process may be searched for, accelerated, and stabilised.

4.5.3.3.2. ANN Characteristics

An Artificial Neural Network is an incredibly refined mechanism with which to tackle convoluted sets of nonlinear data. In truth, regardless of the complexity of the relation between any given set of inputs and outputs, an ANN structure exists that can handle it (Marini *et al.*, 2008). They are effective spicily in situations requiring control, classification, or prediction and forecasting. The

success of ANN may be ascribed to a number of critical factors, which are described below (Siegel *et al.*, 1998; Haykin, 1999; Etheridge *et al.*, 2000; Taha, 2012):

1. ANNs are capable of mapping input patterns to corresponding output patterns.
2. ANNs are taught by example. This implies they may be trained and evaluated on known-solution issues before being unleashed on a real-world challenge.
3. ANNs are capable of generalising from a training data set, allowing them to accurately handle comparatively novel situations based on historical relations.
4. ANNs are flexible and easy to maintain since they are inherently able to adapt to environmental changes. In effect, they can continue to learn during their operation as a means of improving performance.
5. ANNs are very reliable and fault-tolerant systems. As a result, they are capable of recalling entire patterns from incomplete, partial, or noisy patterns.
6. ANNs are capable of resolving new challenges. This has enabled the development of new sectors for decision assistance applications that were previously difficult or impossible to handle computationally.
7. ANNs are capable of dealing with data that is partial, ambiguous, or poorly determined, as well as with unexpected situations (similar to the human brain). Additionally, ANNs can work with massive amounts of data to develop models in the absence of specific, well-defined rules, and may provide accurate results when created correctly.
8. ANNs are fast processors because their component pieces are interconnected yet distributed in parallel, allowing for cross-communication.
9. ANNs are insufficient for testing research hypotheses and are incapable of assigning significance to input variables, which in turn makes interpretation challenging, and training time-consuming.

10. ANNs make future predictions based on prior data patterns, implying that the future would be similar to the past. When an environment or scenario changes, network patterns are no better predictions than traditional statistical patterns, unless the network pattern is recreated.

4.5.3.3.3. Methodology Algorithms

A typical ANN is generally constructed from the experimental data set (X_i) linked to the neurons in the input layer *(1, 2…, i,… m)*. Communication enters this first layer and is passed to neurons held within hidden layers in the network *(1, 2…, j,… n)* that Their values are transformed by multiplying the connection weights (wij) between two neurons and delivering output signals to the output layers through the summing function (*1, 2…, k,… p)* (Bilgili, Sahin and Yasar, 2007). Input data from each layer is processed to the output layer using a nonlinear transfer function, typically one of the following *tansig*, logarithmic sigmoid *(logsig)*, and *purelin*, which are detailed in both equations (4.1), (4.2), and (4.3); and also graphically in Figure 4-5. Of these options, the former is recognised as having the highest level of predictive accuracy, and is typically installed as part of the latent levels, whereas for the output layer, the literature suggest that *purelin* remains the most appropriate (Shojai Kaveh, Ashrafizadeh and Mohammadi, 2008; Magharei, Vahabzadeh and Sohrabi, 2012; Mashhadi Meighani *et al.*, 2013).

$$f(x) = \frac{1}{1+e^{-x}} \tag{4.1}$$

$$f(x) = \frac{e^{x} - e^{-x}}{e^{x} + e^{-x}} \tag{4.2}$$

$$f(x) = x \tag{4.3}$$

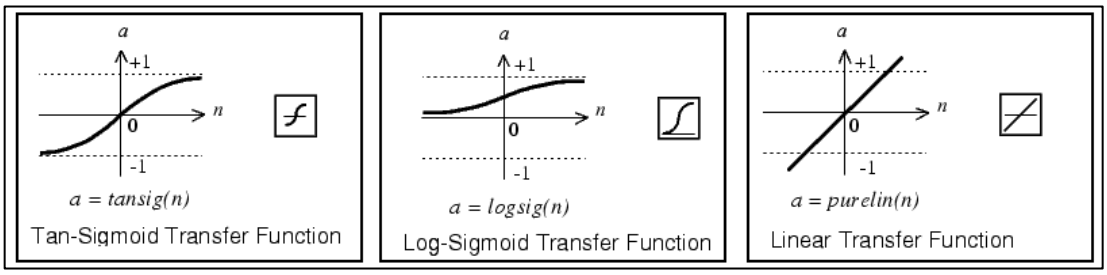

Figure 4-5 Graphical representation for activation (transfer) functions

As seen in Figure 4-6, for a single neuron in the network, the system process begins with each input stream being multiplied by the weight and summed using the function. Following that, this single value is processed using the transfer function to provide the output value for each neuron (Shojai Kaveh, Ashrafizadeh and Mohammadi, 2008).

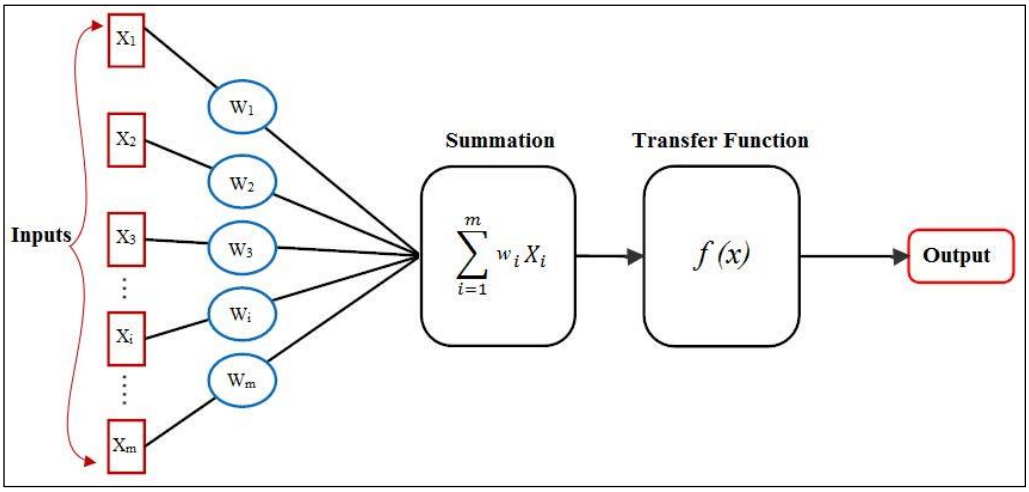

Figure 4-6 Data Flow Process in a Neuron (Shojai Kaveh, Ashrafizadeh and Mohammadi, 2008)

The sturdiness of any ANN model is heavily affected by choice of training methods and activation functions. Typically, linear functions are used on the in- and output layers, whereas nonlinear transfer functions are used on the hidden layers (Yetilmezsoy and Demirel, 2008).

Backpropagation techniques adapt weightings in light of the most negative slopes since they represent the direction of the greatest loss in performance; however, despite the directness of this

approach, it can increase convergence times (Hagan, Demuth and Beale M. H, 1996). An alternative method utilises conjugate gradient algorithms to determine what is known as the conjugate direction, which exhibits the most rapid convergence yet does not deviate from the strongest decline, with a limitation placed to ensure that no rise in errors is experienced (Kişi and Uncuoğlu, 2005). There are many different conjugate gradient algorithms available; among the various versions of CG algorithms, this research uses the Scaled Conjugate Gradient Backpropagation algorithm (SCG/ trainscg) developed by Møller (1993).

4.5.3.4. Step Four (Logistic Regression)

The last step in the analysis includes the use of Binary Logistic Regression (BLR) through Excel (Microsoft Office, 2013) for analysis through the use of Logistic regression analysis that can be found in XLMiner Analysis ToolPack option. The analysis of regression is typically either linear or logistic based. The former is primarily applied to predictive methods due to its ability to interpret continuous results (i.e. those that can be arithmetically processed, such as weight). Working from the assumption that there is a straight line link between the dependent and independent variables, it then works to quantify the extent to which this assumption remained valid (James *et al.*, 2013). On the other hand, Logistic regression is applied to cases with any combination of ordinal, categorical or continuously measured variables, with the aim of determining the most appropriate way to describe the relations that join a dependent and multiple independent variables (James *et al.*, 2013; Ohlmacher and Davis, 2003; Lee, 2005).

As with linear regression, logistic techniques may involve any number of independent variables, though, by its very nature, it is perhaps best applied to multivariate problems, as the interdependencies can then also be considered at the same time, rather than only exploring sequentially without due regard to the effects they may have on each other (James *et al.*, 2013).

Probabilities for binary outcomes must lie between 0 and 1. In comparison, the independent variables in a linear regression equation may have any value. Without resolving this mismatch, the regression model's projected values may fall outside the 0–1 range. Accordingly, logistic regression was chosen in this study.

Logistic regressions can be undertaken in Binary Logistic Regression (BLR), Multinomial Logistic Regression, and Ordinal Logistic Regression forms. The first seeks to determine the link between a binary dependent variable and an associated independent one, examples of this could be— Success/Failure, 0/1, True/False, or Yes/No. Multinomial methods are best applied when the dependent variable is categorical yet has at least 2 discrete, unordered output levels, hence the primary difference is that there is a greater number of (>2) outcomes. The final style of logistic regression—ordinal—is applicable to a case wherein the dependent variable has an ordered structure with a range (>2) of potential categories. In this study, the technique applied to the outcomes from the fourth part of the investigation is binary logistic regression, which is deemed appropriate, given the nature of the question asked, which asks whether a vessel should be purchased or not.

There are four key presumptions that must hold true if logistic regression analysis is to be implemented. The first is that errors are independently formed and that there is thus no duplication. The next is that there should be a linear relationship between any given independent variable and its logit-transformation. A further consideration is that there must be no redundancy in a multivariate system, else this method runs the risk of generating multicollinearities. Finally, it assumes a relatively consistent system, wherein there are no outliers whose effects are significant on the system as a whole's ability to make accurate forecasts from the data set (James *et al.*, 2013).

4.6. Ethical Considerations

Creswell (2009) recommends that before undertaking any research project involving data collection, the researcher must first ensure to secure access to investigations or formal settings. It is further suggested that a summary of the study in letter form should be drafted to include the aims, purpose, and rationale for the experiment. The chosen case study for this work—company (Z)—was contacted in order to attain permission to conduct the study, after which an ethics committee meeting (June 27, 2018; appendix F) was organised so as to ensure the appropriate agreements, such as non-disclosure clauses, were made in advance.

It is necessary to explain the benefits and objectives of the work to potential respondents, and thus all participants were supplied with a participant information sheet (PIS) that described these aspects in detail, including what expectations will be placed on them, and what to expect in return. To ensure that this information had been sufficiently understood, all respondents opting to take part in the study were asked to sign a consent form (appendix G) before any investigation or interviews began.

Confidentiality and anonymity was assured to all participants, along with the freedom to withdraw their participation offer without condition. Anonymous responses are recognised to reduce bias and provide greater levels of truth and openness since any given opinion cannot be linked back to an individual, a notion which is supported by Goodman's (1987) conclusion that the removal of anonymity decreases the accountability of an expert's view. As a result, each expert's viewpoint is given equal weight and significance, and prejudice is removed (Keeney, Hasson and McKenna, 2001, Jeffery, 1995).

4.7. Conclusion

This chapter discussed the methodology used in this thesis. To begin, it outlined the study paradigm and design. This study adopts a pragmatic paradigm and a mixed method research design. This chapter also introduced the target population and sampling method adopted in this study. Moreover, this chapter presents the used instrument for data collection in this study, interviews and questionnaires. It also gives an overview of the process of data collection. This research included the use of a modified version of the Delphi method for data collection as it is considered as a forecasting tool to predict the probability and outcome of future events. In addition to the process of data collection, this chapter provides an overview of the used tools for data analysis; descriptive analysis, ANOVA, DEMATEL, ANN, and Logistic Regression. Lastly, this chapter presents the ethical consideration that was taken prior to conducting the study.

5. Data Analysis

5.1. Introduction

The aim of this section is to describe the analysis performed on the data acquired in Chapter four. In addition, it aims to present some of the findings in order to reach the following objective of the research:

- Collect the indicators affecting the investment decision making in the oil shipping companies from the literature and experts, then evaluate these indicators in order to be ranked according to their influence. In addition, assess the interrelationship between these indicators to ease the process of the investment decision-making in oil shipping companies.

In this chapter, the researcher discusses the analysis and results of the Delphi method that includes an interview, and both the first and second questionnaire in this research which was done with experts in the maritime business, including shipping companies' financial managers, directors of shipping companies and university professors. The Delphi method's ultimate goal is to achieve consensus regarding the factors affecting the financial decision making when investing in a ship. Then, the researcher discusses the results of the third questionnaire that mainly concentrates on ranking the factors affecting the investment decision making when buying a ship and the interrelationship between these factors. The fourth questionnaire will be discussed in the case study chapter.

5.2. Demography of the Participants

It is important to be familiar with the details of the participants in this study; this section targets the demonstrate the demography details for the participants who were involved in the data collection.

5.2.1. Academic Background

As shown in Table 5-1 and Figure 5-1 below, all the experts and participants in this study have academic degrees. It shows that more than have the participants have a professional degree (master's degree) with 57.1% (16 participants). It also indicates that 39.3% of the participants (11 participants) have bachelor's degree, and that only 3.6% (1 participant has Doctorate/ PhD).

Table 5-1 Academic Background

		Frequency	**Percent**
Valid	**Undergraduate**	0	0
	Diploma	0	0
	Bachelor's Degree	11	39.3
	Professional Degree (Master)	16	57.1
	Doctorate	1	3.6
	Other qualification	0	0
	Total	28	100.0

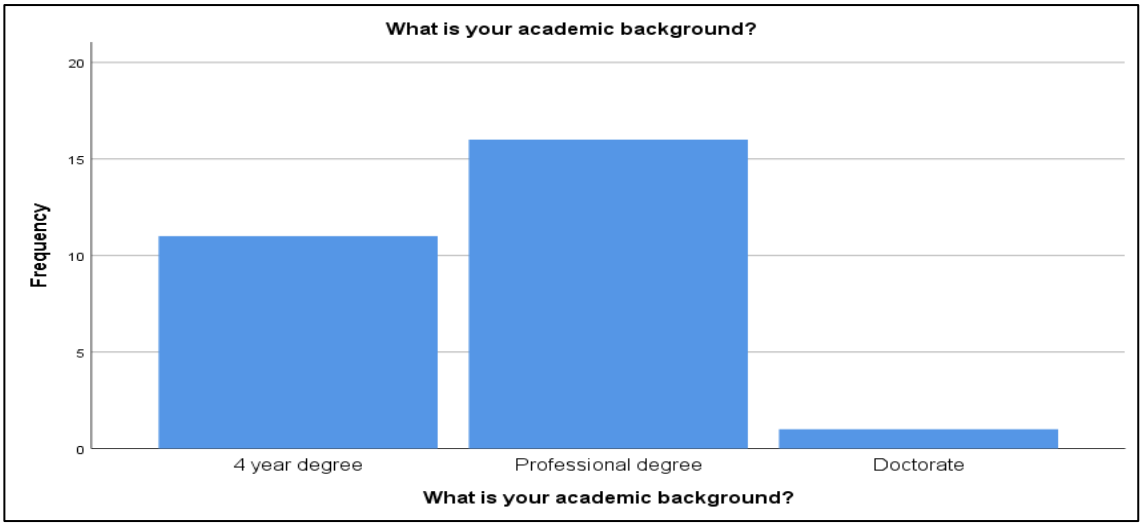

Figure 5-1 Academic Background

5.2.2. Working Region

The participants in this study have different working experience due to different working region. With a total of 100% divided between 57.1% were (16 participants) were from the Middle East/ working in the Middle East and 42.9% (12 participants) were from Europe/ working in Europe (see Table 5-2 and Figure 5-2).

Table 5-2 Working Region

		Frequency	**Percent**
Valid	**Europe**	12	42.9
	Middle East	16	57.1
	Total	28	100.0

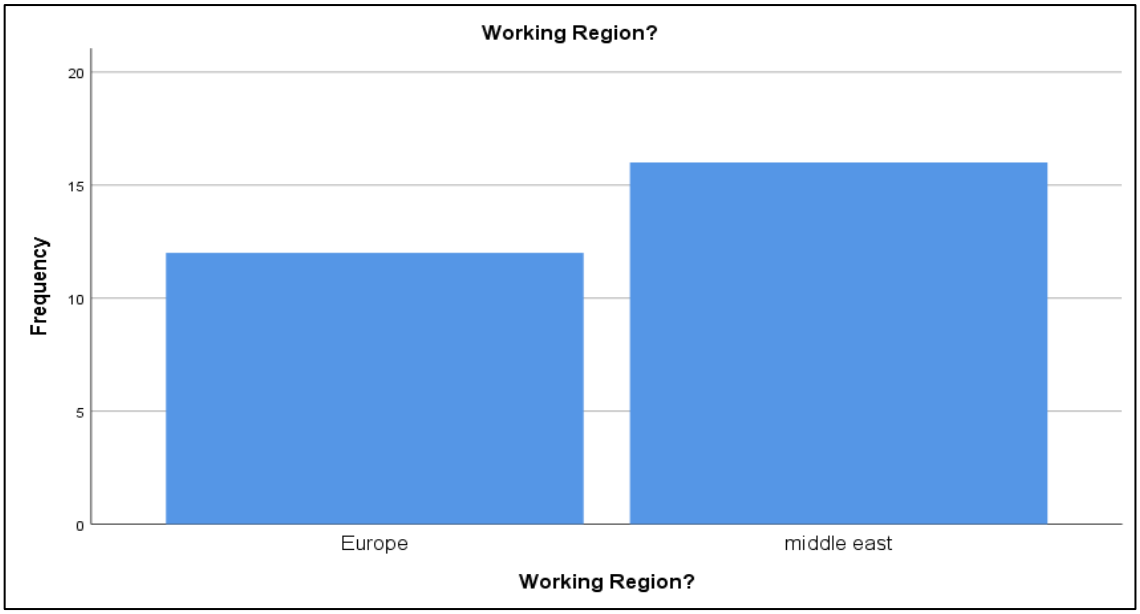

Figure 5-2 Working Region

5.2.3. Working Field

As shown in Table 5-3 below and Figure 5-3, the experts and participant in this study were 4 academics and 24 experts and employees in the shipping industry 14.3% and 85.7%, respectively, making a total of 28 participants (100%).

Table 5-3 Working Field

		Frequency	**Percent**
Valid	**Academic**	4	14.3
	Shipping Industry	24	85.7
	Total	28	100.0

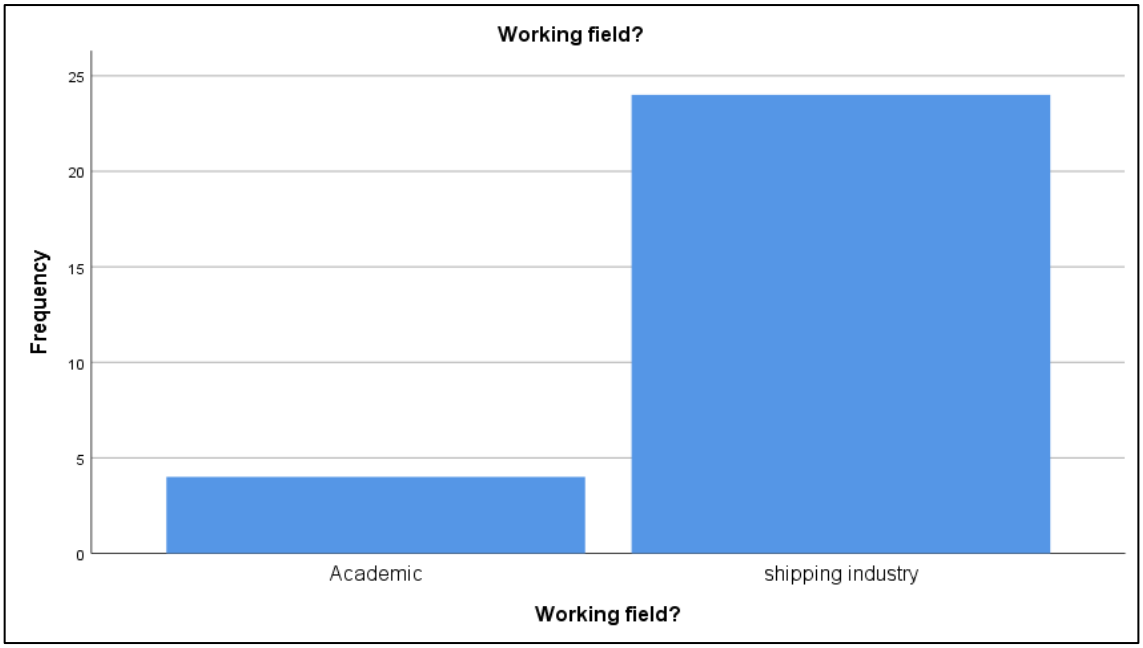

Figure 5-3 Working Field

5.2.4. Working Position

Table 5-4 and Figure 5-4 displays the working position for the participants in this study. Most of the participants are either managers or consultants. It shows more than half the participants, with 53.6% (15 participants) are in some managing positions and 32.1% (9 participants) are consultant, while 14.3% (4 participants) are holding other positions in their place of work.

Table 5-4 Working Position

		Frequency	**Percent**
Valid	**Manager**	15	53.6
	Consultant	9	32.1
	Other	4	14.3
	Total	28	100.0

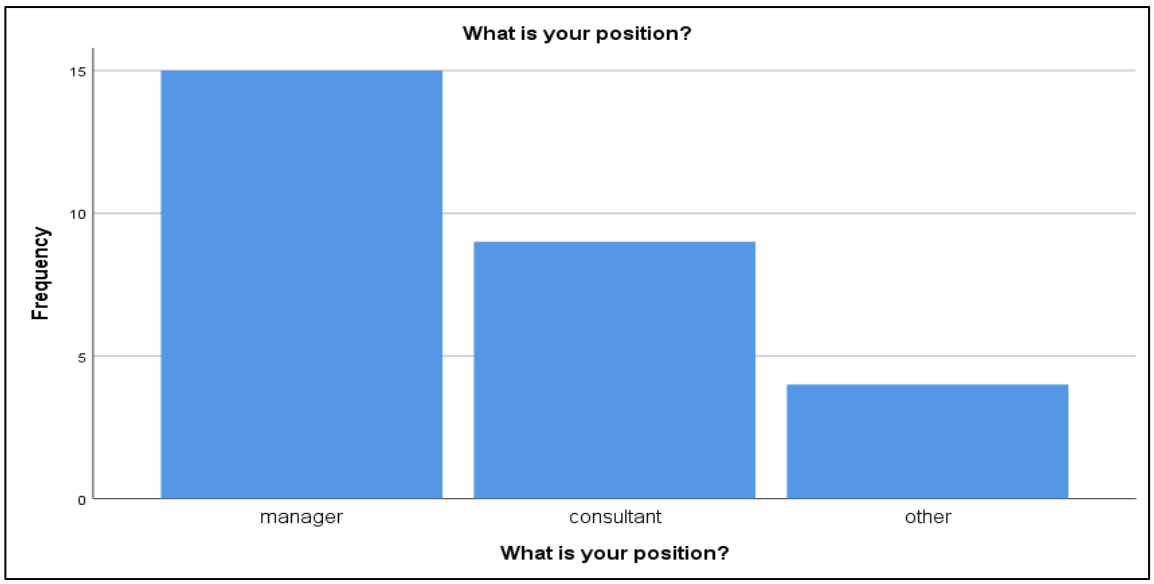

Figure 5-4 Working Position

5.2.5. Working Experience

Table 5-5 and Figure 5-5 below shows that the participants in this study have various years of experience. To illustrate, out of 100% (28 participants), the majority of the participants in this study have more than 11 years of experience, with a total of 85.8 % (24 participants). Also, it shows that almost half the participants, with 42.9% (12 participants), have between 11 to 15 years of experience; while the other participants' years of experience vary from 16 to 20 years with 25.0% (7 participants), 21 years and above with 17.9% (5 participants), and only 14.3% (4 participants) have less than 10 years of experience with 10.7% (3 participants) have between 6-10 years, and only 3.6% (1 participant) have between 0-5 years of experience.

Table 5-5 Working Experience

		Frequency	Percent
Valid	**0 - 5 Years**	1	3.6
	6 - 10 Years	3	10.7
	11 - 15 Years	12	42.9
	16 - 20 Years	7	25.0
	21 Years and above	5	17.9
	Total	28	100.0

Figure 5-5 Working Experience

5.3. Factors Affecting Investment Decision Making

5.3.1. Empirical application of Delphi Method

This section targets the identifiable factors affecting investment decision-making which will be evaluated using the Delphi approach, with the goal of eliciting consensus among experts on these discernible factors.

5.3.2. Pilot study for Delphi Method

The researcher developed the interview questions; accordingly, the developed questions was sent to five experts in the maritime field. The returning comments were beneficial in ensuring the questions were sensible and clear. Minor clarifications and adjustments were requested. The researcher revised the remarks, and the questions were then prepared for usage in the interviews for round one in the Delphi method.

5.3.3. Round One

The first round in the Delphi method included interviews with experts in the maritime field. The First round started by inviting the expert (n=28) to participate in the study. Each interview consists of 31 questions were determined beforehand with the chance to clarify and deviate from the questions. At the beginning of the interviews, the participants were asked to read the participant information sheet (PIS) before answering the questions and sign the consent form if they are willing to take part in this study. The primary goal of the PIS was to inform participants on the critical elements and purposes of this study. Following this process, the researcher collected the identifiable factors that were twenty-nine factors from literature and interviews that influence the

investment decision to buy a ship. These factors were used in the development of the first questionnaire that were used in the second round of the Delphi method in this study.

5.3.4. Round Two

Participants in the first Delphi questionnaire were provided access to the survey using Qualtrics link (Qualtrics, 2018). There was an additional benefit here, in that the personal data collected during the initial interviews could be utilised in later rounds since the experts contacted had given permission to do so. The first round simplified the process of gathering critical data for this round by sending direct emails to experts and reminding them through phone calls. Of the initial 28 participants that were interviewed and to whom the first survey was posted, a total of 21 continued with the study. Upon opening the materials delivered to them, each participant was asked to review the participant information sheet (PIS), which, although identical to the previous PIS, was deemed necessary to ensure they remain aware of the nature of the study.

In this round, participants involved in the study were requested to rank the importance of each factor in the survey on a rising Likert scale spanning 1 through 5, where the former represents not important at all, and the latter, significantly important. This data was processed as per Clayton's (1997) suggestion to consider it as interval data when determining overall ratings. As such, to ensure neutrality and a comparable degree of agreement, the numerical degree of consensus among highlighted criteria was determined (Redmond, Rooney and Bishop, 2006). It is recognised that in the statistical analysis of Delphi-derived data sets, that knowledge of both the median (Med) and inter-quartile range (IQR) is beneficial, and thus for each factor, these have been determined (Faherty, 1979) and presented along with the expert opinions of each of the factors in Table 5-6. In this table, variables with a 'Med' score of four or higher and an IQR of one or fewer were judged to be a consensus and deemed to be considered by experts as universally

important in their decision making. Factors where little consensus was found, and those that were considered relatively unimportant, are also highlighted.

The results obtained from this round of research suggests that there is some consensus between the experts in the field as to the relative priority of different factors in terms of how they impact upon their decisions. This consensus in the data can be used as evidence that both the review and interpretation of the extant literature has been sufficiently broad and well understood. Although the summary of the data analysed herein is that more than half the factors (15 out of 29 factors) reached an adequate consensus level based on the agreed threshold of the suggested median, this means that there are fourteen factors that did not reach consensus in round two. In addition, the participants proposed three new factors; hence, there is a need to add the additional factors for the third-round questionnaire.

Table 5-6 Round-two Panel Opinions

	Reliability indicator (Likert scale from 1 to 5)	Panel opinions			
		n	Med	Aver.	IQR
Factors impact the investment decision making	Freight Rate	21	4	3.8	0
	New build order book	21	4	3.9	1
	Secured cargo	21	4	4.42	0
	Time of order	21	3	3.15	1
	Type of ship (new / second hand)	21	3	3.36	1
	Capital	21	4	3.63	1
	Leverage	21	3	3.21	1
	Geopolitical	21	4	3.63	1
	Company profit	21	4	3.94	1
	Oil price	21	4	3.78	1
	New build price	21	4	3.57	1
	Economic crisis	21	4	3.63	1
	Source of finance	21	4	3.94	1
	Competition	21	4	3.78	1
	Number of current fleet	21	3	3.47	1
	Age of current fleet	21	4	3.73	1
	Demand for oil transportation	21	2	2	2
	Scrap prices	21	2	2.26	2
	Second-hand prices	21	2	2	2
	Bunker prices	21	2	2.15	2
	Oil market	21	4	3.89	1
	Crude oil production	21	4	3.89	1
	Fleet Productivity	21	2	2.1	2
	Seaborne Trade	21	2	2.21	2
	Cost of operation	21	2	2.15	2
	Currency exchange price	21	2	2.31	2
	Destination	21	2	2.31	2
	Global economy	21	4	3.89	1
	Shipping market	21	2	2.31	2

Likert scale used (1=not at all important and 5= very important)
Where: n: the number of participants; Med: median; Aver.: the average; IQR: the inter-quartile range

5.3.5. Round Three

Works within the extant literature recommend that those wishing to implement Delphi techniques should include at least two rounds, with the second round demonstrating participant positions in comparison to the expert panel. This allows the participants to adjust, or keep, their initial responses on the basis of these relations. However, in this research, the third round is where the participants had the choice to reconsider their answers. The round three questionnaire was constructed only once the data collected in round two had been objectively analysed. This allows the statistical inferences gained in the primary exploration to feature in the following questionnaire, i.e. the combined opinions of participants in relation to the relative importance of items considered in round two were used to create the new version of the questionnaire for round three. As the second round found consensus on almost half the factors and there were additional factors to add, this round featured the same factors as the first questionnaire, as well as newly suggested factors and statistical data from the second round, which were returned to the same experts along with the group responses. This step attempted to encourage experts who provided responses that differed from those of the group to defend their decisions.

This round was initiated by requesting that the 21 round two participants to continue with the study, yet only 19 of the participants participated in this round. This round followed the same format as previously used, in the form of ranking each factor through a five-point Likert scale, which was supplemented with the inclusion of basic statistics for the factors evaluated in the previous round, namely the mean, median, and inter-quartile range. It was intended that these values would allow such experts to readily review their original assessments, and either confirm or adjust as necessary, and to provide a concise summary of their reasoning in the associated forms.

In this round and to protect secrecy, each participant was sent a questionnaire including the median and interquartile range for each reliability indicator from the previous round, along with his original responses. An additional feature of this stage, not used in previous sessions, was the implementation of follow-up emails to each respondent to encourage them to complete the survey within the two-week timeframe allocated for this stage of data collection. It is notable that this was in all regards a successful addition to the protocol, given that all professionals that were requested to complete the questionnaire did in fact do so, and the summary of their responses can be readily viewed in Table 5-7.In this table, the median response (Med) and inter-quartile range (IQR) for each factor are also included, with the factors identified as having a narrow IQR, i.e. Med' of 4 or more and IQRs of 1 or less deemed to be considered by experts as important in their decision making. The factors where little consensus was found, and those that were considered relatively unimportant, are also highlighted in Table 5-7.

A key conclusion from the overview of the data collected in round three, is that there are differences of opinion between experts in the field, and that they disagree on the relevance of the proposed factors regarding its impact on decision-making. Notwithstanding this, even with the high median threshold for consensus recognition, for more than half the factors (19 out of 32 factors), the panel can be said to have good agreement on their importance. It is also worth bringing to attention that the same ten factors that did not reach consensus in the previous round, again failed to reach a consensus, and thus the decision has been made that they are thus of comparatively low influence when considering the variables that impact upon the process of buying of new vessels. The researcher then created the third questionnaire in this study with the finalized list of factors as a result of this process with the objective of assigning a weight to each identified element that influences the investment decision to assign a new ship.

Table 5-7 Round-Three Panel Opinions

	Reliability indicator (Likert scale from 1 to 5)	Panel opinions						
		n	Med (R1)	Med (R2)	Aver. (R1)	Aver. (R2)	IQR (R1)	IQR (R2)
Factors impact the investment decision making	Freight Rate	19	4	4	3.8	4.06	0	0
	New build order book	19	4	4	3.9	3.81	1	1
	Secured cargo	19	4	4.5	4.42	4.5	0	0
	Time of order	19	3	4	3.15	3.75	1	1
	Type of ship (new / second hand)	19	3	4	3.36	3.75	1	1
	Capital	19	4	4	3.63	3.81	1	1
	Leverage	19	3	4	3.21	3.75	1	1
	Geopolitical	19	4	4	3.63	3.87	1	1
	Company profit	19	4	4	3.94	4.06	1	0.25
	Oil price	19	4	4	3.78	3.81	1	1
	New build price	19	4	4	3.57	3.81	1	1
	Economic crisis	19	4	4	3.63	3.81	1	1
	Source of finance	19	4	4	3.94	4.06	1	0
	Competition	19	4	4	3.78	3.75	1	1
	Number of current fleets	19	3	4	3.47	3.81	1	1
	Age of current fleet	19	4	4	3.73	4	1	0.25
	Demand for oil transportation	19	2	2	2	2.31	2	2
	Scrap prices	19	2	2	2.26	2.31	2	2
	Second-hand prices	19	2	2	2	2.25	2	2
	Bunker prices	19	2	2	2.15	2.12	2	2
	Oil market	19	4	3.5	3.89	3.62	1	1
	Crude oil production	19	4	3.5	3.89	3.5	1	1
	Fleet Productivity	19	2	2	2.1	2.06	2	2
	Seaborne Trade	19	2	2	2.21	2.18	2	2
	Cost of operation	19	2	2	2.15	2.43	2	2
	Currency exchange price	19	2	2	2.31	2.25	2	2
	Destination	19	2	2	2.31	2.31	2	2
	Global economy	19	4	3.5	3.89	3.56	1	1
	Shipping market	19	2	2	2.31	2.5	2	2
	Added Factors in R2							
	Technology	19	NA	4	NA	3.81	NA	1
	IMO regulation	19	NA	4	NA	3.93	NA	0.25
	Company strategy	19	NA	4	NA	3.93	NA	1

5.4. Investment Decision-Making Tools and Criteria

This section targets the third questionnaire in this research; in particular, it targets the first section in the questionnaire, which consists of two questions and aim to demonstrate the tools and criteria that have been used in investment decision making.

5.4.1. Techniques for Decision Making

As can be seen in Table 5-8 and Figure 5-6, the use of Net Present Value and Accounting Rate of Return technique were the two most recommended techniques to be used in the process of decision making in shipping companies with a total of 96.5% out of 100% (27 out 28 participants), and only 3.6 (1 participant) recommended Multiple Criteria Decision Analysis technique. In details, more than half the participants, 53.6% (15 participants), recommend using the Net Present Value technique in the process of decision making. The Accounting Rate of Return technique was the second most recommended technique in decision making with 42.9% (12 participants).

Table 5-8 Techniques for Decision Making in Shipping Companies

		Frequency	**Percent**
Valid	**Multiple Criteria Decision Analysis**	1	3.6
	Net Present Value	15	53.6
	Accounting Rate of Return	12	42.9
	Total	28	100.0

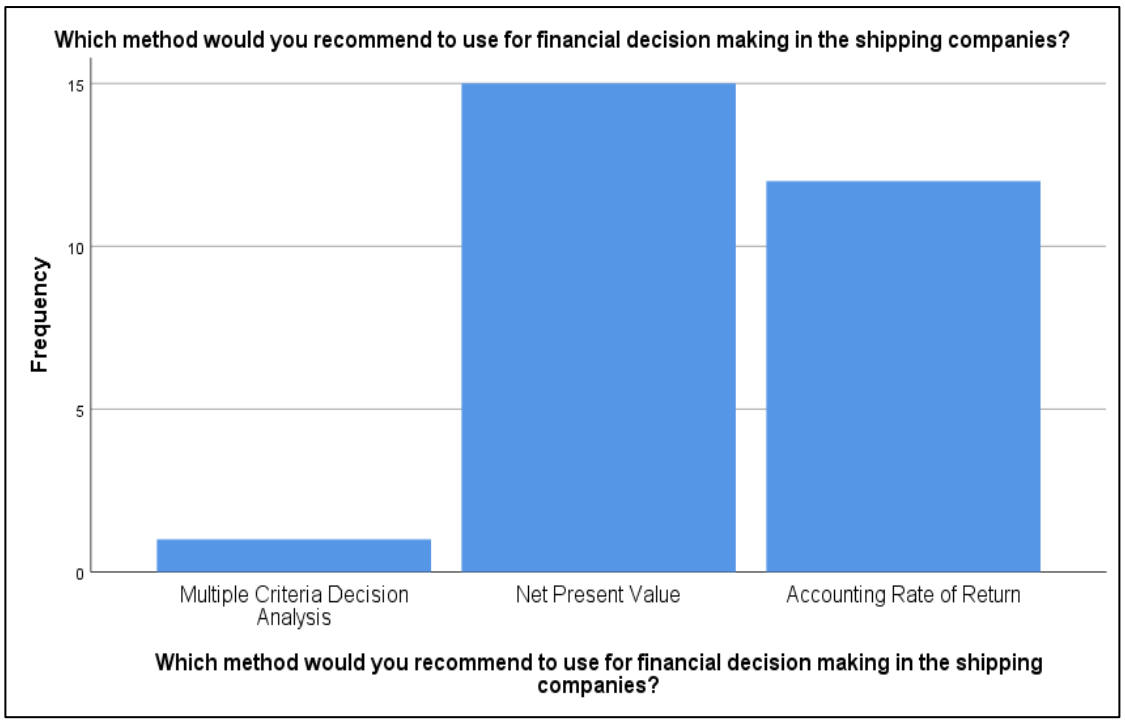

Figure 5-6 Techniques for Decision Making in Shipping

5.4.2. Reasons for Buying a Ship

Table 5-9 and Figure 5-7 display the essential reason to be considered prior to deciding of buying a new ship important according to the participants and experts in this study. Firstly, it shows that the age of existing fleets and the increase of demand are the two most crucial reasons for buying a new ship, according to the experts in this study. To clarify, half the participant, 50% (14 participants), believe that the Increase in demand is the most crucial reason to consider buying a new ship. On the other hand, 42.9% (12 participants) believe that this decision depends on the age of the existing fleet. Additionally, 7.1% (2 participants) believe that the increase in Fright Rate is the main reason to consider when deciding to buy a new ship.

Table 5-9 Reasons for Buying a Ship

		Frequency	Percent
Valid	**Age of Existing Fleet**	12	42.9
	Increase of Demand	14	50.0
	Increase of Fright Rate	2	7.1
	Total	28	100.0

Figure 5-7 Reasons for Buying a Ship

5.5. Factors Degree of Importance

The discussion presented here seeks to explore the third questionnaire's data, and more specifically, that of part two within it. This part sought to determine the priority of each investment factor identified and produce a list of most through to least influential on purchase decisions. The identification of the critical variables that determine investment was a key aim for this study. The Delphi derived study respondents' answers to the survey are presented here. They were asked to rank the importance of all 19 variables on a Likert scale ranging from 1 = Not important, through 2 = slightly important, 3 = important, 4 = fairly important, and finally to 5 = very important. Descriptive statistical analysis was then performed in SPSS 26.0 software (IBM, 2019), which offered a convenient method to store, process, and transform raw data into quantifiable values and graphical depictions from which discussion can be more readily generated (Vogt, 2005). The SPSS 26.0 software (IBM, 2019) was used to determine both the Mean and Mean Score, using equations (5.1) and (5.2), respectively.

$$(\text{Mean} = \frac{(1*f)+(2*f)+(3*f)+(4*f)+(5*f)}{N}) \tag{5.1}$$

in which ***f*** refers to the frequency on each point of a five-point Likert-scale.

These individual means could then be used in equation (5.2) to determine the mean score.

$$(\text{Mean score} = \frac{mean-1}{5-1} * 100 = score\%) \tag{5.2}$$

The relative hierarchy of factor importance is displayed in Table 5-10, which shows the mean, median, and mode for the 19 factors that affect the decisions made in the procurement of new vessels. There is a clear consensus that Secured cargo and Freight Rates are the most influential.

Table 5-10 Factors Degree of Importance

Factors	Degree of Importance					Mode	Mean	Score %
	1	2	3	4	5			
	Frequency							
Freight Rate	0	0	1	12	15	5	4.5	87.5
New build order book	0	11	13	0	4	3	2.89	47.25
Secured cargo	0	0	0	9	19	5	4.68	92
Time of order	4	6	2	12	4	4	3.21	55.25
Type of ship (new / second hand)	7	7	6	8	0	4	2.54	38.5
Capital	1	8	15	4	0	3	2.79	44.75
Technology	5	8	14	1	0	3	2.39	34.75
Leverage	5	10	13	0	0	3	2.29	32.25
Geopolitical	3	9	12	4	0	3	2.61	40.25
Company profit	0	3	11	14	0	4	3.39	59.75
IMO regulation	0	8	8	12	0	4	3.14	53.5
Oil price	4	8	8	8	0	2	2.71	42.75
New build price	4	7	2	9	6	4	3.21	55.25
Economic crisis	4	5	12	7	0	3	2.79	44.75
Company strategy	0	0	16	10	2	3	3.5	62.5
Source of finance	0	7	10	10	1	3	3.18	54.5
Competition	4	13	11	0	0	2	2.25	31.25
Number of current fleet	0	11	6	9	2	2	3.07	51.75
Age of current fleet	0	0	11	12	5	4	3.79	69.75

Factors affecting the decision making with high rate (90% or more)

Factors affecting the decision making with high medium rate (between75% and 89.9)

Factors affecting the decision making with low medium rate (40% and 74.9%)

Factors affecting the decision making with Low rate (39.9% or less)

Table 5-10 displays the degree of importance of each factor among the 19 factors in the decision-making process of buying new ships. It shows a high level of agreement among the participants regarding the two highly influencing factors that is Secured cargo and Freight Rate. To clarify, first, with 92% Mean score and 5 mode (indicated in green), this table reveals that all the participants believe that Secured cargo is highly influencing in the investment decision making in the shipping companies in placing an order to buy new ship; thus, secured cargo can be considered as the most affecting factor in the decision making with a high rate. Second, with 87.5% Mean score and 5 mode (indicated in yellow), this table shows that the majority of participants believe that Freight Rate has a high-medium impact on their decision; hence, Freight Rate can be considered as the second affecting factor with a high-medium rate.

Table 5-10 also reveals that almost two-third of the factors, thirteen factors, are influencing the investment decision making at a low-medium rate (indicated in orange), with their mean score vary between 69.75% and 40.25%. The highest influential factor among this category is Age of the current fleet with 69.75% Mean score, and the lowest is the Geopolitical factor with 40.25% mean score.

Last but not least, this table indicates that the participants in this study believe that the remaining four factors; Type of Ship, Competition, leverage, and technology, have the least influence on the decision whether to buy or not to buy a ship, with the highest mean score among them is the Type of Ship with 38.5% and the lowest and least mean score is the competition with 31. 25%. Hence this table reveals that the most important factor in affecting investment decision to buy ship is secured cargo and the least important factor is competition.

5.6. The Impact of The Participants' Background on Their Responses

In this chapter, a discussion of the effect of a participant's background on their reply to the surveys, and on their ability to choose wise investments is presented through the application of one-way ANOVA assessment through SPSS 26.0 software's (IBM, 2019) tool for Post-Hoc Multiple comparisons. This test should output p-values for every factor represented by a questionnaire topic, in regard to the participant's background, experience and educational circumstances. Laerd Statistics (2018) recommend the use of three or more categories of independent variables as a means of ensuring p-value reliability. If the P-value < 0.05, then there is a noteworthy statistical difference between different groups who responded to a particular statement within the questionnaire. The results presented in this section highlight significant values in orange for ease of comparison. Equation (5.1) can then be applied to determine the limits of the mean.

$$\left(\text{Mean} = \frac{(1*f)+(2*f)+(3*f)+(4*f)+(5*f)}{N}\right) \tag{5.1}$$

in which f refers to the frequency on each point of a five-point Likert-scale.

These individual means could then be used in equation (5.2) to determine the mean score.

$$\left(\text{Mean score} = \frac{\text{mean}-1}{5-1} * 100 = \text{score}\%\right) \tag{5.2}$$

This can be summarised that since (5-1) / 5 = 0.8, the increment for each step in the mean limit (see Table 5-11) should be set at 0.8.

Table 5-11 Mean Limits for each Influence Degree and Color Code

Influence Degree	Mean Limits	Color Code
NO Influence	1 – 1.80	69.9% and below
Low Influence	1.81 – 2.60	
Medium Influence	2.61 – 3.40	
High Influence	3.41 – 4.20	
		70% - 79.9%
Very High Influence	4.21 - 5	80% - 89.9%
		90% and above

This colour scheme is applied in the following section as a means of visually representing the level of influence in ANOVA test. Very high values are coloured in the dark and diminish green, amber indicating high, and all lower values from moderate to zero being coloured red.

5.6.1. Impact of the Participants' Experience

Table 5-12 is showing the Ƥ-value for each statement in relation to the effect of the participants working experience. The highlighted values in orange are reflecting the significant statistical differences between the different working experience and their responses to the rest of the statements in the questionnaire.

Table 5-12 One-way ANOVA for the participants' experience

Question	Sig level	Question	Sig level	Question	Sig level
Q1	0.436	Q8	0.291	Q15	0.130
Q2	0.297	Q9	0.373	Q16	0.264
Q3	0.002	Q10	0.180	Q17	0.013
Q4	0.029	Q11	0.097	Q18	0.798
Q5	0.966	Q12	0.182	Q19	0.248
Q6	0.001	Q13	0.003	Q20	0.086
Q7	0.024	Q14	0.013	Q21	0.001

(Ƥ-value < 0.05 is highlighted in orange and reflects a significant statistical difference)

It is noticeable that there are no significant differences between the participants' responses in relation to their working experience, except statements number 3, 4, 6, 7, 13, 14, 17, and 21. That means the mean limit is almost steady for each statement in relation to their working experience. Table 5-13 below is showing a summary of the post-hoc test for these 8 statements. The scores are the percentage of the mean giving in the test. The gradient in the orange colure code represents the high or the low agreement score among the participants with different working experience (0 to 5 years, 6 to 10 years, 11 to 15 years, 16 to 20 years, 21 years and above).

Table 5-13 Summary of the finding of Post-Hoc test in relation to the working experience

Statement		**Experience**				
		0 to 5 years	**6 to 10 Years**	**11 to 15 Years**	**16 to 20 Years**	**21 Years and above**
Q3	The importance of the fright rate to the investment decision making	100%	75%	79.17%	96.43%	100%
Q4	The importance of the new build order book to the investment decision making	25%	41.67%	47.92%	67.86%	25%
Q6	The importance of the time of order to the investment decision making	25%	8.33%	79.17%	53.57%	35%
Q7	The importance of the type of ship to the investment decision making	0%	8.33%	56.25%	32.14%	30%
Q13	The importance of the IMO regulations to the investment decision making	25%	50%	68.75%	35.71%	50%
Q14	The importance of the oil price to the investment decision making	0%	33.33%	58.33%	42.86%	20%
Q17	The importance of the company strategy to the investment decision making	75%	75%	54.17%	75%	55%
Q21	The importance of the age of current fleet to the investment decision making	75%	83.33%	56.25%	71.43%	90%

5.6.2. Impact of the Participants' Academic Background

Table 5-14 is showing the Ƥ-value for each statement in relation to the effect of the participants' Academic background. The highlighted values in orange are reflecting the significant statistical differences between the different participants' Academic background and their responses to the rest of the statements in the questionnaire.

Table 5-14 One-way ANOVA for the participants' academic background

Question	Sig level	Question	Sig level	Question	Sig level
Q1	0.349	Q8	0.936	Q15	0.263
Q2	0.000	Q9	0.772	Q16	0.841
Q3	0.049	Q10	0.650	Q17	0.049
Q4	0.791	Q11	0.192	Q18	0.884
Q5	0.695	Q12	0.310	Q19	0.058
Q6	0.021	Q13	0.039	Q20	0.006
Q7	0.003	Q14	0.004	Q21	0.003

(Ƥ-value < 0.05 is highlighted in orange and reflects a significant statistical difference)

It is noticeable that there are no significant differences between the participants' responses in relation to their Academic background, except statements number 2, 3, 6, 7, 13, 14, 17, 20 and 21. That means the mean limit is almost steady for each statement in relation to their Academic background. Table 5-15 below is showing a summary of the post-hoc test for these 9 statements. The scores are the percentage of the mean giving in the test. The gradient in the orange colour code represents the high or the low agreement score among the participants from a different academic background (4 years degree, professional degree and decorate).

Table 5-15 Summary of the finding of Post-Hoc test in relation to the participants' academic background

Statement		Academic Background		
		4 Years Degree	**Professional Degree**	**Doctorate**
Q6	The importance of the time of order to the investment decision making	75%	40.63%	75%
Q7	The importance of the type of ship to the investment decision making	50.09%	23.44%	50%
Q13	The importance of the IMO regulations to the investment decision making	65.91%	45.31%	50%
Q14	The importance of the oil price to the investment decision making	61.36%	29.69%	50%
Q17	The importance of the company strategy to the investment decision making	54.55%	68.75%	50%
Q20	The importance of the new build price to the investment decision making	36.36%	59.38%	100%
Q21	The importance of the age of current fleet to the investment decision making	56.82%	76.56%	100%

5.7. Factors Interrelationship

This section targets the third and last section in the third questionnaire that aims to investigate the interrelationship among the factors affecting investment decision-making when buying a ship. This step in the analysis includes the answers to the last section in the 3rd questionnaire from the 28 participants. In this section, each expert was to evaluate the degree of influence of each factor toward the other factors in the process of decision-making. The collected data and all responses towards each factor were analysed using decision-making trial and evaluation laboratory (DEMATEL). The aim of using DEMATEL in this study is to verify the interrelationship between factors that can be reflected through this methodology (Kaushik and Faculty, 2015).

5.7.1. DEMATEL Analysis

The DEMATEL method consists of 4 main steps (see Figure 5-8) and the following sections target the process and steps of analysis using the DEMATEL.

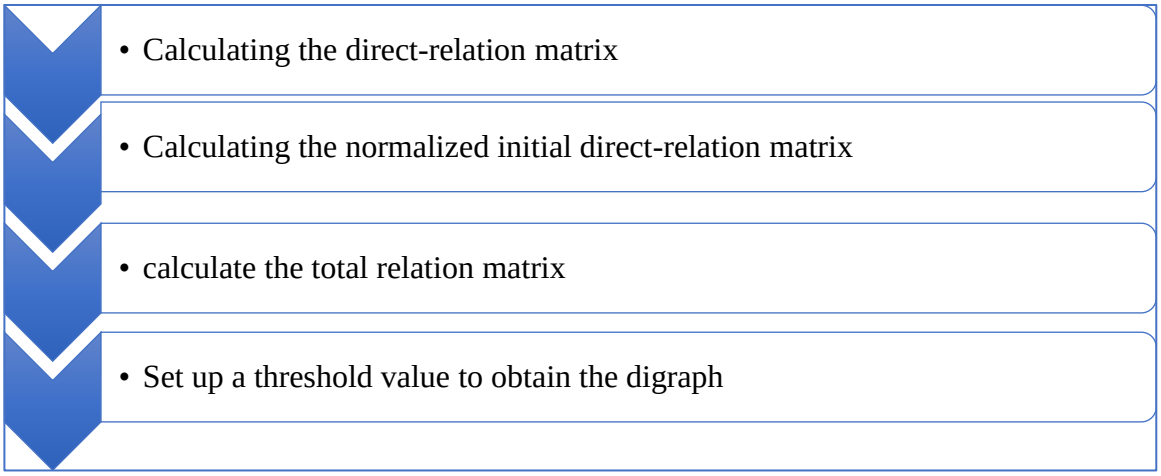

Figure 5-8 Main 4 Steps in The DEMATEL Method

5.7.2. Step 1: Calculate the Average Matrix of an Initial Direct-Relation Matrix A

The DEMATEL method requires the operator to first enter the inputs and then create a direct-relation matrix, for which the average matrix will be required. This means that the subjective views of experts in the field are the first collection requirement (see Table 5-16). This was undertaken by requesting that they rank the effect of one variable on another on a scale running from no influence to very high influence (0–4) as per Ha *et al.*, (2017).

Table 5-16 Influence Measures Using Linguistic Terms (Ha et al., 2017)

Rating scale	Linguistic terms	Linguistic values
0	No influence (No)	(0,0,0.25)
1	Very low influence (VL)	(0,0.25,0.5)
2	Low influence (L)	(0.25,0.5,0.75)
3	High influence (H)	(0.5,0.75,1.0)
4	Very high influence (VH)	(0.75,1.0,1.0)

Ha *et al.*, (2017) technique was applied in this study to determine the initial-direct relation matrix using equation (5.3). In this method, x_{ij} notation is used to illustrate the extent to which a returner understands *i* to impact upon *j*. In the case where the variables are equal (*i*=*j*), the matrix diagonal is null or set to zero. Each response can be described using a$n \times n$ non-negative matrix $X^k = [x_{ij}^k]$, wherein k describes how many respondents, such that $1 \leq k \leq H$. This results in a series of individually representative matrices (X^1, X^2, X^3,.... . , X^H) for each response, which can be averaged as $\boldsymbol{A} = [a_{ij}]$ using equation (5.3).

$$A = [a_{ij}]_{n \times n} = \frac{1}{H} \sum_{k=1}^{H} x_{ij}^k , \qquad i, j = 1 \ldots \ldots . n \tag{5.3}$$

Table 5-17 illustrates the starting direct relation matrix used herein, which was derived from equation (5.3) above.

5.7.3. Step 2: Calculating the Normalized Initial Direct-Relation Matrix (*D*)

The DEMATEL method now requires the direct-relation matrix (D) to be normalised (see Table 5-18) by applying equation (5.4) to each item so that they are all resized to a value from zero to unity. Table 5-18 presents the resultant normalised version of (D) below.

$$D = m \times A \tag{5.4}$$

where, $m = min\left[\frac{1}{max_i \sum_{j=1}^{n} a_{ij}}, \frac{1}{max_j \sum_{j=1}^{n} a_{ij}}\right], i, j \in \{1,2, \dots, n$

Table 5-17 Initial Direct-relation Matrix A

	FR	NBOB	SC	ToO	ToS	CAP	Tech	Leve	Geop	CP	IMOr	OP	NBP	EC	CS	SF	Comp	NOCF	AoF		SUM	
FR	0	0.59	0.39	0.50	0.32	0.14	0.17	0.11	0.07	0.77	0.14	0.11	0.71	0.11	0.54	0.50	0.71	0.50	0.17		7	1.4800
NBOB	0.49	0	0.17	0.59	0.41	0.17	0.17	0.07	0.07	0.14	0.07	0.11	0.79	0.11	0.39	0.41	0.54	0.17	0.17		5	1.2500
SC	0.39	0.11	0	0.77	0.50	0.59	0.11	0.30	0.17	0.79	0.07	0.07	0.07	0.07	0.79	0.56	0.79	0.60	0.32		7	1.2700
ToO	0.11	0.45	0.26	0	0.14	0.36	0.11	0.11	0.07	0.73	0.07	0.07	0.34	0.07	0.50	0.41	0.71	0.30	0.11		5	0.8200
ToS	0.14	0.14	0.39	0.39	0	0.30	0.17	0.07	0.07	0.39	0.07	0.07	0.45	0.07	0.36	0.39	0.36	0.11	0.14		4	1.0600
CAP	0.07	0.07	0.50	0.41	0.36	0	0.14	0.55	0.07	0.45	0.07	0.07	0.07	0.07	0.76	0.71	0.70	0.46	0.14		6	1.0500
Tech	0.11	0.41	0.30	0.23	0.21	0.11	0	0.07	0.07	0.30	0.36	0.11	0.70	0.07	0.21	0.17	0.41	0.17	0.17		4	1.0500
Leve	0.07	0.07	0.41	0.28	0.23	0.36	0.07	0	0.07	0.39	0.07	0.07	0.07	0.07	0.39	0.78	0.39	0.30	0.14		4	0.8300
Geop	0.77	0.50	0.61	0.54	0.45	0.64	0.23	0.36	0	0.78	0.39	0.79	0.73	0.79	0.78	0.77	0.73	0.30	0.14		10	2.4200
CP	0.07	0.07	0.66	0.67	0.50	0.59	0.17	0.66	0.07	0	0.07	0.07	0.11	0.07	0.71	0.71	0.71	0.64	0.23		7	1.4700
IMOr	0.21	0.36	0.17	0.51	0.28	0.17	0.71	0.07	0.07	0.36	0	0.07	0.46	0.07	0.39	0.20	0.30	0.36	0.50		5	1.2500
OP	0.72	0.64	0.45	0.64	0.50	0.07	0.11	0.07	0.61	0.50	0.07	0	0.50	0.71	0.45	0.23	0.17	0.37	0.26		7	2.4500
NBP	0.21	0.78	0.14	0.78	0.62	0.39	0.14	0.23	0.07	0.59	0.07	0.07	0	0.07	0.55	0.55	0.66	0.59	0.36		7	1.9100
EC	0.77	0.77	0.54	0.71	0.50	0.62	0.17	0.45	0.55	0.79	0.07	0.79	0.79	0	0.78	0.72	0.77	0.71	0.17		11	2.7900
CS	0.17	0.07	0.36	0.72	0.71	0.76	0.07	0.62	0.07	0.78	0.07	0.07	0.14	0.07	0	0.49	0.72	0.60	0.30		7	1.3200
SF	0.07	0.36	0.14	0.76	0.60	0.62	0.11	0.36	0.07	0.77	0.07	0.07	0.41	0.07	0.76	0	0.71	0.34	0.21		7	1.3300
Comp	0.70	0.39	0.71	0.71	0.50	0.76	0.11	0.50	0.07	0.79	0.07	0.07	0.50	0.07	0.79	0.50	0	0.71	0.30		8	2.5100
NOCF	0.30	0.14	0.39	0.55	0.26	0.46	0.11	0.17	0.07	0.78	0.07	0.07	0.17	0.07	0.71	0.45	0.78	0	0.26		6	1.3800
AoF	0.11	0.17	0.50	0.71	0.46	0.62	0.17	0.17	0.07	0.68	0.14	0.07	0.14	0.07	0.61	0.14	0.61	0.30	0		6	1.4900
																					MAX	10.6700
SUM	5	6	7	10	8	8	3	5	2	11	2	3	7	3	10	9	11	8	4	**MAX**		
	0.99	1.15	0.82	1.86	1.37	1.26	0.56	0.59	0.38	2.43	0.35	0.36	1.91	0.36	2.22	1.88	2.75	1.57	0.77	10.7800		

Table 5-18 Normalized Initial Direct-relation Matrix 'D'

(FR: Freight Rate, NBOB: New Build Order Book, SC: Secured Cargo, ToO: Time of Order, ToS: Type of Ship, CAP: Capital, Tech: Technology, Geop: Geopolitical, CP: Company profit, IMOr: IMO regulation, OP: Oil Price, NBP: New build price, EC: Economic crisis, CS: Company strategy, SF: Source of finance, Comp: Competition, NOCF: Number of current fleet, AoF: Age of current fleet)

	FR	NBOB	SC	ToO	ToS	CAP	Tech	Leve	Geop	CP	IMOr	OP	NBP	EC	CS	SF	Comp	NOCF	AoF	M20
FR	0	0.05	0.04	0.05	0.030	0.013	0.016	0.010	0.007	0.071	0.013	0.010	0.066	0.010	0.050	0.046	0.066	0.046	0.016	100
NBOB	0.05	0	0.02	0.05	0.038	0.016	0.016	0.007	0.007	0.013	0.007	0.010	0.073	0.010	0.036	0.038	0.050	0.016	0.016	100
SC	0.04	0.01	0	0.07	0.046	0.055	0.010	0.028	0.016	0.073	0.007	0.007	0.007	0.007	0.073	0.052	0.073	0.056	0.030	100
ToO	0.01	0.04	0.02	0	0.013	0.033	0.010	0.010	0.007	0.068	0.007	0.007	0.032	0.007	0.046	0.038	0.066	0.028	0.010	100
ToS	0.013	0.013	0.036	0.036	0	0.028	0.016	0.007	0.007	0.036	0.007	0.007	0.042	0.007	0.033	0.036	0.033	0.010	0.013	100
CAP	0.007	0.007	0.046	0.038	0.033	0	0.013	0.051	0.007	0.042	0.007	0.007	0.007	0.007	0.071	0.066	0.065	0.043	0.013	100
Tech	0.010	0.038	0.028	0.021	0.020	0.010	0	0.007	0.007	0.028	0.033	0.010	0.065	0.007	0.020	0.016	0.038	0.016	0.016	100
Leve	0.007	0.007	0.038	0.026	0.021	0.033	0.007	0	0.007	0.036	0.007	0.007	0.007	0.007	0.036	0.072	0.036	0.028	0.013	100
Geop	0.071	0.046	0.057	0.050	0.042	0.059	0.021	0.033	0	0.072	0.036	0.073	0.068	0.073	0.072	0.071	0.068	0.028	0.013	100
CP	0.007	0.007	0.061	0.062	0.046	0.055	0.016	0.061	0.007	0	0.007	0.007	0.010	0.007	0.066	0.066	0.066	0.059	0.021	100
IMOr	0.020	0.033	0.016	0.047	0.026	0.016	0.066	0.007	0.007	0.033	0	0.007	0.043	0.007	0.036	0.019	0.028	0.033	0.046	100
OP	0.067	0.059	0.042	0.059	0.046	0.007	0.010	0.007	0.057	0.046	0.007	0	0.046	0.066	0.042	0.021	0.016	0.034	0.024	100
NBP	0.020	0.072	0.013	0.072	0.058	0.036	0.013	0.021	0.007	0.055	0.007	0.007	0	0.007	0.051	0.051	0.061	0.055	0.033	100
EC	0.071	0.071	0.050	0.066	0.046	0.058	0.016	0.042	0.051	0.073	0.007	0.073	0.073	0	0.072	0.067	0.071	0.066	0.016	100
CS	0.016	0.007	0.033	0.067	0.066	0.071	0.007	0.058	0.007	0.072	0.007	0.007	0.013	0.007	0	0.046	0.067	0.056	0.028	100
SF	0.007	0.033	0.013	0.071	0.056	0.058	0.010	0.033	0.007	0.071	0.007	0.007	0.038	0.007	0.071	0	0.066	0.032	0.020	100
COMP	0.065	0.036	0.066	0.066	0.046	0.071	0.010	0.046	0.007	0.073	0.007	0.007	0.046	0.007	0.073	0.046	0	0.066	0.028	100
NOCF	0.028	0.013	0.036	0.051	0.024	0.043	0.010	0.016	0.007	0.072	0.007	0.007	0.016	0.007	0.066	0.042	0.072	0	0.024	100
AoF	0.010	0.016	0.046	0.066	0.043	0.058	0.016	0.016	0.007	0.063	0.013	0.007	0.013	0.007	0.057	0.013	0.057	0.028	0	100
M20	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0

(FR: Freight Rate, NBOB: New Build Order Book, SC: Secured Cargo, ToO: Time of Order, ToS: Type of Ship, CAP: Capital, Tech: Technology, Geop: Geopolitical, CP: Company profit, IMOr: IMO regulation, OP: Oil Price, NBP: New build price, EC: Economic crisis, CS: Company strategy, SF: Source of finance, Comp: Competition, NOCF: Number of current fleet, AoF: Age of current fleet)

5.7.4. Step 3: Calculate the Total Relation Matrix (T)

As the variables are all initially measured using different scales, they are hard to compare. Application of a normalised direct-relation matrix (D) allows for this comparison to go ahead, and in doing so, finishes DEMATEL's tertiary phase, whose primary objective is to determine the total relation matrix (T). This matrix is created through the application of equations (5.5) and (5.6) to an n x n sized identity matrix (I). In this notation, the impacts of variable i on j is written as $\tilde{t}_{ij}$, with matrix T showing the sum of all links between all the variables.

$$T = \lim_{m=\infty}(D^1 + D^2 + \cdots + D^m) = \sum_{m=1}^{\infty} D^i \tag{5.5}$$

$$\sum_{m=1}^{\infty} D^i = D^1 + D^2 + \cdots + D^m$$

$$= D(I + D^1 + D^2 + \cdots + D^{m-1})$$

$$= D\,(I - D)^{-1}(I - D)(D^1 + D^2 + \cdots + D^m)$$

$$= D(I - D)^{-1}(I - D)^m$$

$$T = D(I - D)^{-1} \tag{5.6}$$

An overview of the questionnaire data representing the extent of each variable's influence on investment decisions, as considered by the experts interviewed, is presented in Table 5-19. Every value in this table can be considered the sum of the indirect and direct effects each variable 'i' has over a second variable 'j'. An example reading of this chart might state that there is a total effect of 0.09 by FR on NBOB.

Table 5-19 Total Relation matrix (T).

	FR	NBOB	SC	ToO	ToS	CAP	Tech	Leve	Geop	CP	IMOr	OP	NBP	EC	CS	SF	COMP	NOCF	AoF	SUM Ri
FR	0.03	0.09	0.09	0.12	0.0860	0.0754	0.0340	0.0525	0.0188	0.1473	0.0243	0.0228	0.1070	0.0226	0.1255	0.1092	0.1438	0.1031	0.0460	1.4524
NBOB	0.07	0.03	0.05	0.11	0.0805	0.0622	0.0297	0.0374	0.0161	0.0753	0.0156	0.0202	0.1061	0.0200	0.0937	0.0857	0.1101	0.0602	0.0386	1.1204
SC	0.07	0.05	0.06	0.15	0.1042	0.1210	0.0293	0.0746	0.0281	0.1567	0.0189	0.0202	0.0503	0.0200	0.1538	0.1201	0.1569	0.1156	0.0600	1.5529
ToO	0.04	0.07	0.06	0.06	0.0572	0.0813	0.0240	0.0449	0.0157	0.1251	0.0152	0.0162	0.0629	0.0160	0.1048	0.0873	0.1249	0.0727	0.0333	1.1098
ToS	0.0334	0.0368	0.0673	0.0840	0.0362	0.0667	0.0270	0.0339	0.0143	0.0855	0.0139	0.0146	0.0668	0.0144	0.0816	0.0760	0.0837	0.0474	0.0318	0.9156
CAP	0.0344	0.0353	0.0902	0.1028	0.0812	0.0565	0.0278	0.0878	0.0169	0.1105	0.0162	0.0171	0.0406	0.0169	0.1347	0.1197	0.1315	0.0913	0.0385	1.2499
Tech	0.0326	0.0631	0.0586	0.0707	0.0554	0.0483	0.0133	0.0318	0.0146	0.0763	0.0404	0.0185	0.0918	0.0149	0.0675	0.0558	0.0870	0.0524	0.0358	0.9288
Leve	0.0273	0.0289	0.0708	0.0760	0.0583	0.0749	0.0182	0.0293	0.0146	0.0882	0.0139	0.0148	0.0327	0.0146	0.0871	0.1120	0.0883	0.0650	0.0322	0.9469
Geop	0.1281	0.1109	0.1380	0.1727	0.1322	0.1539	0.0518	0.0997	0.0254	0.1970	0.0544	0.0970	0.1395	0.0962	0.1935	0.1733	0.1929	0.1217	0.0611	2.3393
CP	0.0387	0.0402	0.1116	0.1357	0.1006	0.1174	0.0330	0.1027	0.0187	0.0823	0.0179	0.0188	0.0495	0.0186	0.1419	0.1293	0.1445	0.1147	0.0504	1.4665
IMOr	0.0437	0.0626	0.0545	0.1035	0.0675	0.0612	0.0791	0.0365	0.0157	0.0920	0.0106	0.0165	0.0766	0.0161	0.0921	0.0651	0.0884	0.0749	0.0681	1.1246
OP	0.1080	0.1053	0.0989	0.1442	0.1083	0.0750	0.0318	0.0518	0.0725	0.1355	0.0211	0.0218	0.1007	0.0829	0.1276	0.0954	0.1084	0.0981	0.0562	1.6434
NBP	0.0524	0.1058	0.0653	0.1462	0.1113	0.0974	0.0313	0.0627	0.0184	0.1317	0.0181	0.0191	0.0446	0.0189	0.1265	0.1138	0.1400	0.1089	0.0617	1.4742
EC	0.1286	0.1339	0.1336	0.1892	0.1376	0.1541	0.0455	0.1081	0.0733	0.2004	0.0265	0.0960	0.1450	0.0269	0.1960	0.1714	0.1997	0.1574	0.0639	2.3873
CS	0.0466	0.0400	0.0868	0.1387	0.1175	0.1306	0.0245	0.0991	0.0184	0.1487	0.0177	0.0187	0.0521	0.0185	0.0791	0.1107	0.1444	0.1107	0.0558	1.4587
SF	0.0374	0.0659	0.0646	0.1405	0.1076	0.1162	0.0275	0.0752	0.0178	0.1440	0.0173	0.0184	0.0761	0.0182	0.1416	0.0641	0.1406	0.0865	0.0473	1.4069
COMP	0.1001	0.0776	0.1262	0.1558	0.1126	0.1426	0.0321	0.0968	0.0211	0.1674	0.0204	0.0215	0.0938	0.0212	0.1646	0.1256	0.1008	0.1335	0.0629	1.7766
NOCF	0.0562	0.0439	0.0835	0.1181	0.0745	0.0991	0.0262	0.0564	0.0172	0.1416	0.0167	0.0176	0.0518	0.0174	0.1334	0.0991	0.1419	0.0535	0.0501	1.2982
AoF	0.0380	0.0446	0.0913	0.1284	0.0890	0.1099	0.0314	0.0539	0.0170	0.1291	0.0228	0.0172	0.0473	0.0170	0.1215	0.0698	0.1242	0.0776	0.0255	1.2557
SUM Ci	1.1154	1.2331	1.6036	2.3509	1.7177	1.8438	0.6175	1.2349	0.4547	2.4346	0.4019	0.5072	1.4351	0.4912	2.3666	1.9834	2.4522	1.7450	0.9193	

(FR: Freight Rate, NBOB: New Build Order Book, SC: Secured Cargo, ToO: Time of Order, ToS: Type of Ship, CAP: Capital, Tech: Technology, Geop: Geopolitical, CP: Company profit, IMOr: IMO regulation, OP: Oil Price, NBP: New build price, EC: Economic crisis, CS: Company strategy, SF: Source of finance, Comp: Competition, NOCF: Number of current fleet, AoF: Age of current fleet)

After calculating the matrix ($\tilde{T}$), both the rows r and columns c can be summed in their respective directions as a means of determining the level of relationship for each variable. These summations can be expressed as a pair of vectors with respective dimensions of r=n x 1, and c=1 x n respectively, and are explicitly calculated using equations (5.7) and (5.8) below.

$$r = [r_i]_{n\times 1} = \left[\sum_{j=1}^{n} t_{ij}\right]_{n\times 1} \tag{5.7}$$

$$c = [r_i]_{n\times 1} = \left[\sum_{j=1}^{n} t_{ij}\right]_{n\times 1} \tag{5.8}$$

The relevance of these summations can be seen by considering that if r_i is the sum of a given row in $\tilde{T}$, then it can be said to represent the total effects both direct and indirect effects, *i* has on the remaining variables. Similarly, c_j indicates a columnar summation of $\tilde{T}$, which itself I representative of the effects both direct and indirect impact that *j* exerts on the other variables (Yang *et al.*, 2008; Akyuz and Celik, 2015; Kaushik and Faculty, 2015).

An example of this might show that the sum of the FR row (r_i) (1.4524) represents the total direct and indirect influence that the FR as an individual factor has over the investment decision making. In contrast, the total sum of the FR column (c_i) (1.1154) represents the total direct, and indirect influence of the investment decision making has over the FR as an individual, as shown in Table 5-20

A further observation is that when $j = i$, the sum ($r_i + c_j$) shows the total effects given and received by factor i. That is, ($r_i + c_j$) indicates the degree of importance that factor i plays in the entire system. On the contrary, the difference ($r_i - c_j$) depicts the net effect that factor i contributes to the decision. Specifically, if ($r_i - c_j$) is positive, factor i is a net cause, if ($r_i - c_j$) is a negative factor is an effect (Yang *et al.*, 2008; Akyuz and Celik, 2015; Kaushik and Faculty, 2015). Table 5-20 summarises the factors, and both the indirect and direct links between them.

Table 5-20 The Direct, Indirect Relations and Type of Factors

	Ri	Ci	Ri+Ci	Ri-Ci	Type
FR	1.4524	1.1154	2.5678	0.3370	**Cause**
NBOB	1.1204	1.2331	2.3535	-0.1127	**Effect**
SC	1.5529	1.6036	3.1565	-0.0507	**Effect**
ToO	1.1098	2.3509	3.4607	-1.2411	**Effect**
ToS	0.9156	1.7177	2.6333	-0.8022	**Effect**
CAP	1.2499	1.8438	3.0937	-0.5939	**Effect**
Tech	0.9288	0.6175	1.5463	0.3113	**Cause**
Leve	0.9469	1.2349	2.1817	-0.2880	**Effect**
Geop	2.3393	0.4547	2.7940	1.8846	**Cause**
CP	1.4665	2.4346	3.9011	-0.9681	**Effect**
IMOr	1.1246	0.4019	1.5265	0.7227	**Cause**
OP	1.6434	0.5072	2.1506	1.1362	**Cause**
NBP	1.4742	1.4351	2.9093	0.0390	**Cause**
EC	2.3873	0.4912	2.8785	1.8961	**Cause**
CS	1.4587	2.3666	3.8252	-0.9079	**Effect**
SF	1.4069	1.9834	3.3903	-0.5765	**Effect**
COMP	1.7766	2.4522	4.2288	-0.6755	**Effect**
NOCF	1.2982	1.7450	3.0432	-0.4467	**Effect**
AoF	1.2557	0.9193	2.1750	0.3364	**Cause**

5.7.5. Step 4: Set up a Threshold Value to Obtain the Influence-Relations Map (IRM)

The precise nature of this threshold can be identified either using an expert's opinion (subjective), or using mathematics (objective) (Liou, Tzeng and Chang, 2007; Shieh, Wu and Huang, 2010; Ha *et al.*, 2017). When considering the values presented in matrix ***T***, values higher than the mean are considered as the threshold (Tzeng, Chiang and Li, 2007; Shieh, Wu and Huang, 2010; Alkhatib *et al.*, 2015), which is representative of the interdependent relationship between the related factors. The fourth stage in the DEMATEL framework involves evaluating the value of these thresholds (α), by calculating the mean of the $\tilde{T}$ matrix as per equation (5.9), which primarily functions as a method for removing insignificant effects from the overall matrix itself.

$$\alpha = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} t_{ij}}{N} \tag{5.9}$$

Where, N is the total number of elements in the matrix T = ($i \times j$)

The insignificant elements of the matrix $\tilde{T}$ are best removed through the application of thresholds, which must be determined by the decision maker. The complete matrix $\tilde{T}$, which describes all relations, is observable in Table 5-21. The variables that surpass this minimum value in terms of the extent to which they affect (t_{ij}) can be used to construct a causal relationship diagram (Ha *et al.*, 2017). In this case study, Table 5-21 utilises a minimum value for the interest of 0.0745, which is the threshold value in the T matrix, wherein variables above this value are deemed significant and taken forward to construct the influential relationship image depicted in Figure 5-9.

Table 5-21 Total-relation Matrix T and Threshold Value (α)

	FR	NBOB	SC	ToO	ToS	CAP	Tech	Leve	Geop	CP	IMOr	OP	NBP	EC	CS	SF	COMP	NOCF	AoF	SUM Ri
FR	0.03	0.09	0.09	0.12	0.0860	0.0754	0.0340	0.0525	0.0188	0.1473	0.0243	0.0228	0.1070	0.0226	0.1255	0.1092	0.1438	0.1031	0.0460	1.4524
NBOB	0.07	0.03	0.05	0.11	0.0805	0.0622	0.0297	0.0374	0.0161	0.0753	0.0156	0.0202	0.1061	0.0200	0.0937	0.0857	0.1101	0.0602	0.0386	1.1204
SC	0.07	0.05	0.06	0.15	0.1042	0.1210	0.0293	0.0746	0.0281	0.1567	0.0189	0.0202	0.0503	0.0200	0.1538	0.1201	0.1569	0.1156	0.0600	1.5529
ToO	0.04	0.07	0.06	0.06	0.0572	0.0813	0.0240	0.0449	0.0157	0.1251	0.0152	0.0162	0.0629	0.0160	0.1048	0.0873	0.1249	0.0727	0.0333	1.1098
ToS	0.0334	0.0368	0.0673	0.0840	0.0362	0.0667	0.0270	0.0339	0.0143	0.0855	0.0139	0.0146	0.0668	0.0144	0.0816	0.0760	0.0837	0.0474	0.0318	0.9156
CAP	0.0344	0.0353	0.0902	0.1028	0.0812	0.0565	0.0278	0.0878	0.0169	0.1105	0.0162	0.0171	0.0406	0.0169	0.1347	0.1197	0.1315	0.0913	0.0385	1.2499
Tech	0.0326	0.0631	0.0586	0.0707	0.0554	0.0483	0.0133	0.0318	0.0146	0.0763	0.0404	0.0185	0.0918	0.0149	0.0675	0.0558	0.0870	0.0524	0.0358	0.9288
Leve	0.0273	0.0289	0.0708	0.0760	0.0583	0.0749	0.0182	0.0293	0.0146	0.0882	0.0139	0.0148	0.0327	0.0146	0.0871	0.1120	0.0883	0.0650	0.0322	0.9469
Geop	0.1281	0.1109	0.1380	0.1727	0.1322	0.1539	0.0518	0.0997	0.0254	0.1970	0.0544	0.0970	0.1395	0.0962	0.1935	0.1733	0.1929	0.1217	0.0611	2.3393
CP	0.0387	0.0402	0.1116	0.1357	0.1006	0.1174	0.0330	0.1027	0.0187	0.0823	0.0179	0.0188	0.0495	0.0186	0.1419	0.1293	0.1445	0.1147	0.0504	1.4665
IMOr	0.0437	0.0626	0.0545	0.1035	0.0675	0.0612	0.0791	0.0365	0.0157	0.0920	0.0106	0.0165	0.0766	0.0161	0.0921	0.0651	0.0884	0.0749	0.0681	1.1246
OP	0.1080	0.1053	0.0989	0.1442	0.1083	0.0750	0.0318	0.0518	0.0725	0.1355	0.0211	0.0218	0.1007	0.0829	0.1276	0.0954	0.1084	0.0981	0.0562	1.6434
NBP	0.0524	0.1058	0.0653	0.1462	0.1113	0.0974	0.0313	0.0627	0.0184	0.1317	0.0181	0.0191	0.0446	0.0189	0.1265	0.1138	0.1400	0.1089	0.0617	1.4742
EC	0.1286	0.1339	0.1336	0.1892	0.1376	0.1541	0.0455	0.1081	0.0733	0.2004	0.0265	0.0960	0.1450	0.0269	0.1960	0.1714	0.1997	0.1574	0.0639	2.3873
CS	0.0466	0.0400	0.0868	0.1387	0.1175	0.1306	0.0245	0.0991	0.0184	0.1487	0.0177	0.0187	0.0521	0.0185	0.0791	0.1107	0.1444	0.1107	0.0558	1.4587
SF	0.0374	0.0659	0.0646	0.1405	0.1076	0.1162	0.0275	0.0752	0.0178	0.1440	0.0173	0.0184	0.0761	0.0182	0.1416	0.0641	0.1406	0.0865	0.0473	1.4069
COMP	0.1001	0.0776	0.1262	0.1558	0.1126	0.1426	0.0321	0.0968	0.0211	0.1674	0.0204	0.0215	0.0938	0.0212	0.1646	0.1256	0.1008	0.1335	0.0629	1.7766
NOCF	0.0562	0.0439	0.0835	0.1181	0.0745	0.0991	0.0262	0.0564	0.0172	0.1416	0.0167	0.0176	0.0518	0.0174	0.1334	0.0991	0.1419	0.0535	0.0501	1.2982
AoF	0.0380	0.0446	0.0913	0.1284	0.0890	0.1099	0.0314	0.0539	0.0170	0.1291	0.0228	0.0172	0.0473	0.0170	0.1215	0.0698	0.1242	0.0776	0.0255	1.2557
SUM Ci	1.1154	1.2331	1.6036	2.3509	1.7177	1.8438	0.6175	1.2349	0.4547	2.4346	0.4019	0.5072	1.4351	0.4912	2.3666	1.9834	2.4522	1.7450	0.9193	

(FR: Freight Rate, NBOB: New Build Order Book, SC: Secured Cargo, ToO: Time of Order, ToS: Type of Ship, CAP: Capital, Tech: Technology, Geop: Geopolitical, CP: Company profit, IMOr: IMO regulation, OP: Oil Price, NBP: New build price, EC: Economic crisis, CS: Company strategy, SF: Source of finance, Comp: Competition, NOCF: Number of current fleet, AoF: Age of current fleet)

Threshold Value	**0.0745**

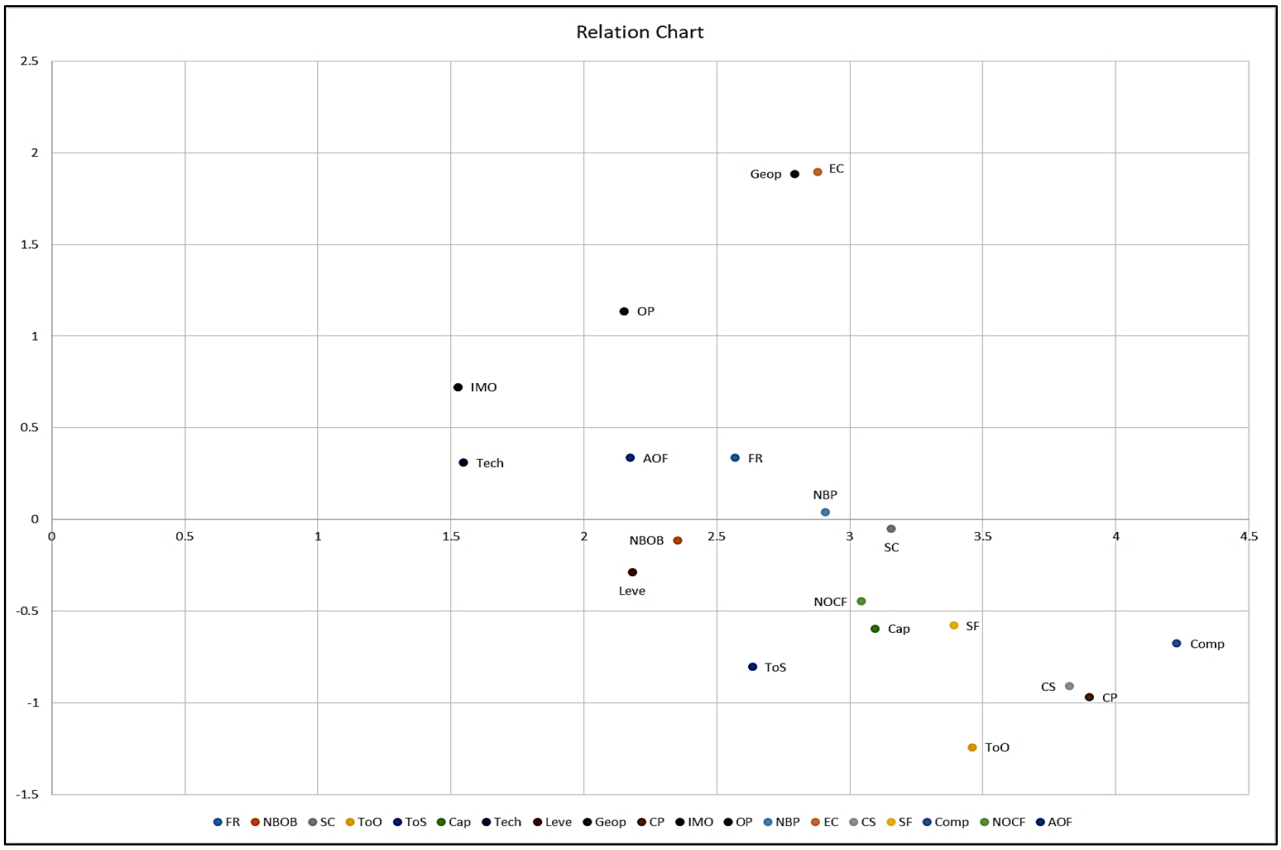

Figure 5-9 Factors Influence-Relations Map (IRM)

A total of nineteen variables were determined to impact investment choices, with competition, company profit, and overall strategy deemed to have the greatest effect (see Table 5-21, and Figure 5-9 for details). In addition to these three parameters, time of order and source of finance was also noteworthy. The significance of this is that these criteria should be considered foremost when determining the viability of a given investment, whereas factors such as technology or IMO regulation, can be paid comparatively little attention. The decision to seek out a new vessel for purchase appears to be primarily driven by the economic crisis, oil price, and geopolitical factors (see Table 5-21, and Figure 5-9for a detailed depiction of the web of the inter-factorial relationships), yet it appears that the eventual purchase decision is ultimately determined by profit, strategy, and the specific ordering time. (for more details about the interrelationship between the factors, see Table 5-21 and Figure 5-9).

5.8. Conclusion

In summary, this chapter offers a detailed discussion of the Delphi method results, which include interview and questionnaire. The primary data in this study was collected from shipping companies, experts in professional roles such as financial management and company directors, and university professors. It also describes how the Delphi technique may be applied as a means of guiding those wishing to determine the key factors that impact upon the decision to invest or divest in a given shipping vessel. This chapter also offers a detailed discussion of the third questionnaire that was used to gather data that could then be used to inform about the importance of each factor, and the interrelationship that lies between them.

6. Case Study

6.1. Chapter Overview

The purpose of this chapter is to present a case study using company (Z) as an attempt to reach the following objectives:

- Forecast the future of oil price.
- Create an investment decision-making equation whereby the shipping companies can incorporate into their decision-making process in order to make informed and faster decisions about placing newbuild tanker order.

6.2. Artificial Neural Networks (ANN)

The third step of data collection aims to reach one of the research objectives that is forecasting future oil prices for the period from 2021 till 2030 using Artificial Neural Network (ANN).

6.2.1. Empirical Application of ANN

This study utilises MATLAB's Neural Network Toolbox Version 2016b (MathWorks, 2016) to investigate the future for the price of oil. MATLAB is mathematical software that offers an engaging interface through which data can be evaluated and models, tool, or algorithms created from it using either computation, graphical means, or more fundamental programming. The integrated nature of the software, along with the library of pre-defined functions and subroutines, allows for solutions to questions posed in the research to be accessed more rapidly than could be achieved in a more basic programming language or spreadsheet-style software. Furthermore, it contains additional functionalities in that it is able to communicate in both directions with other software as a means of including based algorithms in its repertoire. The process of using Scaled Conjugate Gradient Backpropagation algorithm (SCG/ trainscg) in this research is introduced in three stages: training stage, testing stage, forecasting stage.

In the training stage, the historical data were collected that are related to the factors affecting the oil price from 1980 till 2020, as mentioned before in chapter 4, section 4.5.2.3. The collected data from 1980 till 2017 were inserted into MATLAB version 2016b (MathWorks, 2016), and the SCG data training algorithm was used. It includes three layers: input, hidden, and output layers. Each layer consists of 6 nods: Oil price, oil supply, oil demand, economic crisis, the strength of the US dollar, and world GDP see Figure 6-1. However, it is important to note that initially, each layer consisted of 7 nods with geopolitical factor as the 7th nods, yet it was excluded during training since it does not reflect any sign of correlation with the other nods see Figure 6-2. The training results in layers Map Figure 6-3 shows a high level of validation with the Regression (R)= 0.99. since R range between $1 \leq R \leq 0$ with one indicates a high level of validation according to (Harrell Jr, 2015).

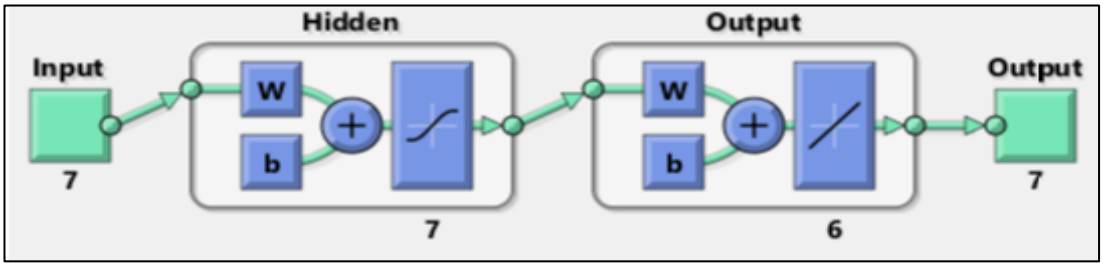

Figure 6-1 Second Run of ANN Training

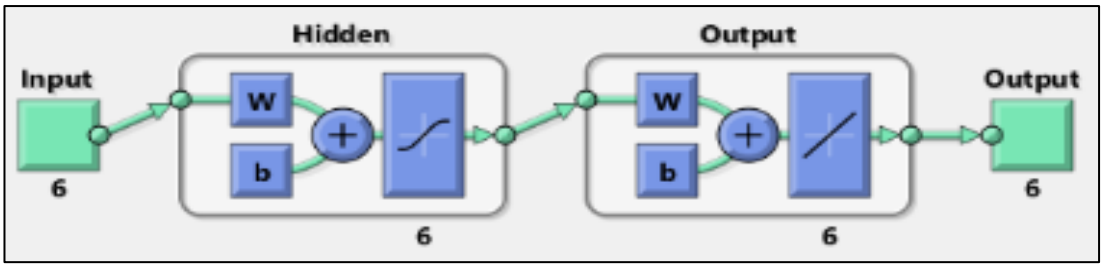

Figure 6-2 First Run of ANN Training

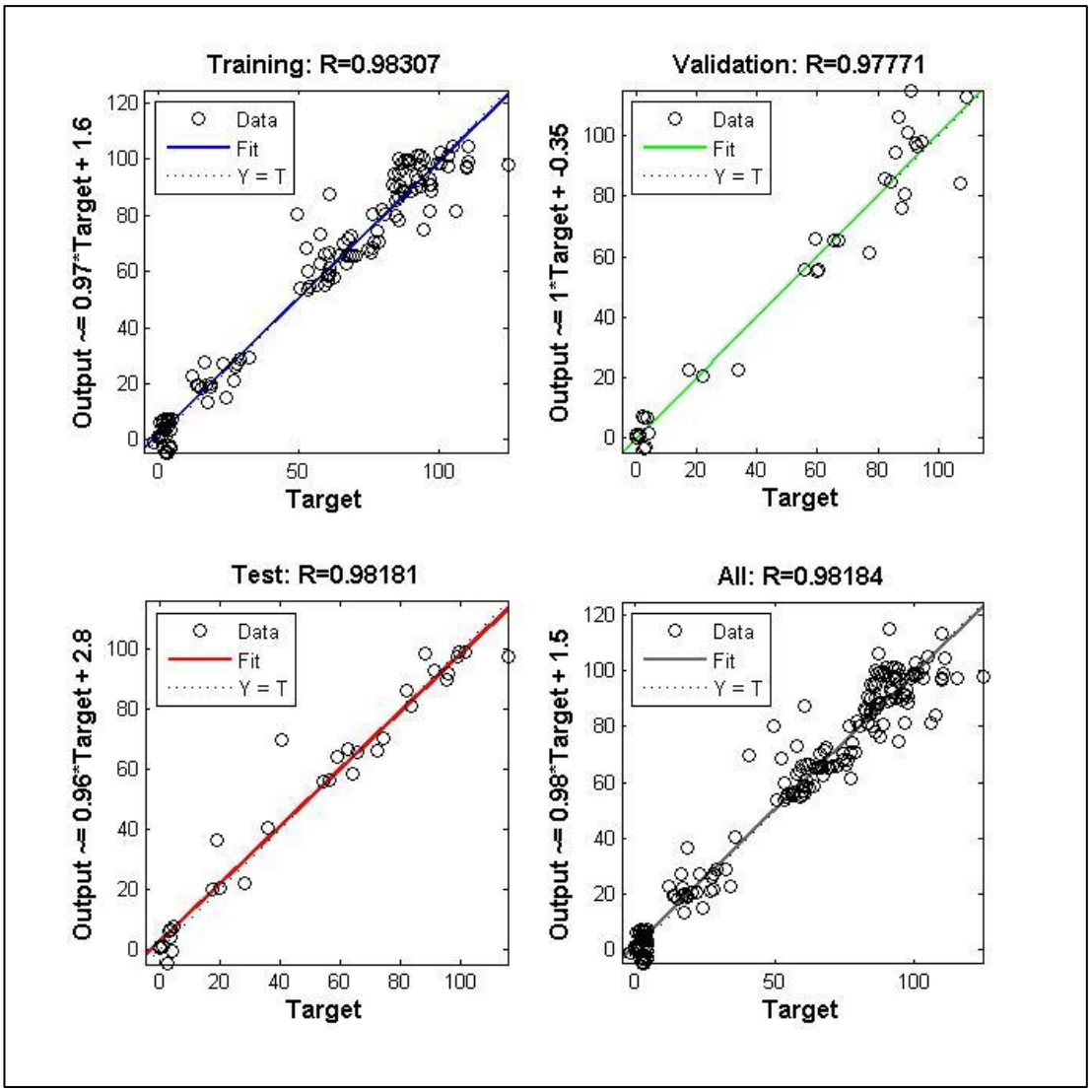

Figure 6-3 ANN Training Validity

The soundness of the predictions was then tested using the SCG data trainer available in MATLAB version 2016b (MathWorks, 2016). In the testing stage, MATLAB version 2016b (MathWorks, 2016) and the SCG data training algorithm was used as an attempt to test the validity of the forecasting. First, the collected historical data of 2017 for the six nods were inserted and resulted in estimation for all six nods for the year 2018. The estimated oil price for 2018 was compared with the actual price in that year which reflects a high level of validity, please see Table 6-1. After that, the estimated data for all six nodes from 2018 were inserted into MATLAB to predict the data for 2019, then the estimated oil price for 2019 was compared with the actual price in the same year which also reflects a high level of validity Table 6-1.

Lastly, the predicted data for all six nodes from 2019 were inserted into MATLAB to predict the data for 2020, then the estimated oil price for 2020 was compared with the actual price in the same year. Unlike the previous years, the case of 2020 shows a significant difference between the estimated and actual price validity Table 6-1. However, it is of great importance to note that the oil price in the year 2020 was tremendously impacted with COVID-19.

It is reckoned herein that this difference in the expected and true value of oil in 2020 is primarily attributable to the effects of the COVID-19 pandemic, which Anderson and Engebretse (2020) have previously described as a key factor in the largest reduction in the value of oil since 2002. This has meant that the value of oil has not moved as anticipated due to the lack of demand induced by societal lockdowns, which are estimated to reduce consumption by approximately 20%, and may soon mean that oil reservoirs across the world can no longer accept additional deliveries (BBC News, 2020). There are also critical elements governing both demand and supply in this market, wherein for the former, the reduced global movement and overall manufacturing output of many nations have lowered the need for oil (IEA, 2020), whereas, in terms of supply, several oil exporters opted to oversaturate the market as means of countering this reduced demand, which is recognised to have had a detrimental effect on the market itself (Blas and Pismennaya, 2020).

The impact of COVID-19 can be considered as an example of the uncertainty related to the field. Henceforth, it was necessary to use the actual real data to have a possible accurate forecast. Accordingly, the data inserted into MATLAB were updated with the recent actual data. In order to avoid the uncertainty related to the impact of COVID-19, the real data for all six nodes from 2020 were inserted into MATLAB to predict the data from 2021 until 2030. The same procedure should be done by the end of 2021 to forecast the data from 2022 until 2030.

Table 6-1 ANN Forecasting Validation Test

Year	Actual Average Annual Price $/B	Estimated Average Annual Price Based on ANN Forecasting $/B
2018	69.78	69.99
2019	64.04	64.45
2020	41.47	59.75

The forecasting stage aims to reach the main purpose of using (trainscg) in this study that is forecasting the future oil prices. Similar to the process in the testing phase, the collected data for the six nods from 2020 were inserted into MATLAB version 2016b (MathWorks, 2016), and the SCG data training algorithm was used in order to predict the 6 nods for the year 2021 including the oil price. The same process continued, and the oil price was forecasted for the next 9 years until 2030 (see Table 6-2 and Figure 6-4).

The results of the prediction of future oil prices for the coming 9 years from 2021 to 2030 reveals, that the future oil prices will increase to 70.30 in 2021. Then from 2022 until 2030 the oil price will be fluctuating between 65.10 as the lowest price in 2030 and 71.80 in 2022.

Table 6-2 ANN Forecasting Result

Year	Actual Average Annual Price $/B	Estimated Average Annual Price Based on ANN Forecasting $/B
2018	69.78	69.99
2019	64.04	64.45
2020	41.47	59.75
2021		70.30
2022		71.80
2023		70.92
2024		71.55
2025		68.66
2026		70.90
2027		69.40
2028		71.65
2029		67.64
2030		65.10

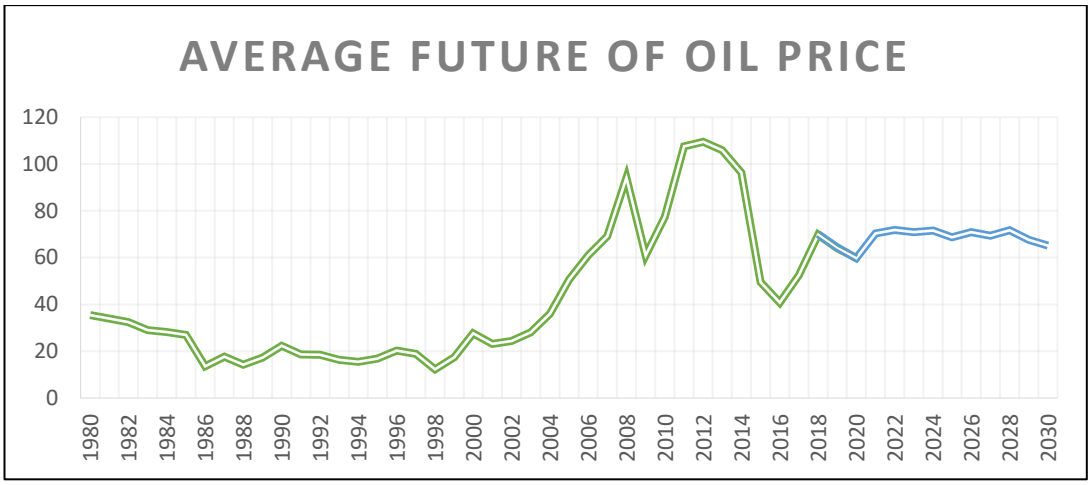

Figure 6-4 ANN Forecasting Result Chart

Using ANN aimed to reach one of the research objectives that is to forecast the future oil price for the years 2021 till 2030. After that, the remaining collected historical data between 1980 and 2020 for the factors affecting decision-making will be used in order to reach another objective that is to create an equation for decision-making to buy a new ship in the following section.

6.3. Logistic Regression

The last step in the analysis and the final part of this work aims to create a formula for decision-making using Regression Analysis (RA) that goes with the perspectives of the board members of the company (Z). The style of RA utilised herein is of a form known as binary logistic regression, which is utilised as a means of exploring the relations between a single output that is derived from a series of independent variables, and can deduce the extent to which a given model can accurately forecast these relationships. Logistic regression is undertaken on the basis of the methods detailed by McCullagh and Nelder (1989). In brief, the key notion contained within this technique is that the natural logarithm (ln) of probability (Y), also known as logit, is the ratio of the likelihoods of a given event of Y occurring (π) versus Y not occurring ($1-\pi$), which in this case amounts to purchase, or no purchase (see equation 6.1).

$$\text{logit}(y)=\text{In}\frac{}{1-\pi} = a+\beta_2 x_{i2}+\cdots+\beta_p x_{ip} \quad (6.1)$$

where π is the probability of the event, a is the *Y* intercept, βs are regression coefficients, and *X*s are a set of predictors.

6.3.1. Empirical Application of Logistic Regression

The last step in the analysis is using a Binary Logistic Regression (BLR) through Excel (Microsoft Office, 2013). Binary Logistic Regression (BLR) is a machine learning algorithm which can be used for decision making based on prediction of the result of different variables. BLR seeks to determine the link between a binary dependent variable and an associated independent one (see section 4.5.3.4 for further details). This analysis involved the collation of extant information describing the variables that impact upon decision-making between 1980 and 2020. Additionally, this dataset contains the responses by 8 of business Z's board to the questions posed in the fourth questionnaire in this study, that were designed to investigate the investment decision when buying a ship according to the different market scenarios for the twelve factors affecting the decision making in the span of 1980–2020. These factors were the twelve factors are the ones that reach agreement in the previous questionnaire that are freight rate, new build price, oil price, guaranteed cargo (oil production of the country which is needed to know the accurate percentage of guaranteed cargo), new build order book, IMO regulation, economic crisis, company fleet, age of company fleet 20 years or over, the interest rate for vessel investment, and company profit. Table 6-3 summarises the results of the logistic regression performed using Excel's (Microsoft Office, 2013) XLMiner Analysis ToolPack. However, it is important to note that three factors that are: country production, geopolitical, and interest rate for financing VLCC were excluded based on their p-value, since their p-value was less than 0.05 (Vakhitova and Alston-Knox, 2018).

Table 6-3 Logistic Regression Analysis

SUMMARY OUTPUT	
Regression Statistics	
Chi Square	52.28354
Residual Dev.	353.6108
# of iterations	6
Observations	327
	Coefficients
Intercept	2.766431
FREIGHT RATE (VLCC)	0.00029
NEW BUILD PRIECE (VLCC)	-0.05255
OIL PRICE $/b	0.004153
SECURED CARGO	19.21395
NEW BUILD ORDER BOOK	-0.07233
ECONOMIC CRISIS	0.110284
COMPANY FLEET	-0.07387
AGE OF COMPANY FLEET 20 YEARS OR OVER	-0.09723
COMPANY RPOFIT	1.03E-08

Then, the results from the logistic regression analysis were used in equation (6.1) to create equation (6.2) for decision-making that goes with the company (Z) and board member visions when buying a new ship.

2.7664+0.0003***Freight Rate***-0.053***New VLCC Build Price***+0.0042***Oil Price***+19.214***Secured Cargo***-0.072***New VLCC Order Book***+0.01103* ***Economic Crisis***-0.097***Company Fleet***-0.097***Number of Ships over 20 years old***+0.00000001***Company Profit***. (6.2)

6.3.2. Equation Validation

As an attempt to examine the validity of the created equation, equation (6.2) were used with real data from previous years in the following examples.

6.3.2.1. Example (1)

In the first example, real data from the year 2016 were calculated through equation (6.2)

A= logit(odds)

A= 2.7664+0.0003***Freight Rate***-0.053***New VLCC Build Price***+0.0042***Oil Price***+19.214***Secured Cargo***-0.072***New VLCC Order Book***+0.01103* ***Economic Crisis*** -0.097***Company Fleet***-0.097***Number of Ships over 20 years old***+0.00000001***Company Profit.*** (6.2)

A= 2.7664+0.0003*59.67-0.053*81+0.0042*40.76+19.214*0.18-0.072*25+0.01103*0-0.097*36-0.097*5+0.00000001*466594000

Equation (6.3) can then be applied as a means of determining the relevant likelihoods.

P=exp(A)/(1+exp(A)) (6.3)

P= 0.733011

According to Konis (2007), πi is considered a success or happening if πi > 0.5 and a failure if πi < 0.5. therefore, based on the results of the equation, the πi, in this case, is 0.73, which means that it is recommended to make the decision to buy a new VLCC.

6.3.2.2. Example (2)

In the second example, real data from the year 2020 were calculated through equation (6.2)

A= logit(odds)

A= 2.7664+0.0003***Freight Rate***-0.053***New VLCC Build Price***+0.0042***Oil Price***+19.214***Secured Cargo***-0.072***New VLCC Order Book***+0.01103* ***Economic Crisis*** -0.097***Company Fleet***-0.097***Number of Ships over 20 years old***+0.00000001***Company Profit.*** (6.2)

A= 2.7664+0.0003*100-0.053*90+0.0042*50+19.214*0.20-0.072*19+0.01103*1-0.097*41-0.097*2+0.00000001*171600000

Equation (6.3) can then be applied as a means of determining the relevant likelihoods.

P=exp(A)/(1+exp(A)) (6.3)

P= 0.1502336

Based on the results of the equation, the πi, in this case, is 0.15, which means that it is not recommended to make the decision to buy a new VLCC.

6.4. Conclusion

This chapter aimed to reach two of the research objectives. The first objective is forecasting future oil prices between 2021 and 2030 through using ANN. The second objective is to create an equation through using Binary Logistic Regression in the process of developing an investment decision-making technique by determine the link between a binary dependent variable and an associated independent one. This equation the shipping companies can incorporate into their decision-making process in order to make informed and faster decisions about placing newbuild tanker order.

7. Discussion

7.1. Chapter Overview

The purpose of this chapter is to present and discuss the overall results of this thesis and their contribution to the field. These results are discussed in relation to the aims and objectives.

7.2. Achievement of Research Aims and Objectives

The essential purpose of conducting this thesis is to develop an investment decision-making technique for the oil shipping companies to assist the decision-making of ordering newbuild ship with consideration of influential factors and uncertainty. Accordingly, a list of objectives was constructed and listed in chapter 2 as an attempt to achieve the main purpose. Details on each of these objectives are given below.

- Explore the relevant literature and hypotheses to determine the indicators that may have an impact on the decision-making in the oil shipping companies in order to invest in new ships.
- Investigate the relevant factors that influence and affect the oil price.

The first two objectives are mainly concerned with the background and the basis of the field. Therefore, In order to build the study on a strong basis, a wide-ranging and comprehensive review of the shipping industry, its characteristics, and the factors impacting the industry was performed. This review also includes a review on shipping market forecasting and oil market forecasting, and the factors affecting the forecast. The area of investment decision-making was also explored along with the factors affecting decision-making and the different methods and criteria related to decision-making. This review leads to the following objective.

- Collect the indicators affecting the investment decision making in the oil shipping companies from the literature and experts, then Evaluate these indicators in order to be ranked according to their influence. In addition, assess the interrelationship between these indicators to ease the process of the investment decision-making in oil shipping companies.

Through the review of relevant literature, a list was conducted for the factors affecting investment decision-making when buying a new ship. These factors were added and reconsidered along with the collected factors through the Delphi method, which is considered one of the effective tools to collect and aggregate experts' opinion and composed a list of factors affecting decision-making that reach experts agreement (Chapter 5). The 19 factors that reach consensus were: Freight Rate, New Build Order Book, Secured Cargo, Time of Order, Type of Ship, Capital, Technology, Leverage, Geopolitical, Company profit, IMO regulation, Oil Price, New build price, Economic crisis, Company strategy, Source of finance, Competition, Number of the current fleet, Age of current fleet. This leads to the ranking and evaluation of the indicators that were achieved under factors degree of importance (chapter 5, section 5.5). In order to evaluate the degree of importance for the factors affecting rank the factors affecting investment decision-making when buying a ship according to their degree of importance among the experts. After evaluating each factor individually, the interrelationship among the 19 factors affecting decision-making when buying a ship that through the same questionnaire and the analysis was conducted through DEMATEL. This interrelationship was achieved under factors interrelationship (Chapter 5, section 5.7). The significant findings were listed in chapter 5, section 5.5 (factors degree of importance) and in chapter 5, section 5.7 (Factors Interrelationship). Before using these factors in the development decision-making method, the concentration is shifted toward reaching the following objective.

- Forecast the future of the oil price.

The price of oil is considered to be a crucial influence on the timing of buying new ships. Accordingly, based on the historical data collected for the factors affecting oil price, future oil prices were forecasted using ANN, SCG data training algorithm in particular, in MATLAB version 2016b (MathWorks, 2016). The results of the analysis and the prediction of future oil prices were listed and discussed in chapter 6, section 6.2 (Artificial Neural Network). In addition to achieving this objective, the same chapter aimed to achieve the main purpose (the last objective) of this research.

- Create an investment decision-making equation whereby the shipping companies can incorporate into their decision-making process in order to make informed and faster decisions about placing newbuild tanker order.

In order to reach this objective, historical data for some influential factors that reach consensus were used to create an equation in the process to develop a technique for investment decision-making that goes with the company (Z) and board member visions to be used in the future through the use of binary logistic regression with testing the validation of the equation with real data. All the details were presented clearly in chapter 6, section 6.3, under Logistic Regression. (Case study).

8. Conclusion

8.1. Chapter Overview

This chapter summarises the study's accomplishments and contributions, as well as the novelty and implications of the findings for the field, along with the limitation of the study, future work and recommendations.

8.2. Research Novelty and Contributions to the Field

This thesis has provided a generous amount of information for decision-making when investing in a new vessel for the industry in general and for a specific shipping company in practice. This information was gathered and analysed in order to fill the gap in the field of shipping business through reaching the main purpose of this research, which is to develop investment decision-making method for the oil shipping companies in order to support the oil companies' decisions on whether or not to purchase new ships. This study was conducted in relation to three main areas: Factors affecting decision-making when buying a new ship, forecasting future oil prices, and developing a technique for investment decision-making.

8.2.1. Factors Affecting Decision-Making

The main target in this area was to identify the factors affecting investment decision-making when buying a new ship. First, the first aim was to identify and collect the factors affecting decision-making from both the literature and experts. Then a list that included 19 factors that reach consensus was constructed and included: Freight Rate, New Build Order Book, Secured Cargo, Time of Order, Type of Ship, Capital, Technology, Leverage, Geopolitical, Company profit, IMO regulation, Oil Price, New build price, Economic crisis, Company strategy, Source of finance, Competition, Number of the current fleet, Age of current fleet. These factors were then evaluated and ranked by calculating the mean score, and the interrelation between factors

were found through DEMATEL. The importance of this action lies in determining the significant factors to be involved in the development of the investment technique in decision-making (For more details see chapter 5).

8.2.2. Forecasting Future Oil Prices

The main aim in this area is to forecast the future oil prices due to its significant impact on buying new ships. Accordingly, historical data were collected for the factors affecting oil prices that are: Oil price, oil supply, oil demand, economic crisis, the strength of the US dollar, and world GDP. These data were then inserted in MATLAB version 2016b (MathWorks, 2016) to forecast future oil prices from 2020 till 2030 through using SCG data training algorithm in ANN. The results for the coming 10 exposes that the future oil prices will drop to 59.75 in 2020. Then from 2021 till 2030, the oil price will be changing between 65.10 as the lowest price in 2030 and 71.80 in 2022 (For more details, see chapter 6).

8.2.3. Developing a Technique for Investment Decision-Making

This main aim in this area is to create an equation for decision-making for the oil shipping companies to support the oil companies' decisions on whether or not to purchase new ships. Accordingly, historical data were collected for some of the identified factors affecting decision-making. Through Binary Logistic Regression, these data were used to create equation (6.2) then the validity was examined with real data (For more details, see chapter 6).

2.7664+0.0003*__Freight Rate__-0.053*__New VLCC Build Price__+0.0042*__Oil Price__+19.214*__Secured Cargo__-0.072*__New VLCC Order Book__+0.01103* __Economic Crisis__-0.097*__Company Fleet__-0.097*__Number of Ships over 20 years old__+0.00000001*__Company Profit.__ (6.2)

8.3. Limitations of Research

Throughout the study process, a variety of issues arose. Several of these difficulties are discussed and analysed in the research. Nonetheless, other issues are as follow:

- Collecting the data for this research was difficult and time-consuming as there is a lack of public data as all financial data are considered classified it was difficult to gain access to these data with applying for a request which took a lot of time, and it is important to note that a limited number of companies agreed to share their data.
- The number of participants could be considered small; however, it was justified through using the sampling strategy in this research. This small number was due to the busy schedules of the experts or the fact that they were hard to reach. In particular, it was difficult to arrange more than one meeting with members, especially the board of the company and it required follow-up emails for the questionnaires to be completed.
- Covid-19 had a huge impact on the process of data collecting and cause delays. Due to the travel ban and lockdown, the third and fourth phases of the collection were delayed as the experts were hard to reach.
- Artificial neural network (ANN) and Logistic regression require more data and participants in order to improve the validity results.

8.4. Recommendation for Further Research

After conducting this research, recommendations for further work are presented:

- Special recommendation to the company (Z) that cooperated with the researcher to conduct this study to adopt the new decision-making technique when buying a new ship.
- The researcher would highly recommend finding more companies and participant to

share their data and knowledge as an attempt to generalize the results.

- The researcher would highly suggest applying and testing the same decision-making technique when buying a new ship with other companies as an attempt to improve the validity of the technique.
- The researcher would highly recommend testing the same decision-making technique for other types of ships for example, Container ships.
- The researcher would recommend using the same technique and process for forecasting the oil price to furcate the future freight rate.
- The researcher would recommend using the same technique and process for developing a technique for decision-making when buying a second-hand ship.
- The researcher would recommend using different process and methods to support the investment decision making in the shipping companies.
- The researcher would recommend the shipping companies use alternative fuels that reach the purpose of the new IMO' regulations.
- The researcher would recommend the shipping companies to start the necessary modification in order to reach the IMO new legislation such as EEXI and CII.

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Appendixes

Appendixes A

The current lifespan for the tanker fleet

Data Collection:

In order to develop a strong understanding of decision-making process the research needs to build a deep insight into information that is used in that process. Decision making for investment into new Tanker vessels takes into consideration all aspects of the business thus the questions designed for the shipping companies cover a wide cross section of the business and its operations.

1. What is your current working region?
2. What is your current working field?
3. How long have you been working in this field?
4. What is your current position?
5. What is your academic background?
6. What are the situation that leading to consider buying Ship?
7. Do you use any approach to support your investment decisions?
8. What techniques you use for investment decision making?
9. What are the different indicators that affect the investment decision making in the maritime shipping? Why? Are they directly or indirectly linked with the decision making (e.g. USD strength)?
10. How many destinations your company deliver oil too?
11. Are there any chartered ships in your fleet?
12. How many barrel/ ton you move in day/year?
13. Is the price fixed when you sign contract for building new ship?

14. Do you consider second-hand ships, or you consider only new ships?
15. Do you consider chartering ships or you consider only buying ships?
16. Have you considered any alternative transportation model (pipeline)?
17. Is there any business agreement between your company and an oil producer in regard oil Transportation/ how long?
18. In percentage, how much your company deliver from the total production? The rest is it moved by another national carriers?
19. Do you have any other agreement for other products in regard transportation?
20. Is there any business agreement between your company and any refineries/ how long?
21. Does your company have any agreement to deliver oil for any other exporting/importing countries?
22. Do use any 3rd part for financial intelligence unit or decision-making supports?
23. What is the current situation in your company in regard forecasting/ do you do long term forecasting or short term/how far these forecasting is updated?
24. Is your company able to identify the best investment decision for vessel in different market situations?
25. What are the steps or procedures that you follow in order to make decision to buy new ships?
26. What limitations or problems exist in the current decision making processes or strategies?
27. What does you believe to be the targeted improvements required to enhance its decision-making processes or strategies?
28. Are these indicators will be different in the oil shipping companies than other type of products shipping company?

29. Do individual indicators interact with each other to increase or reduce risk to financial and investment decision making?
30. What are the possible impacts of each significant indicator on investment decision making under different scenario?
31. What measures can be taken to minimize or eliminate risks posed by individual or collective indicators?

Appendixes B

Delphi Questionnaire

Round One

Developing Investment Decision-Making Method for the Oil Shipping Companies

Personal Information

1- Name (optional): …….

2- Nationality: …….

3- Working Region: …….

4- E-mail: …….

Questionnaire

The aim of this questionnaire is to identify how significant are the factors that influence the decision maker during the investment decision making in the oil shipping companies in order to buy a ship.

It is important to be aware of that, the following identified factors have been selected carefully after an intensive literature review of different disciplines and interviews with experts in the maritime field.

Therefore, based on your experience, kindly rate the level of significance of the factors below, using the following rating scale:

'1' represents 'Not at all important'

'5' represents 'Extremely important'

After you have carried out the rating, kindly add any comments in the 'comment box' (if you have).

Factors	Importance scale				
	Not at all important < ------ > extremely important				
Freight Rate	1	2	3	4	5
Comment:					
New Build Order Book	1	2	3	4	5
Comment:					
Secured Cargo	1	2	3	4	5
Comment:					
Time of Order	1	2	3	4	5
Comment:					
Type of Ship (new / second hand)	1	2	3	4	5
Comment:					

Capital	1	2	3	4	5
Comment:					
Leverage	1	2	3	4	5
Comment:					
Geopolitical	1	2	3	4	5
Comment:					
Company Profit	1	2	3	4	5
Comment:					
Oil price	1	2	3	4	5
Comment:					
New Build Price	1	2	3	4	5
Comment:					
Economic Crisis	1	2	3	4	5
Comment:					

Source of Finance	1	2	3	4	5
Comment:					
Competition	1	2	3	4	5
Comment:					
Number of Current Fleet	1	2	3	4	5
Comment:					
Age of Current Fleet	1	2	3	4	5
Comment:					
Demand for Oil Transportation	1	2	3	4	5
Comment:					
Scrap Price	1	2	3	4	5
Comment:					
Second-Hand Price	1	2	3	4	5
Comment:					

Bunker Price	1	2	3	4	5
Comment:					
Oil Market	1	2	3	4	5
Comment:					
Crude Oil Production	1	2	3	4	5
Comment:					
Fleet Productivity	1	2	3	4	5
Comment:					
Seaborn Trade	1	2	3	4	5
Comment:					
Cost of Operation	1	2	3	4	5
Comment:					
Currency Exchange Price	1	2	3	4	5
Comment:					

Destination	1	2	3	4	5
Comment:					
Global Economy	1	2	3	4	5
Comment:					
Shipping Market	1	2	3	4	5
Comment:					

If you think there are other factors which affect the investment decision making in the shipping company and not listed above, please list them in the below

Thank you for your participation.

Appendixes C

Delphi Questionnaire

Round Two

Developing Investment Decision-Making Method for the Oil Shipping Companies

Personal Information

1. Name (optional): ……

2. Nationality: ……

3. Working Region: ……

4. E-mail: ……

Delphi Questionnaire (Round Two)

You have rated each indicator described below in round one except three indicators which been add to the list. However, if you think it necessary to reconsider your answers from round one, please rate how important you think this particular indicator is to the decision maker during the investment decision making in the oil shipping companies in order to buy a ship, using the rating scale 1 to 5, where:

'1' represents 'Not at all important'
'5' represents 'Extremely important'

In round two, each indicator is followed by three numbers, comprising the median (M), inter-quartile range (IQR), and your response (YRes) from round one. To

achieve the goal of this study, the median score must be equal to 3.75 or more on every indicator criterion in order to consider that the indicator has reached a suitable level of importance. For an indicator to be considered as having reached a suitable level of consensus amongst the expert panel, the inter-quartile range must be 1.00 or less. If any of the indicators meet the above two criteria at the same time, this means that the indicator has reached a suitable level of importance and consensus. Finally, I have presented your response (YRes) score from the first round.

In this questionnaire (the second round), you have been given the chance to reconsider your answer by comparing it to the average rating from other members of the expert panel or to rate it with the same score as you did previously. However, if your response from the previous round is shown to be outside of the median and the IQR resulting from the first round, then your response will be highlighted in red. For instance, if the median of an indicator scored 4, the IQR is 1 and your response was 3, then you will see the following: (M = 4, IQR = 1, YRes = 3). If you are still satisfied with your response, despite it being outside the IQR, I would appreciate it if you could comment in the "Comment box" as to why you still consider it as an appropriate choice, despite it remaining outside the consensus range.

Factors	Importance scale				
	Not at all important < ------ > extremely important				
Freight Rate (M = 4, IQR = 0, YRes = 0)	1	2	3	4	5
Comment:					
New Build Order Book (M = 4, IQR = 1, YRes = 0)	1	2	3	4	5
Comment:					
Secured Cargo (M = 4, IQR = 0, YRes = 0)	1	2	3	4	5
Comment:					
Time of Order (M = 3, IQR = 1, YRes = 0)	1	2	3	4	5
Comment:					
Type of Ship (new / second hand) (M = 3, IQR = 1, YRes = 0)	1	2	3	4	5
Comment:					
Capital (M = 4, IQR = 1, YRes = 0)	1	2	3	4	5
Comment:					

Leverage (M = 3, IQR = 1, YRes = 0)	1	2	3	4	5
Comment:					
Geopolitical (M = 4, IQR = 1, YRes = 0)	1	2	3	4	5
Comment:					
Company Profit (M = 4, IQR = 1, YRes = 0)	1	2	3	4	5
Comment:					
Oil price (M = 4, IQR = 1, YRes = 0)	1	2	3	4	5
Comment:					
New Build Price (M = 4, IQR = 1, YRes = 0)	1	2	3	4	5
Comment:					
Economic Crisis (M = 4, IQR = 1, YRes = 0)	1	2	3	4	5
Comment:					
Source of Finance (M = 4, IQR = 1, YRes = 0)	1	2	3	4	5

Comment:					
Competition (M = 4, IQR = 1, YRes = 0)	1	2	3	4	5
Comment:					
Number of Current Fleet (M = 3, IQR = 1, YRes = 0)	1	2	3	4	5
Comment:					
Age of Current Fleet (M = 4, IQR = 1, YRes = 0)	1	2	3	4	5
Comment:					
Demand for Oil Transportation (M = 2, IQR =2, YRes = 0)	1	2	3	4	5
Comment:					
Scrap Price (M = 2, IQR =2, YRes = 0)	1	2	3	4	5
Comment:					
Second-Hand Price (M = 2, IQR =2, YRes = 0)	1	2	3	4	5

Comment:					
Bunker Price (M = 2, IQR =2, YRes = 0)	1	2	3	4	5
Comment:					
Oil Market (M = 4, IQR =1, YRes = 0)	1	2	3	4	5
Comment:					
Crude Oil Production (M = 4, IQR =1, YRes = 0)	1	2	3	4	5
Comment:					
Fleet Productivity (M = 2, IQR =2, YRes = 0)	1	2	3	4	5
Comment:					
Seaborn Trade (M = 2, IQR =2, YRes = 0)	1	2	3	4	5
Comment:					
Cost of Operation (M = 2, IQR =2, YRes = 0)	1	2	3	4	5
Comment:					

Currency Exchange Price (M = 2, IQR =2, YRes = 0)	1	2	3	4	5
Comment:					
Destination (M = 2, IQR =2, YRes = 0)	1	2	3	4	5
Comment:					
Global Economy (M = 4, IQR =1, YRes = 0)	1	2	3	4	5
Comment:					
Shipping Market (M = 2, IQR =2, YRes = 0)	1	2	3	4	5
Comment:					
Technology	1	2	3	4	5
Comment:					
IMO Regulation	1	2	3	4	5
Comment:					
Company Strategy	1	2	3	4	5
Comment:					

Thank you for your participation.

Appendixes D

Research Information and consent form

Welcome to the research study!

This research is interested in developing investment decision-making method for the oil shipping companies in order to invest in new vessels. Please be assured that your responses will be kept completely confidential and used for the research purposes.

The study should take you around **45 MINUTES** to complete. Your participation in this research is voluntary. You have the right to withdraw at any point during the study, for any reason, and without any prejudice. If you would like to contact the Principal Investigator in the study to discuss this research, please find me on:

Full name: Bassam Aljahdali
Occupation: PhD Researcher at University of Strathclyde, Glasgow, UK
Email: b**********@strath.ac.uk
Mobile:
Address: Department of Naval Architecture, Ocean & Marine
Engineering, University of Strathclyde
Henry Dyer Building, 100 Montrose Street, Glasgow G4 0LZ, United Kingdom

By clicking the button below, you acknowledge that your participation in the study is voluntary, you are 18 years of age, and that you are aware that you may choose to terminate your participation in the study at any time and for any reason.
Please note that this survey will be best displayed on a laptop or desktop computer. Some features may be less compatible for use on a mobile device.

- I do consent, Begin the survey
- I do not consent, I do not like to participate

Demography

Working field?

- Academic
- Banking
- Ship Yard
- Shipping Industry
- Other please specify

Working Region?

- Europe
- Middle East
- Far East
- North America
- South America
- Africa

What is your position?

- Owner
- Manager
- Employee
- Consultant
- Other please specify

How long have you been working in this field?

- 0 - 5 Years
- 6 - 10 Years
- 11 - 15 Years
- 16 - 20 Years
- 21 Years and above

What is your academic background?

- Less than high school
- High school graduate
- Some college
- 2-year degree
- 4-year degree
- Professional degree
- Doctorate

Financial Decision-making

Which method would you recommend to use for investment decision making in the shipping companies?

- Multiple Criteria Decision Analysis
- Net Present Value
- Decision Tree
- Analytic Hierarchy Process
- Other please specify

What are the situation that leading to consider buying ship?

- Age of existing fleet
- Increase of Demand
- Increase of Fright Rate
- Other please specify

Factors' degree of importance

These are some factors which affect the investment decision making in the shipping companies around the world. Would you kindly evaluate the importance of the following factors (where as 5 is very important and 1 is not important).

Factors	degree of importance				
	1	2	3	4	5
Freight Rate					
New build order book					
Secured cargo					
Time of order					
Type of ship (new / second hand)					
Capital					
Technology					
Leverage					
Geopolitical					
Company profit					
IMO regulation					
Oil price					
New build price					
Economic crisis					
Company strategy					
Source of finance					
Competition					
Number of current fleet					
Age of current fleet					

If you think there are other factors which affect the investment decision making in the shipping company and not listed above, please list them in the below and kindly evaluate them (where as 5 is very important and 1 is not important).

(open end)

Factors influence

The following tables are designed to examine the influence of each factor to the others, so would you kindly evaluate the degree of influence by filling the cells. Where as:

NO Influence	Low Influence	Medium Influence	High Influence	Very High Influence
0	1	2	3	4

Influence Comparisons						
Dimension (A)	NO Influence	Low Influence	Medium Influence	High Influence	V. High Influence	Dimension (B)
FREIGHT RATE						NEW BUILD ORDER BOOK
FREIGHT RATE						SECURED CARGO
FREIGHT RATE						TIME OF SHIP BUILD ORDER
FREIGHT RATE						TYPE OF SHIP (new / second hand)
FREIGHT RATE						CAPITAL
FREIGHT RATE						TECHNOLOGY
FREIGHT RATE						LEVERAGE
FREIGHT RATE						GEOPOLITICAL
FREIGHT RATE						COMPANY PROFIT
FREIGHT RATE						IMO REGULATION
FREIGHT RATE						OIL PRICE
FREIGHT RATE						NEW BUILD PIECE
FREIGHT RATE						ECONOMIC CRISIS
FREIGHT RATE						COMPANY STRATEGY
FREIGHT RATE						SOURCE OF FINANCE
FREIGHT RATE						COMPETATION
FREIGHT RATE						NUMBER OF CURRENT FLEET
FREIGHT RATE						AGE OF FLEET

Influence Comparisons						
Dimension (A)	NO Influence	Low Influence	Medium Influence	High Influence	V. High Influence	Dimension (B)
NEW BUILD ORDER BOOK						FREIGHT RATE
NEW BUILD ORDER BOOK						SECURED CARGO
NEW BUILD ORDER BOOK						TIME OF SHIP BUILD ORDER
NEW BUILD ORDER BOOK						TYPE OF SHIP (new / second hand)
NEW BUILD ORDER BOOK						CAPITAL
NEW BUILD ORDER BOOK						TECHNOLOGY
NEW BUILD ORDER BOOK						LEVERAGE
NEW BUILD ORDER BOOK						GEOPOLITICAL
NEW BUILD ORDER BOOK						COMPANY PROFIT
NEW BUILD ORDER BOOK						IMO REGULATION
NEW BUILD ORDER BOOK						OIL PRICE
NEW BUILD ORDER BOOK						NEW BUILD PIECE
NEW BUILD ORDER BOOK						ECONOMIC CRISIS
NEW BUILD ORDER BOOK						COMPANY STRATEGY
NEW BUILD ORDER BOOK						SOURCE OF FINANCE
NEW BUILD ORDER BOOK						COMPETATION
NEW BUILD ORDER BOOK						NUMBER OF CURRENT FLEET
NEW BUILD ORDER BOOK						AGE OF FLEET

Influence Comparisons						
Dimension (A)	NO Influence	Low Influence	Medium Influence	High Influence	V. High Influence	Dimension (B)
SECURED CARGO						FREIGHT RATE
SECURED CARGO						NEW BUILD ORDER BOOK
SECURED CARGO						TIME OF SHIP BUILD ORDER
SECURED CARGO						TYPE OF SHIP (new / second hand)
SECURED CARGO						CAPITAL
SECURED CARGO						TECHNOLOGY
SECURED CARGO						LEVERAGE
SECURED CARGO						GEOPOLITICAL
SECURED CARGO						COMPANY PROFIT
SECURED CARGO						IMO REGULATION
SECURED CARGO						OIL PRICE
SECURED CARGO						NEW BUILD PIECE
SECURED CARGO						ECONOMIC CRISIS
SECURED CARGO						COMPANY STRATEGY
SECURED CARGO						SOURCE OF FINANCE
SECURED CARGO						COMPETATION
SECURED CARGO						NUMBER OF CURRENT FLEET
SECURED CARGO						AGE OF FLEET

Influence Comparisons						
Dimension (A)	NO Influence	Low Influence	Medium Influence	High Influence	V. High Influence	Dimension (B)
TIME OF SHIP BUILD ORDER						FREIGHT RATE
TIME OF SHIP BUILD ORDER						NEW BUILD ORDER BOOK
TIME OF SHIP BUILD ORDER						SECURED CARGO
TIME OF SHIP BUILD ORDER						TYPE OF SHIP (new / second hand)
TIME OF SHIP BUILD ORDER						CAPITAL
TIME OF SHIP BUILD ORDER						TECHNOLOGY
TIME OF SHIP BUILD ORDER						LEVERAGE
TIME OF SHIP BUILD ORDER						GEOPOLITICAL
TIME OF SHIP BUILD ORDER						COMPANY PROFIT
TIME OF SHIP BUILD ORDER						IMO REGULATION
TIME OF SHIP BUILD ORDER						OIL PRICE
TIME OF SHIP BUILD ORDER						NEW BUILD PIECE
TIME OF SHIP BUILD ORDER						ECONOMIC CRISIS
TIME OF SHIP BUILD ORDER						COMPANY STRATEGY
TIME OF SHIP BUILD ORDER						SOURCE OF FINANCE
TIME OF SHIP BUILD ORDER						COMPETATION
TIME OF SHIP BUILD ORDER						NUMBER OF CURRENT FLEET
TIME OF SHIP BUILD ORDER						AGE OF FLEET

Influence Comparisons						
Dimension (A)	NO Influence	Low Influence	Medium Influence	High Influence	V. High Influence	Dimension (B)
TYPE OF SHIP (new / second hand)						FREIGHT RATE
TYPE OF SHIP (new / second hand)						NEW BUILD ORDER BOOK
TYPE OF SHIP (new / second hand)						SECURED CARGO
TYPE OF SHIP (new / second hand)						TIME OF SHIP BUILD ORDER
TYPE OF SHIP (new / second hand)						CAPITAL
TYPE OF SHIP (new / second hand)						TECHNOLOGY
TYPE OF SHIP (new / second hand)						LEVERAGE
TYPE OF SHIP (new / second hand)						GEOPOLITICAL
TYPE OF SHIP (new / second hand)						COMPANY PROFIT
TYPE OF SHIP (new / second hand)						IMO REGULATION
TYPE OF SHIP (new / second hand)						OIL PRICE
TYPE OF SHIP (new / second hand)						NEW BUILD PIECE
TYPE OF SHIP (new / second hand)						ECONOMIC CRISIS
TYPE OF SHIP (new / second hand)						COMPANY STRATEGY
TYPE OF SHIP (new / second hand)						SOURCE OF FINANCE
TYPE OF SHIP (new / second hand)						COMPETATION
TYPE OF SHIP (new / second hand)						NUMBER OF CURRENT FLEET
TYPE OF SHIP (new / second hand)						AGE OF FLEET

Influence Comparisons						
Dimension (A)	**NO Influence**	**Low Influence**	**Medium Influence**	**High Influence**	**V. High Influence**	**Dimension (B)**
CAPITAL						FREIGHT RATE
CAPITAL						NEW BUILD ORDER BOOK
CAPITAL						SECURED CARGO
CAPITAL						TIME OF SHIP BUILD ORDER
CAPITAL						TYPE OF SHIP (new / second hand)
CAPITAL						TECHNOLOGY
CAPITAL						LEVERAGE
CAPITAL						GEOPOLITICAL
CAPITAL						COMPANY PROFIT
CAPITAL						IMO REGULATION
CAPITAL						OIL PRICE
CAPITAL						NEW BUILD PIECE
CAPITAL						ECONOMIC CRISIS
CAPITAL						COMPANY STRATEGY
CAPITAL						SOURCE OF FINANCE
CAPITAL						COMPETATION
CAPITAL						NUMBER OF CURRENT FLEET
CAPITAL						AGE OF FLEET

Influence Comparisons						
Dimension (A)	**NO Influence**	**Low Influence**	**Medium Influence**	**High Influence**	**V. High Influence**	**Dimension (B)**
TECHNOLOGY						FREIGHT RATE
TECHNOLOGY						NEW BUILD ORDER BOOK
TECHNOLOGY						SECURED CARGO
TECHNOLOGY						TIME OF SHIP BUILD ORDER
TECHNOLOGY						TYPE OF SHIP (new / second hand)
TECHNOLOGY						CAPITAL
TECHNOLOGY						LEVERAGE
TECHNOLOGY						GEOPOLITICAL
TECHNOLOGY						COMPANY PROFIT
TECHNOLOGY						IMO REGULATION
TECHNOLOGY						OIL PRICE
TECHNOLOGY						NEW BUILD PIECE
TECHNOLOGY						ECONOMIC CRISIS
TECHNOLOGY						COMPANY STRATEGY
TECHNOLOGY						SOURCE OF FINANCE
TECHNOLOGY						COMPETATION
TECHNOLOGY						NUMBER OF CURRENT FLEET
TECHNOLOGY						AGE OF FLEET

Influence Comparisons						
Dimension (A)	**NO Influence**	**Low Influence**	**Medium Influence**	**High Influence**	**V. High Influence**	**Dimension (B)**
LEVERAGE						FREIGHT RATE
LEVERAGE						NEW BUILD ORDER BOOK
LEVERAGE						SECURED CARGO
LEVERAGE						TIME OF SHIP BUILD ORDER
LEVERAGE						TYPE OF SHIP (new / second hand)
LEVERAGE						CAPITAL
LEVERAGE						TECHNOLOGY
LEVERAGE						GEOPOLITICAL
LEVERAGE						COMPANY PROFIT
LEVERAGE						IMO REGULATION
LEVERAGE						OIL PRICE
LEVERAGE						NEW BUILD PIECE
LEVERAGE						ECONOMIC CRISIS
LEVERAGE						COMPANY STRATEGY
LEVERAGE						SOURCE OF FINANCE
LEVERAGE						COMPETATION
LEVERAGE						NUMBER OF CURRENT FLEET
LEVERAGE						AGE OF FLEET

Influence Comparisons						
Dimension (A)	NO Influence	Low Influence	Medium Influence	High Influence	V. High Influence	Dimension (B)
GEOPOLITICAL						FREIGHT RATE
GEOPOLITICAL						NEW BUILD ORDER BOOK
GEOPOLITICAL						SECURED CARGO
GEOPOLITICAL						TIME OF SHIP BUILD ORDER
GEOPOLITICAL						TYPE OF SHIP (new / second hand)
GEOPOLITICAL						CAPITAL
GEOPOLITICAL						TECHNOLOGY
GEOPOLITICAL						LEVERAGE
GEOPOLITICAL						COMPANY PROFIT
GEOPOLITICAL						IMO REGULATION
GEOPOLITICAL						OIL PRICE
GEOPOLITICAL						NEW BUILD PIECE
GEOPOLITICAL						ECONOMIC CRISIS
GEOPOLITICAL						COMPANY STRATEGY
GEOPOLITICAL						SOURCE OF FINANCE
GEOPOLITICAL						COMPETATION
GEOPOLITICAL						NUMBER OF CURRENT FLEET
GEOPOLITICAL						AGE OF FLEET

Influence Comparisons						
Dimension (A)	NO Influence	Low Influence	Medium Influence	High Influence	V. High Influence	Dimension (B)
COMPANY PROFIT						FREIGHT RATE
COMPANY PROFIT						NEW BUILD ORDER BOOK
COMPANY PROFIT						SECURED CARGO
COMPANY PROFIT						TIME OF SHIP BUILD ORDER
COMPANY PROFIT						TYPE OF SHIP (new / second hand)
COMPANY PROFIT						CAPITAL
COMPANY PROFIT						TECHNOLOGY
COMPANY PROFIT						LEVERAGE
COMPANY PROFIT						GEOPOLITICAL
COMPANY PROFIT						IMO REGULATION
COMPANY PROFIT						OIL PRICE
COMPANY PROFIT						NEW BUILD PIECE
COMPANY PROFIT						ECONOMIC CRISIS
COMPANY PROFIT						COMPANY STRATEGY
COMPANY PROFIT						SOURCE OF FINANCE
COMPANY PROFIT						COMPETATION
COMPANY PROFIT						NUMBER OF CURRENT FLEET
COMPANY PROFIT						AGE OF FLEET

Influence Comparisons						
Dimension (A)	NO Influence	Low Influence	Medium Influence	High Influence	V. High Influence	Dimension (B)
IMO REGULATION						FREIGHT RATE
IMO REGULATION						NEW BUILD ORDER BOOK
IMO REGULATION						SECURED CARGO
IMO REGULATION						TIME OF SHIP BUILD ORDER
IMO REGULATION						TYPE OF SHIP (new / second hand)
IMO REGULATION						CAPITAL
IMO REGULATION						TECHNOL OGY
IMO REGULATION						LEVERAGE
IMO REGULATION						GEOPOLITI CAL
IMO REGULATION						COMPANY PROFIT
IMO REGULATION						OIL PRICE
IMO REGULATION						NEW BUILD PIECE
IMO REGULATION						ECONOMI C CRISIS
IMO REGULATION						COMPANY STRATEGY
IMO REGULATION						SOURCE OF FINANCE
IMO REGULATION						COMPETA TION
IMO REGULATION						NUMBER OF CURRENT FLEET
IMO REGULATION						AGE OF FLEET

Influence Comparisons						
Dimension (A)	**NO Influence**	**Low Influence**	**Medium Influence**	**High Influence**	**V. High Influence**	**Dimension (B)**
OIL PRICE						FREIGHT RATE
OIL PRICE						NEW BUILD ORDER BOOK
OIL PRICE						SECURED CARGO
OIL PRICE						TIME OF SHIP BUILD ORDER
OIL PRICE						TYPE OF SHIP (new / second hand)
OIL PRICE						CAPITAL
OIL PRICE						TECHNOLOGY
OIL PRICE						LEVERAGE
OIL PRICE						GEOPOLITICAL
OIL PRICE						COMPANY PROFIT
OIL PRICE						IMO REGULATION
OIL PRICE						NEW BUILD PIECE
OIL PRICE						ECONOMIC CRISIS
OIL PRICE						COMPANY STRATEGY
OIL PRICE						SOURCE OF FINANCE
OIL PRICE						COMPETATION
OIL PRICE						NUMBER OF CURRENT FLEET
OIL PRICE						AGE OF FLEET

Influence Comparisons						
Dimension (A)	**NO Influence**	**Low Influence**	**Medium Influence**	**High Influence**	**V. High Influence**	**Dimension (B)**
NEW BUILD PIECE						FREIGHT RATE
NEW BUILD PIECE						NEW BUILD ORDER BOOK
NEW BUILD PIECE						SECURED CARGO
NEW BUILD PIECE						TIME OF SHIP BUILD ORDER
NEW BUILD PIECE						TYPE OF SHIP (new / second hand)
NEW BUILD PIECE						CAPITAL
NEW BUILD PIECE						TECHNOLOGY
NEW BUILD PIECE						LEVERAGE
NEW BUILD PIECE						GEOPOLITICAL
NEW BUILD PIECE						COMPANY PROFIT
NEW BUILD PIECE						IMO REGULATION
NEW BUILD PIECE						OIL PRICE
NEW BUILD PIECE						ECONOMIC CRISIS
NEW BUILD PIECE						COMPANY STRATEGY
NEW BUILD PIECE						SOURCE OF FINANCE
NEW BUILD PIECE						COMPETATION
NEW BUILD PIECE						NUMBER OF CURRENT FLEET
NEW BUILD PIECE						AGE OF FLEET

Influence Comparisons						
Dimension (A)	**NO Influence**	**Low Influence**	**Medium Influence**	**High Influence**	**V. High Influence**	**Dimension (B)**
ECONOMIC CRISIS						FREIGHT RATE
ECONOMIC CRISIS						NEW BUILD ORDER BOOK
ECONOMIC CRISIS						SECURED CARGO
ECONOMIC CRISIS						TIME OF SHIP BUILD ORDER
ECONOMIC CRISIS						TYPE OF SHIP (new / second hand)
ECONOMIC CRISIS						CAPITAL
ECONOMIC CRISIS						TECHNOLOGY
ECONOMIC CRISIS						LEVERAGE
ECONOMIC CRISIS						GEOPOLITICAL
ECONOMIC CRISIS						COMPANY PROFIT
ECONOMIC CRISIS						IMO REGULATION
ECONOMIC CRISIS						OIL PRICE
ECONOMIC CRISIS						NEW BUILD PIECE
ECONOMIC CRISIS						COMPANY STRATEGY
ECONOMIC CRISIS						SOURCE OF FINANCE
ECONOMIC CRISIS						COMPETATION
ECONOMIC CRISIS						NUMBER OF CURRENT FLEET
ECONOMIC CRISIS						AGE OF FLEET

Influence Comparisons						
Dimension (A)	NO Influence	Low Influence	Medium Influence	High Influence	V. High Influence	Dimension (B)
COMPANY STRATEGY						FREIGHT RATE
COMPANY STRATEGY						NEW BUILD ORDER BOOK
COMPANY STRATEGY						SECURED CARGO
COMPANY STRATEGY						TIME OF SHIP BUILD ORDER
COMPANY STRATEGY						TYPE OF SHIP (new / second hand)
COMPANY STRATEGY						CAPITAL
COMPANY STRATEGY						TECHNOLOGY
COMPANY STRATEGY						LEVERAGE
COMPANY STRATEGY						GEOPOLITICAL
COMPANY STRATEGY						COMPANY PROFIT
COMPANY STRATEGY						IMO REGULATION
COMPANY STRATEGY						OIL PRICE
COMPANY STRATEGY						NEW BUILD PIECE
COMPANY STRATEGY						ECONOMIC CRISIS
COMPANY STRATEGY						SOURCE OF FINANCE
COMPANY STRATEGY						COMPETATION
COMPANY STRATEGY						NUMBER OF CURRENT FLEET
COMPANY STRATEGY						AGE OF FLEET

Influence Comparisons						
Dimension (A)	NO Influence	Low Influence	Medium Influence	High Influence	V. High Influence	Dimension (B)
SOURCE OF FINANCE						FREIGHT RATE
SOURCE OF FINANCE						NEW BUILD ORDER BOOK
SOURCE OF FINANCE						SECURED CARGO
SOURCE OF FINANCE						TIME OF SHIP BUILD ORDER
SOURCE OF FINANCE						TYPE OF SHIP (new / second hand)
SOURCE OF FINANCE						CAPITAL
SOURCE OF FINANCE						TECHNOLOGY
SOURCE OF FINANCE						LEVERAGE
SOURCE OF FINANCE						GEOPOLITICAL
SOURCE OF FINANCE						COMPANY PROFIT
SOURCE OF FINANCE						IMO REGULATION
SOURCE OF FINANCE						OIL PRICE
SOURCE OF FINANCE						NEW BUILD PIECE
SOURCE OF FINANCE						ECONOMIC CRISIS
SOURCE OF FINANCE						COMPANY STRATEGY
SOURCE OF FINANCE						COMPETATION
SOURCE OF FINANCE						NUMBER OF CURRENT FLEET
SOURCE OF FINANCE						AGE OF FLEET

Influence Comparisons						
Dimension (A)	NO Influence	Low Influence	Medium Influence	High Influence	V. High Influence	Dimension (B)
COMPETATION						FREIGHT RATE
COMPETATION						NEW BUILD ORDER BOOK
COMPETATION						SECURED CARGO
COMPETATION						TIME OF SHIP BUILD ORDER
COMPETATION						TYPE OF SHIP (new / second hand)
COMPETATION						CAPITAL
COMPETATION						TECHNOLOGY
COMPETATION						LEVERAGE
COMPETATION						GEOPOLITICAL
COMPETATION						COMPANY PROFIT
COMPETATION						IMO REGULATION
COMPETATION						OIL PRICE
COMPETATION						NEW BUILD PIECE
COMPETATION						ECONOMIC CRISIS
COMPETATION						COMPANY STRATEGY
COMPETATION						SOURCE OF FINANCE
COMPETATION						NUMBER OF CURRENT FLEET
COMPETATION						AGE OF FLEET

Influence Comparisons						
Dimension (A)	NO Influence	Low Influence	Medium Influence	High Influence	V. High Influence	Dimension (B)
NUMBER OF CURRENT FLEET						FREIGHT RATE
NUMBER OF CURRENT FLEET						NEW BUILD ORDER BOOK
NUMBER OF CURRENT FLEET						SECURED CARGO
NUMBER OF CURRENT FLEET						TIME OF SHIP BUILD ORDER
NUMBER OF CURRENT FLEET						TYPE OF SHIP (new / second hand)
NUMBER OF CURRENT FLEET						CAPITAL
NUMBER OF CURRENT FLEET						TECHNOLOGY
NUMBER OF CURRENT FLEET						LEVERAGE
NUMBER OF CURRENT FLEET						GEOPOLITICAL
NUMBER OF CURRENT FLEET						COMPANY PROFIT
NUMBER OF CURRENT FLEET						IMO REGULATION
NUMBER OF CURRENT FLEET						OIL PRICE
NUMBER OF CURRENT FLEET						NEW BUILD PIECE
NUMBER OF CURRENT FLEET						ECONOMIC CRISIS
NUMBER OF CURRENT FLEET						COMPANY STRATEGY
NUMBER OF CURRENT FLEET						SOURCE OF FINANCE
NUMBER OF CURRENT FLEET						COMPETATION
NUMBER OF CURRENT FLEET						AGE OF FLEET

Influence Comparisons						
Dimension (A)	NO Influence	Low Influence	Medium Influence	High Influence	V. High Influence	Dimension (B)
AGE OF FLEET						FREIGHT RATE
AGE OF FLEET						NEW BUILD ORDER BOOK
AGE OF FLEET						SECURED CARGO
AGE OF FLEET						TIME OF SHIP BUILD ORDER
AGE OF FLEET						TYPE OF SHIP (new / second hand)
AGE OF FLEET						CAPITAL
AGE OF FLEET						TECHNOLOGY
AGE OF FLEET						LEVERAGE
AGE OF FLEET						GEOPOLITICAL
AGE OF FLEET						COMPANY PROFIT
AGE OF FLEET						IMO REGULATION
AGE OF FLEET						OIL PRICE
AGE OF FLEET						NEW BUILD PIECE
AGE OF FLEET						ECONOMIC CRISIS
AGE OF FLEET						COMPANY STRATEGY
AGE OF FLEET						SOURCE OF FINANCE
AGE OF FLEET						COMPETATION
AGE OF FLEET						NUMBER OF CURRENT FLEET

Appendixes E

Research Information and consent form

Welcome to the research study!

This research is interested in developing investment decision-making method for the oil shipping companies in order to invest in new vessels. Please be assured that your responses will be kept completely confidential and used for the research purposes.

Your participation in this research is voluntary. You have the right to withdraw at any point during the study, for any reason, and without any prejudice. If you would like to contact the Principal Investigator in the study to discuss this research, please find me on:

Full name: Bassam Aljahdali
Occupation: PhD Researcher at University of Strathclyde, Glasgow, UK
Email: b**********@strath.ac.uk
Mobile:
Address: Department of Naval Architecture, Ocean & Marine
Engineering, University of Strathclyde
Henry Dyer Building, 100 Montrose Street, Glasgow G4 0LZ, United Kingdom

By clicking the button below, you acknowledge that your participation in the study is voluntary, you are 18 years of age, and that you are aware that you may choose to terminate your participation in the study at any time and for any reason.
Please note that this survey will be best displayed on a laptop or desktop computer. Some features may be less compatible for use on a mobile device.

- I do consent, Begin the survey
- I do not consent, I do not like to participate

Please Fill the red column with your decision whether to buy a ship or not, based on the given data, where 0 = not to buy and 1 = buy.

DATE	FREIGHT RATE (VLCC)	NEW BUILD PRIECE (VLCC)	OIL PRICE $/b	COUNTRY PRODECTIO N	SECURED CARGO	NEW BUILD ORDER BOOK	ECONOMIC CRISIS	NEW IMO REGULATIO	COMPANY FLEET	AGE OF COMPANY FLEET 20 YEARS OR OVER	INTEREST RATE FOR VESSEL	COMPANY RPOFIT	DECISION
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1981													
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Appendixes F

[redacted]

[redacted]

NON-DISCLOSURE AGREEMENT

This Non-Disclosure Agreement (the "**Agreement**") is entered on June 27,2018 by and between:

1) [redacted]

2) **Bassam Mohammed Saleh S Al Jahdali, Saudi with National ID number:** [redacted] **(The "Second party "or" Recipient")**

Each of the parties hereto shall be referred to as "**Party**" and together they shall be referred to as the "**Parties**".

RECITALS

WHEREAS, The Recipient intends to use the discloser data as a case study for his PHD dissertation (the "Research").

WHEREAS, Discloser is willing to allow the Recipient to access its data on a confidential basis, and the Recipient is willing to keep such data confidential pursuant to the terms and conditions set forth in this Agreement.

NOW, THEREFORE, in consideration of the mutual covenants and agreements contained herein, Discloser and Recipient agree as follows:

1. Definition of Confidential Information.
The parties acknowledge that the following will be considered confidential ("Confidential Information"): (a) the terms and conditions of this Agreement; (b) the existence of the discussions between the parties and information made available during the Research; (c) information that is marked clearly as confidential or proprietary; (d) information that is designated as confidential or proprietary at the time of disclosure; or (e) information that, by its very nature, the Recipient knows or should know is confidential, including without limitation Discloser's strategic goals, product plans, customer information and lists, designs, costs, prices and names, finances, marketing plans, business opportunities, personnel, research, development or know-how. Confidential Information does not include information that: (1) is now or subsequently becomes generally available to the public through no fault or breach on the part of Recipient; (2) Recipient can demonstrate to have had rightfully in its possession prior to disclosure to Recipient by Discloser; (3) is independently developed by Recipient without the use of any Confidential Information.

2. Nondisclosure and Non-use of Confidential Information.
Recipient agrees to use high degree of care, to prevent any unauthorized use, disclosure, publication or dissemination of Confidential Information. Recipient agrees to use Discloser's Confidential Information for the sole purpose of conducting of the Research.

[redacted]

[redacted]

[redacted]

3. No Warranty.

All Confidential Information remains the property of Discloser and no license or other rights in the Confidential Information is granted hereby. All information is provided "AS IS" and without any warranty, express, implied or otherwise, regarding its accuracy or performance. Recipient will return all tangible Confidential Information, including but not limited to all documentation, notes, plans, drawings, computer programs, and copies thereof, to Discloser immediately upon Discloser's written request.

4. Indemnity.

The Recipient shall indemnify and hold harmless the Discloser from and against any harm, liability, loss, damages or expense incurred by the Discloser as a result of any act, procedure, negligence, omission or willful misconduct of the Recipient in connection with the performance of its duties and obligations hereunder.

5. Term.

[redacted]

6. Entire Agreement.

This Agreement constitutes the entire agreement with respect to the Confidential Information disclosed herein and supersedes all prior or contemporaneous oral or written agreements concerning such Confidential Information. This Agreement may not be amended except by the written agreement signed by authorized representatives of both parties.

7. Governing Law and Jurisdiction.

This Agreement is made under and shall be governed and construed according to the laws and regulations of [redacted] The parties irrevocably agree that the courts of [redacted] shall have exclusive jurisdiction to settle any dispute or claim that arises out of or in connection with this agreement or its subject matter.

IN WITNESS WHEREOF, the Parties have caused this Agreement to be executed by their duly authorized representatives on the date set forth above.

[redacted]

The
Nam
Title
Sign

Bassam Mohammed Saleh S Al Jahdali:

ID number: [redacted]

Signature: [redacted]

[redacted]

Appendixes G

Research Information and consent form

Welcome to the research study!

This research is interested in developing investment decision-making method for the oil shipping companies in order to invest in new vessels. Please be assured that your responses will be kept completely confidential and used for the research purposes.

Your participation in this research is voluntary. You have the right to withdraw at any point during the study, for any reason, and without any prejudice. If you would like to contact the Principal Investigator in the study to discuss this research, please find me on:

Full name: Bassam Aljahdali
Occupation: PhD Researcher at University of Strathclyde, Glasgow, UK
Email: b**********@strath.ac.uk
Mobile:
Address: Department of Naval Architecture, Ocean & Marine
Engineering, University of Strathclyde
Henry Dyer Building, 100 Montrose Street, Glasgow G4 0LZ, United Kingdom

By clicking the button below, you acknowledge that your participation in the study is voluntary, you are 18 years of age, and that you are aware that you may choose to terminate your participation in the study at any time and for any reason.
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