Modelling of Nigeria's Liquefied Natural Gas Shipping Trade

By

IGBOANUSI CHINEMEREM C

B.Tech, M.Sc.

2011477128

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CERTIFICATION

This is to certify that this dissertation was carried out by **IGBOANUSI CHINEMEREM C** with Registration number **2011477128**, Department of Maritime Management Technology, Federal University of Technology Owerri under the supervision of **Dr. D.E Onwuegbuchunam** in partial fulfilment of the requirement for the Award of Doctor of Philosophy (Ph.D.) degree in Maritime Management Technology.

Dr. D.E Onwuegbuchunam
.... 16/01/23
Supervisor **Signature** **Date**

Prof. G.C Emeghara
.... 16/1/23
Co-Supervisor **Signature** **Date**

Dr. H.O Amuji
.... 16/01/23
Co-Supervisor **Signature** **Date**

Dr. O.B. Ndikom
.... 18/01/23
Head of Department **Signature** **Date**

Prof. O T Ebiringa
.... 19/01/2023.
Dean, SMAT **Signature** **Date**

Prof B.O Esonu
....
Dean Postgraduate School **Signature** **Date**

Prof. P. U. Owuala
.... 23/1/2023
External Examiner **Signature** **Date**

DEDICATION

I dedicate this project to GOD ALMIGHTY for His guidance and protection throughout the duration of the Program

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ABSTRACT

Nigeria has the largest proven natural gas reserves in Africa and its reserves ranked as ninth (9th) largest in the World- accounting for 188.8tcf (trillion cubic feet) of proven reserves as at the year 2019. However, Nigeria's capacity to participate in the global natural gas shipping trade and earn freight revenue has been constrained by shipping tonnage market domination by other nations. Thus, as the nation strives to improve her revenue earnings through robust visible and invisible trade policy; it has become imperative to investigate empirically the determinants of Nigeria's international shipping trade in Natural gas. This research developed the gravity model of Nigeria's natural gas (NLNG) shipping trade to determine the factors affecting NLNG international freight market. The secondary data for the study comprised of volume of natural gas production (in billion cubic meters) shipped between Nigeria and other trading partner countries, geographical distance data between trading partner countries, population mass of trading partners, price of natural gas and bilateral trade agreements. Others include: logistics performance indices and shipping freight rates. These were sourced from global databases, Nigeria LNG limited, the Nigerian Ports Authority and covered the periods between years 2003 to 2020. To address the hypotheses governing this research, we developed an augmented gravity model of natural gas shipping trade in Nigeria's international freight market and examined trends in demand. The following variables were found statistically significant in explaining NLNG trade namely: quality of transport infrastructure (-225.448), geographical distance (-232.721), trade agreement (42.534) and population mass (0.955). These coefficients are in their natural logs and can therefore be interpreted as elasticities. In terms of most important trading blocs or shipping routes, the most important shipping routes (which are dummy variables) are namely: The United States of America (3,360.056), EuroAsia (3,090.082), Europe (904.810) and South America (786.413). These findings indicate that robust policy interventions are needed to promote trade with our trading partners. Robust investments are also needed in our transport infrastructure quality (especially that of bunkering facilities for LNG vessels) in order to reduce impediments to trade. From the positive trend analysis results, demand for natural gas is positive and the federal government should encourage more private sector investment in LNG shipping fleet to increase Nigeria's participation in LNG international freight market. As recommendation for further studies, modelling of constraints of natural gas trade involving gasification and re-gasification stations should be explored in order to expand the scope of the present work.

Liquefied Natural Gas, Gravity Model, Natural Gas Shipping, Shipping Freight Market, Production and Consumption, Import and Export, Future Outlook, Energy Consumption

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Liquefied Natural Gas (LNG) is natural gas with some mixture of ethane (C_2H_6) that has been cooled down to liquid form for ease and safety of non-pressurized storage or transport. In accordance with the IMO, the definition of liquefied gas is a substance which is gaseous at ambient temperature and pressure, but which can be liquefied by increasing the pressure or lowering the temperature or a combination of both methods. At standard temperature and pressure, liquefied natural gas takes up about 1/600th the volume of natural gas in the gaseous state. It is an odorless, colorless, non-toxic and non-corrosive_gas_(Qcip.uk, 2018). Its hazards may include flammability after vaporization into a gaseous state, freezing and asphyxia. The liquefaction process involves the removal of certain components, such as dust, acid gases, helium, water, and heavy hydrocarbons. Natural gas is then transformed into a liquid at atmospheric pressure by cooling it to approximately −163°C.

Over the past decade, natural gas consumption has continued to increase, accounting for 24 % of the global primary energy mix in 2014 (British Petroleum

(BP), 2015). Natural gas is mainly converted to LNG for transport over the seas where pipelines are said not to be economically reasonable. LNG achieves a higher reduction in volume than compressed natural gas (CNG) so that the energy density of LNG is 2.4 times greater than that of CNG (at 250 bar) or 60 percent that of diesel fuel. Thus making LNG cost efficient in marine transport over long distances (Energy Choices, 2018). Natural gas is an important source of clean energy and has been estimated to be a primary fuel source by 2030 (U.S. EIA, 2012).

The natural gas industry consists of three main parts; production and processing, transmission and storage, and distribution; without conversion to LNG, natural gas can only be transported via pipelines, which leads to regional pricing differences based upon the pipeline grid. The gas is first extracted and transported to a processing plant where it is purified by removing any condensates such as water, oil, mud, as well as other gases such as CO_2 and H_2S. An LNG process train will also be used to remove trace amounts of mercury from the gas stream to prevent mercury amalgamating with aluminum in the cryogenic heat exchangers. The gas is then cooled down in stages until it is liquefied. After natural gas has been processed, its transportation is done through pipelines to the local distribution companies (LDCs) or it is stored either as liquid natural gas in tanks or back underground in aquifers or salt caverns. The LDCs purchases these natural gas and supply to residential, commercial, and industrial consumers. LDC gas supply system consists of gate stations, compressors, gas storage, and customers. (Gregory et al. 2018).

Natural gas is relatively cheap, environmental friendly and it is an efficient fossil fuel that is gaining in attractiveness daily as it can be used in many sectors with the largest being power generation; followed by industrial use for the production of chemicals, etc and lastly residential uses which includes; heating, cooking etc. (BP, 2011). In recent times, a strong growth in natural gas consumption in the Asia-Pacific region and the Middle East has been noticed, although North America still remains the largest gas consumer (BP, 2011). Natural gas is an important part in the global energy market that is expected to play an increasingly vital role in meeting global energy demand (Prerna, 2012). Considering that not all consumers can be reached by pipelines; the technique of transporting natural gas in the liquefied form was developed.

Natural Gas in liquid form is transported in Liquefied Natural Gas Vessels over a long distance. LNG has been safely handled for several decades, with LNG vessels having made more than 100,000 voyages without major accidents or safety problems (Timrileylaw.com, 2017). To move 1 mmtpa of LNG from the US Gulf to Japan requires about 1.9 ships, compared to 0.7 to move the same amount of

LNG from an Australian port. For LNG shipping this increase in supply is favorable, as much of it is coming from the US Gulf which is a long way from the largest LNG markets in Northeast Asia, (Andrew, 2018).

Transportation of liquefied gas at sea started in 1934 by converting two ships transporting oil products to transport liquefied petroleum gas vessels under pressure, thereby allowing long distance transport of substantial amounts of refined oil products used mainly for consumer use. Interest in the use of natural gas began to grow in 1990, which led to an increase in orders for LNG ships and subsequent increase in the world fleet. The first LNG carrier Methane Pioneer (5,034 DWT) left the Calcasieu River on the Louisiana Gulf coast on 25 January 1959. Carrying the world's first ocean cargo of LNG, it sailed to the UK where the cargo was delivered. Subsequent expansion of that trade has brought on a large expansion of the fleet to today where giant LNG ships carrying up to 260,000 m^3 are sailing worldwide. Typically, new ship order is sized at 170-180,000m^3, compared to 155,000m^3, this is due to advances in design and maximization of carrying capacity through the newly expanded Panama Canal, (Andrew, 2018).

In recent years, a steady growth in global LNG trade has been observed with 2017 marking the highest growth rate of 293.1 million tones, an increase of 12 percent from that of 2016. It has also been recorded to be the highest growth since 2010

(LNG world news, 2018). In volume terms, international LNG trade has increased from 143 billion cubic meters (BCM) in 2001 to 325 BCM in 2013 and 393 BCM in 2017 (British Petroleum, 2002; 2014; International Gas Union, 2014; Statista, 2018). Rising population across the globe has surged the demand for LNG as a source of fuel and, in turn, will propel the growth of the LNG carrier market. As the LNG market grows rapidly, the fleet of LNG carriers continues to experience tremendous growth. LNG is one of the fastest growing sectors in shipping and advances in design have made new ships more attractive when compared to the existing LNG fleet. The market clearly calls for new ships and it could be said that ship orders have been too little too late (Andrew, 2018).

1.2 Problem Statement

Nigeria has the largest proven natural gas reserves in Africa and its reserves ranked as ninth (9^{th}) largest in the world, despite Africa as a whole having just 7.3% of proven reserves. The country alone accounts for 188.8tcf (trillion cubic feet) of proven reserves (BP, 2019). With the highly significant proven gas reserve, Nigeria thus has enormous potential for LNG exports and capacity for meeting increasing global demand for clean energy. However, this potential has not been harnessed. For example, Nigeria exported 27.8bcm (billion cubic meters) of 49bcm produced LNG in 2018; a relatively low quantity given that Malaysia exports

33.8bcm of its production of 72.5bcm in the same year. Malaysia’s reserve is estimated at 84.5tcf at the end of 2018, (BP, 2019). The problem this research intend to solve was first observed by Nze (2013), who asserted that African countries are responsible for only 5.2% fleet of National carriers in West and Central African Sub regions with few, ill-equipped and inadequate capacity to cope with their share of 40%. In Nigeria, of the 2,739 ships with net registered tonnage of 47.4 million that entered the country in 1985 less than 10% were national carries. By 1990, this did not improve as only 3% of the registered tonnage of 13.3 million was freights by national carriers. The vessels in the fleet of the national carriers gradually reduced and Nigeria has not been able to carry its own share of 40% approved by UNCTAD (Nze, 2013). This research will address the trends in LNG markets with a view to determining the viability of investment in shipping business, the capacity of vessels needed to meet with the quota allocated to Nigeria by UNCTAD and to maximize profit from shipping trade. Since the demands for vessels are derived demand; that is, it depends on the demand for LNG and its prices, we are interested in the demand for vessels based on the demand for LNG on one hand and to determine the vessel volume (size) in bcm that will yield optimal return (profit) to the investors.

1.3 Objectives of Study

The main objective of the study is to determine significant factors affecting Nigeria's LNG shipping trade with trading partners.

The specific objectives of the study are to determine the following:

1. To determine the effect of population mass on Nigeria's LNG shipping trade.
2. To access the impact of geographical distance on Nigeria's LNG shipping trade.
3. To ascertain the effect of price of natural gas on Nigeria's LNG shipping trade
4. To evaluate the impact of trade agreement on Nigeria's LNG shipping trade
5. To appraise the effect of transport infrastructure quality on Nigeria's LNG shipping trade
6. To determine significant NLNG shipping routes showing intense demand for sea transport.

1.4 Hypotheses

i. There is no significant effect of population mass on Nigeria's LNG trade (volume) with trading partners.

ii. Geographical distance does not significantly affect Nigeria’s LNG shipping trade.

iii. International price of natural gas does not significantly affect Nigeria’s LNG shipping trade.

iv. Trade agreement (bilateral/multilateral) does not significantly affect Nigeria’s LNG shipping trade.

v. Transport infrastructure quality does not affect Nigeria’s LNG trade with other nations.

vi. There are no significant LNG shipping routes showing intense transport demand.

All hypotheses are tested at $\alpha = 0.05$ level of significance.

1.5 Justification of Study

This research work will serve as a tool for contributing to existing body of knowledge given the paucity of academic literature in LNG shipping sector in Nigeria’s freight market. This research would be an aid to businesses trying to venture or invest in the oil and gas sector, especially on the transport sector. This work will also help to determine the best market for LNG which is important to ship building companies and investors in the shipping industry. It will also help players in the oil and gas sectors as it will provide information on the future of LNG shipping market.

1.6 Scope of the Study

This research work will cover the analysis of global demands of LNG which impact the demand for vessels in Nigeria shipping trade. The time scope will cover LNG trade between Nigeria and other trading partner nations for the period between years 2003 to 2020. In terms of geographical scope, Europe, Euroasia, Asia, Africa and North America trades with Nigeria will be covered.

1.7 Limitations of the Study

This research work is limited to the analysis of the global demands and prices of LNG which impact the demand for vessels in Nigeria shipping trade. And to determine the vessel capacity that will optimize return on investment. In the course of carrying out this research, the researcher finds it difficult to obtain the needed data for Nigerian LNG market, since Nigeria is still young in LNG market compared to already established LNG producing countries such as USA, etc. that has been in the trade for decades. An attempt to isolate Nigerian LNG production was greeted with very scanty data that were insignificant to what is required from this king of research. Also, the demand for shipping LNG is periodical and not daily as palm oil and petroleum that have daily demand; it becomes very difficult to rely on the Nigerian LNG market to obtain the needed data. And for this reason, the researcher resorted to global LNG market where he can get reasonable data points for the study. Other limitations include finance to carry out the research. A lot of money is required to carry out this research. The cost of sourcing for materials (published and unpublished) and moving from one location to the other to ascertain the nature and firsthand information needed for the study was enormous to the researcher. Hence, the researcher was limited to the area he worked.

CHAPTER TWO

LITERATURE REVIEW

2.1 Conceptual Framework

2.1.1 The Concept of Natural Gas

Natural gas is the cleanest fossil fuel mainly composed of methane, carbon dioxide and some noble gases found in reservoirs beneath the earth surface as an accompanying product of oil (Fpz.unizg.hr, 2018), formed as a result of the transformation of organic matter due to heat and pressure of overlaying rocks in the earth's crust (Patin, 1999). During combustion, natural gas, in comparison to the combustion of oil and coal, emit minute amounts of nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon dioxide (CO_2), carbon monoxide (CO) and other reactive hydrocarbons, whereas a higher level of harmful gases such as nitrogen oxides and sulfur dioxide are released during the combustion of oil and coal as a result of the composition of a much more complex molecular structure (Liang et al., 2012). Extensive processing of natural gas must be undertaken before it could be economically useful, as it was formerly considered a useless by-product in the oil industry. By cooling natural gas below its liquefaction point of about -163^oC at atmospheric pressure, natural gas is converted into liquid form for easy storage and/or transportation (Peter, 2018). Natural gas is cleaner and cheaper and therefore environmentally friendlier than any other known fossil fuel. Its reserves are abundant; widely distributed and has high heating capacity of > 10KWh/m^3 (knees et al., 2018). The uses of natural gas are heterogeneous. It can be used for electricity generation; source of supplying electricity as a fuel source for vehicles, airplanes and ships. It is used at homes for heating and cooking purposes and in various industries such as chemical industry or glass industry or as a fertilizer (BP statistical review of world energy, 2017). When natural gas at atmospheric pressure is cooled to temperatures of -163 ^oC , it condenses into colorless, odorless, non-toxic, non-corrosive and non-carcinogenic liquid. Natural gas occupies only 1/600 of the volume of its gaseous state in liquefied state, so it is transported more economically and stored more effectively (Foss, 2007). When it is in liquid form natural gas is commonly measured in metric tons and when it’s in gaseous state, it is measured in cubic feet.

2.1.2 Natural Gas Composition

Natural gas is a naturally occurring mixture, consisting mainly of methane. Methane is composed of one carbon and four hydrogen atoms (CH_4). When natural gas is produced from the earth, it includes many other molecules, like methane (used for manufacturing), propane (commonly used for backyard grills) and butane used in lighters, (Foss, 2007). Natural gas is odorless, colorless, non-corrosive, non-toxic and shapeless fossil fuel which is formed as a result of organic particles being compressed by sediments and exposed to a high temperature. Like the rest of its carbon relatives, it is an ideal energy source and has been used as early as 940 BC by the Chinese for desalination of sea water (Qcip.uk, 2018). From the table below, it can be seen that an unprocessed natural gas is mainly composed of methane as well as other petroleum gas products and gases.

Table 1: Table showing the chemical composition of unprocessed natural Gas

S/N	Component	Typical Analysis (mole %)	Range (mole %)
1	Methane	94.9	87.0 - 96.0
2	Ethane	2.5	1.8 - 5.1
3	Propane	0.2	0.1 - 1.5
4	iso – Butane	0.03	0.01 - 0.3
5	normal – Butane	0.03	0.01 - 0.3
6	iso – Pentane	0.01	trace - 0.14
7	normal – Pentane	0.01	trace - 0.04
8	Hexanes plus	0.01	trace - 0.06
9	Nitrogen	1.6	1.3 - 5.6
10	Carbon Dioxide	0.7	0.1 - 1.0
11	Oxygen	0.02	0.01 - 0.1
12	Hydrogen	Trace	trace - 0.02
13	Specific Gravity	0.585	0.57 - 0.62

Source: www.uniongas.com

The gas is refined in order to remove impurities according to the consuming market requirements. It can be refined to be in the form of LNG (liquefied natural gas), NGL (Natural gas liquids), LPG (liquefied petroleum gas), CNG (Compressed natural gas), and GTL (Gas to liquids). LNG is the main subject of this work, but in order to have a proper understanding of the concept, it will be necessary to give a little explanation of the other forms of natural gas as they are often mistakenly interchanged for the other.

Refining Process Stages of Natural Gas

The following are the products formed during natural gas refining process:

i. LNG is made up of mostly about 95% methane and 5% of other gases. In the process of liquefying it, non-methane components, such as carbon dioxide, water, butane, pentane and heavier components are removed. As stated earlier, it is odorless, non-corrosive and non-toxic. It burns in concentration of 5% to 15% when vaporized and mixed with air.

ii. NGLs are made up mostly of molecules heavier than methane. These molecules are easier to liquefy than methane. It contains 95% ethane, propane and butane, then 5% of others gases.

iii. LPG is predominantly a mixture of propane and butane in a liquid state at room temperature when under moderate pressure of less than 200psig (pounds per square inch gauge). It contains 95% butane and propane, then 5% of other gases. LPG is highly flammable. It is used heavily for domestic purposes such as cooking and heating.

iv. CNG is not the same as LNG, it is compressed natural gas, natural gas that is pressurized and stored in welding bottle-like tanks at pressure up to 3600psig. It has the same composition with pipeline quality natural gas, i.e. the gas has been dehydrated (water removed) and all other elements to trace so that corrosion is prevented. CNG, LPG and LNG are used as common transport fuels.

v. GTL refers to the conversion of natural gas to products like methanol, dim ethyl ether (DME), middle distillates (diesel and jet fuel), and specialty chemicals and waxes (Foss, 2007).

2.1.3 Historical Records on the Discovery of Natural Gas.

Experiments on the properties of gases started in the seventeenth century. Robert Boyle by the mid seventeenth century had derived the inverse relationship between the volume of gases and the pressure. Another scientist by name Guillaume

Amontons, about the same time, started looking into temperature effects on gas. For the next 200 years' various gas experiments continued. Efforts to liquefy gases were made during that time (En.wikipedia.org, 2018).

Discoveries have been on many aspects of nature of gases; Michael Faraday, James Joule, and William Thomson (Lord Kelvin) amongst a number of scientists conducted experiments in that area. Karol Olszewski in 1886 liquefied methane, which is the primary constituent of natural gas. All gases had been liquefied by 1900 except helium which was liquefied in 1908. In 1918, the first large scale liquefaction of natural gas in the U.S was achieved when natural gas was liquefied as a way to extract helium by the U.S. government, which is a small component of some natural gas. The liquefaction of natural gas which happen to be the main invention was in 1915 and the mid-1930s. Godfrey Cabot discovered that liquid gases can be stored at very low temperatures in 1915. The apparatus consisted of a Thermos bottle type design which comprised of a cold inner tank within an outer tank having the tanks separated by insulation (En.wikipedia.org, 2018). Lee Twomey received credit for a process in 1937 for liquefaction of large scale natural gas. To store natural gas, as a gas, near atmospheric pressure is not practicable because of large volumes. Nonetheless, it can be stored in a volume 600 times smaller when it, if liquefied. To store this gas, it must be stored at −163 °C (−260 °F).

Liquefaction of natural gas in large quantities requires two processes as explained below:

i. The cascade process: here the natural gas is cooled by another gas which previously has not been cooled yet by another gas, which brings the name the "cascade" process. Prior to the liquid natural gas there are usually two cascade cycles.

ii. The Linde process: this is done with a variation of the Linde process, called the Claude process being used sometimes. In this method, cooling of the gas is done by continually passing it through a tube until it is cooled to a temperature at which it liquefies. James Joule and William Thomson developed the cooling of gas by expanding it through a tube and it is generally known as the Joule–Thomson effect.

The first to experiment liquefaction of methane was Michael Faraday in the mid-nineteenth century. West Virginia had its first LNG plant built in 1912 and began operation in 1917. Cleveland, Ohio being the first commercial liquefaction plant was built in 1941 for natural gas storage (Peter, 2018). The implementation of LNG facilities was further delayed by the fire for several years. However, the stage for a revival of the industry was set for research on better insulation materials and low-temperature alloys over the next 15 years. Transportation of liquefied natural gas took-off in 1959 when the Methane Pioneer, a U.S. World War II Liberty ship was converted to carry LNG to energy starved Great Britain from the U.S. Gulf coast. The "Methane Princess’’, the world's first purpose-built LNG carrier entered service. In Algeria a large natural gas field was discovered soon after that. As LNG was shipped from the Algerian fields to France and Great Britain, International trade in LNG quickly followed. An important attribute of LNG had now been exploited. Liquefaction of natural gas not only made storage easier but also the transportation. This means that the same way oil was shipped; natural gas could now be shipped over the oceans in the form of LNG using LNG carriers.

2.1.4 Uses of Natural Gas

Between the 19th and early 20th centuries, natural gas was used mainly to provide light to street and building but due to the advancements in technology today, natural gas now has an extensive variety of uses in homes, businesses, factories, power plants etc. In 2011, the United States of America consumed approximately 30% of United States energy, about 24 billion cubic feet of natural gas consumption and the energy equivalent of almost 190 billion gallons of gasoline [Energy Information Administration, 2011], In 2012, the United States accounted for nearly 26 billion cubic feet of natural gas consumption from mainly the electric power and industrial sector swith electric power being the major consuming sector, whereas by the year 2017, the United States accounted for over 27 trillion cubic feet of natural gas consumption mainly from the electric power and industrial sector. Natural gas is used throughout the United States but states such Texas, California, Louisiana, Florida, and Pennsylvania accounted for about 30 % of the total US natural gas consumption in 2017 in a ratio of 14.3%, 7.8%, 5.9%, 5.1%, and 4.7% respectively [Energy Information Administration, 2018].

The global demand for gas has since 2014 been rising and by 2017 the demand rate accelerated prompted by Asia with china being the largest contributor to the increase in gas consumption, followed by India, Japan, and South Korea. The increase in gas demand was as a result of economic growth (Enerdata, 2018). Natural gas is a multipurpose, clean-burning, and efficient fuel that is used in a wide variety of applications. Natural gas consumers are grouped into five categories which include; residential, commercial, industrial, transportation, and electricity generation. Electricity generation happens to be the highest consumers of natural gas and then residential consumers being the least.

I. Residential Use

Natural gas is unquestionably one of the cheapest forms of energy, if not the cheapest. It is readily available to residential consumers for usage. According to Department of Energy, in the year 2011 natural gas was the cheapest source of energy obtainable, which was less than 68% the cost of electricity per Btu (British thermal unit), natural gas is cheaper than electricity. It is not only a good value for the residential consumers, it also has a number of uses such as natural gas heating and cooking. Using natural gas for cooking by residential customers is safer because it is characterized by its easy temperature control, self-ignition and self-cleaning. Approximately 56% of the heated homes in the United States made use of natural gas for heating which represent about 62 million households as at 2009, according to American Gas Association (AGA). Natural gas serves as the most popular used fuel for residential heating.

Just as natural gas is used for heating homes, it can also be used to cool down the temperature of houses through natural gas powered air conditioning. Unlike electric air conditioning unit, natural gas air conditioning units, like many other natural gas powered appliances are more expensive but cheaper to operate and with longer expected life and low maintenance cost. Due to new technological advancements, natural gas appliances are rising rapidly in popularity due to their efficiency and cost effectiveness. Modern residential air conditioner units use close to 30 percent less energy and with very little maintenance has an expected working life of 20 years (Nat-gas, 2013). With the aid of natural gas fuel cells and micro turbines, residential consumers now have the capacity to disconnect from their local electric distributor, and generate enough electricity to meet their requirements. Other natural gas appliances include outdoor lights, clothes dryers, barbecues, fireplaces, pool and Jacuzzi heaters, garage heaters and space heaters.

Although natural gas is capable of supplying energy to a huge number of residential appliances, there are some appliances in the house that require energy which cannot be supplied by natural gas. They include; television set, blender or microwave, these appliances for instance, are likely never to be powered directly by natural gas but will in its place need an electricity source. However, with the aid of a newly developed technology known as distributed generation (that is using natural gas to generate electricity right to your doorstep), natural gas is now capable of supplying power to these appliances in the home. Although this technology is still at its beginning stage, it is able to offer reliable, independent, efficient, environmentally-friendly electricity for household uses. In 2017, the residential sector accounted for about 16% of U.S. natural gas consumption and approximately 23 percent of the total natural gas consumed nationwide is used for residential purposes. In fact, natural gas has historically been a better value than electricity as a source of energy in the home (EIA, 2018).

II. Commercial Uses

The commercial uses of natural gas are similar to that of residential uses, while residential uses of natural gas talks only on the application of natural gas to households and its appliances. Commercial uses involve the use of natural gas in places such as public and private enterprises, place of worship, schools, office buildings, hotels, eateries and government structures. Natural gas may be used for commercial purpose but the main uses of natural gas include water heating, space heating and cooling. According to the Energy Information Administration (EIA) in 2017, the commercial sector accounted for about 12% of the US natural gas consumption and natural gas was the source of about 18% of the US commercial sector's energy consumption of which most are used for various purposes such as space and water heating, cooking, drying, lighting and commercial cooling purposes. This percentage of natural gas used for cooling is expected to increase due to technological modernizations in commercial natural gas cooling techniques. In commercial buildings, natural gas is said to be the most efficient and economical fuel as majority of the usage of natural gas in the commercial sector where expected to come from the Non-space heating applications of natural gas, cooling and cooking are two main growth areas for the use of natural gas in commercial settings. The demand for natural gas in the food service industry has experienced rapid growth. Natural gas is a very flexible energy source and the appliances powered by it can prepare meals in many different ways that are economical and efficient to large commercial food service industries. Gas-fired fryer, griddle, oven, hot/cold storage areas and multiple venting options can be integrated with smaller systems as natural gas-powered appliances can be simple, effective and efficient while packed together.

In commercial settings, because of the high demand in electricity, many buildings have on-site generators that produce their own electricity, the advancements in technology such as natural gas-powered fuel cells, reciprocating engines and turbines has made it possible to increased energy efficiency and electricity generation by using natural gas in commercial industries. These types of distributed generation units offer commercial environments more freedom from power disruption, high-quality steady electricity, and control over their own energy supply.

The combination of heating and power (CHP) and combination of cooling, heating and power (CCHP) systems is another technological innovation, which are used to increase energy efficiency in commercial settings. These integrated systems are able to convert heat lost energy. For example, the heat emitted from natural gas powered electricity generators can be connected to run space or water heaters, or commercial boilers. With these, wasted energies can radically improve energy efficiency (Natgas, 2013).

III. Industrial Uses

Natural gas is used for the production of products like plastic, fertilizer, anti-freeze, fabrics, etc. Industrial users of natural gas are the largest consumers of natural gas as they account for about 35% of natural gas use across all sectors, after electricity the second most used energy source in industry is natural gas (EIA, 2018). To heat and cool water in an efficient, economical, and environmentally sound way, natural gas absorption systems are also being used extensively in industry. Natural gas is converted to synthesis (a mixture of hydrogen and carbon oxides formed by the process of steam reforming in the process, natural gas is exposed to a catalyst that causes oxidization of natural gas when brought in contact with steam) used for the manufacturing of a number of chemicals and products and as a building block for methanol, which has a number of industrial applications which is used primarily in chemical, stone, clay and glass, pulp and paper, plastic and food-processing industries of which account for more than 84% of the total industrial natural gas use. Natural gas can be used for waste treatment and incineration, metal preheating, glass melting, drying and dehumidification, food processing etc. (Shively and Ferrare, 2007). It is also used to make substances like acetic acid, formaldehyde and an additive for cleaner burning gasoline called MTBE (methyl tertiary butyl ether). Pharmaceutical, plastic, candy and recycling industries make use of Natural gas desiccant systems (used for dehumidification). In addition to these uses, there are a number of innovative and industry specific uses such as natural gas co-firing and direct contact water heating. Most of these uses are relatively price-sensitive, and as such, their commercial success depends highly on the availability of cheap natural gas (Lazaridis, 2007). Infrared (IR) heating units provide a ground-breaking and economic method of using natural gas to generate heat in an industry. Direct contact water heating is an application that works by having the energy from the combustion of natural gas transferred directly from the flame into the water.

IV. Electric Power Generation

Electric power generation is the fastest growing use of natural gas today. By using the hot exhaust gases of fuel combustion in gas turbines, natural gas power plants commonly generate electricity by converting the heat energy from the combustion to electricity with the aid of a single-cycle gas turbine at efficiency of about 35% to 40% or at higher efficiencies of 50% or more in natural gas combined-cycle plants.

Natural gas-fired plants are presently amongst the cheapest power plants to be constructed and they have greater operational flexibility than coal plants because they can be fired up and turned down rapidly. At times such as summer (when air conditioning is widely used) when electricity demand were particularly high, natural gas plants were originally used to provide peaking capacity. Nevertheless, as from 2009, the price of natural gas in the United States decreased significantly; right now natural gas is increasingly being used as a base and intermediate load power source in many places. The contribution of Natural gas to electricity generation is increasing swiftly from around 17 percent in 2001 to 32.1 percent in 2017 [Energy Information Administration, 2018]. In North America, CIS, the Middle East and Africa natural gas is the dominant fuel used for power generation. In South and Central America, more than half of its power generation comes from hydroelectricity. In Europe, the major source of electricity is from nuclear energy.

V. Transportation Sector

Natural gas is also used as a fuel for transportation. It was first applied in the transportation industry in 1930 as an alternative to fuel, since then till now; it has only been able to obtain a small yet respectable share of the transportation market. This has mainly been through the firm emissions regulation and often in the form of public transportation systems like buses which are either government owned or partially financed. A lot of advantages are obtainable with regards to emissions control especially in huge cities where car congestions causes serious emission problem. When compared to oil, natural gas has lower harmful emission and can be used in cars with similar engines to today's average petrol car. The engine difference is however sufficient to mean that transportation users of natural gas are unable to switch fuel for reasons such as adverse short-term price fluctuations. Nearly all vehicles that use natural gas as a fuel are in government and private vehicle. In 2017, the transportation sector accounted for about 3% of total U.S. natural gas consumption. Natural gas was the source of about 3% of the U.S. transportation sector's energy consumption in 2017 of which 94% was for natural gas pipeline and distribution operations (EIA, 2018).

2.1.5 Implications of Competing Uses

The wide range of uses for natural gas makes it a critical resource for the world economies. The flexibility in the uses of natural gas also means that when there is a change in the demand for natural gas for one use, it is likely to affect the natural gas price for other applications. Natural gas prices in the United States throughout the 1990s were mostly low and stable. The major development of natural gas use in power plants led to steady increases in gas prices for all uses, including residential heating and industry. Since the early 2000s, gas prices have been distinguished for their instability. The amount of this instability stems from the difficulties in shipping gas where pipeline infrastructure is not already in place. Due to this restriction, there has been no worldwide market price for natural gas, and the local prices can be deeply reliant on regional production and availability. The reliance on regional gas supplies can also threaten a countries' energy security. Ample amount of Eastern and Central Europe's natural gas supply comes from Russia and passes through pipelines in several different countries on its way westward. Continual disagreements between Russia and Ukraine, for example, have led gas to shutoff, which have caused a serious shortage in countries as far as France and Italy [Kramer, 2009.]

2.1.6 Challenges in Handling of LNG

The challenges of liquefied natural gas include:

i. Storage/Transportation: Natural gas is difficult to store or be transported because of its physical nature and needs high pressures and low temperatures to increase the bulk density. Due to the difficulty of natural gas storage, natural gas needs to be transported immediately to its destination after production from a reservoir. (Cranmore, 2000)

Ii. Transportation Cost: The cost of transporting natural gas per unit of energy to distant markets is much higher compared to oil because of its volume–pressure behavior. LNG production at present costs around US$ 15/bbl oil equivalent (i.e. $ 2.5/thousand scf of gas) but many importing countries do not have the capital to build the huge storage and regasification facilities. (Cranmore, 2000)

2.1.7 Economics of LNG

LNG projects are very much capital intensive. The entire chain from surface of the oil well (wellhead) to the receiving terminal can cost around US$4 billion. Economies of scale are very significant as in the case of pipelines: liquefaction plants typically comprise of one or two processing trains of about 3 to 3.5 million tonnes per year is the economic size of each train as now, the capital cost of just the LNG production facility with this size of project is in the range of $1-2 billion. Normally a single-train plant costs around $1 billion, although actual costs vary geographically according to environmental and safety regulations, other local market conditions, labor costs and land costs. Sharp decrease in investment and operating costs of liquefaction plants are as a result of technological progress achieved in the past decades. For a liquefaction plant the average unit investment dropped from $550 ton/year of capacity in the 1960s, to approximately $350 in the 1970s and 1980s, and $250 in the late 1990s. For projects starting operation today, the price is slightly under \$200 (all in current dollars). Transport costs is a function of large size of the vessel, the distance between the, regasification and liquefaction terminals, more flexibility and reduced storage requirements are obtainable using a larger number of smaller carriers which raises the unit shipping costs. The maximum capacity for the largest LNG carriers today is approximately 150,000-180,000m^3 due to the expansion of the Panama Canal (Moryadee and Gabriel, 2017). Thanks to economies of scale, substantial reductions in cost have been achieved over the past decades. The sizes of tanker vessels have now increased from some 40,000 m^3 for the first generation to a range of 150,000 to 180,000 m^3 nowadays. Labor costs which vary considerably according to location, throughput capacity, storage capacity and land development regasification plant construction costs depend on it.

The most cost efficiently produced energy in relatively large facilities due to economies of scale is the LNG (En.wikipedia.org., 2018), at sites with marine access allowing regular large bulk shipments direct to market. In 2017, the global trade in LNG grew rapidly from negligible to what is by 2020 anticipated to be a globally meaningful amount. LNG global trade was of 3 billion cubic metres (bcm) in 1970 and it was 393bcmin 2017 (Statista, 2018). By 2020, the U.S. alone will export between 10 Bcf/d (3.75 quads/yr) and 14 Bcf/d (5.25 quads/yr) as forecast

(Black & Veatch, 2014). The LNG market will be roughly 10% the size of the global crude oil market if that occurs, the vast majority of natural gas which is delivered via pipeline directly from the well to the consumer will not be accounted for (Jadidzadeh and Serletis, 2017).

LNG accounted for 7 % of the world's natural gas demand in 2004. Substantially the LNG global trade, which has increased at a rate of 7.4 percent per year over the decade from 1995 to 2005, and over 10% in 2017(Cho, 2017;Everythingexplained.today, 2018). LNG demand was heavily concentrated in North-East Asia until the mid-1990s: South Korea, Japan and Taiwan. Pacific Basin supplies at the same time dominated LNG world trade. The failure of North American natural gas supplies to meet the increasing demand, coupled with the worldwide interest in using natural gas-fired combined cycle generating units for electric power generation, expanded significantly the regional markets for LNG. New Atlantic Basin and Middle East suppliers were also brought into the trade (Ltd, 2017). There were 18 LNG exporting countries and 36 LNG importing countries by the end of 2017. The top five exporters of LNG by share includes Qatar, Australia, Malaysia, Nigeria, Indonesia, respectively by the end of 2017. Although Australia remains the clear second-largest exporter, it gained significant ground in 2017 and is poised to do so again in 2018 with three new liquefaction projects. (World IGU LNG Report, 2018)

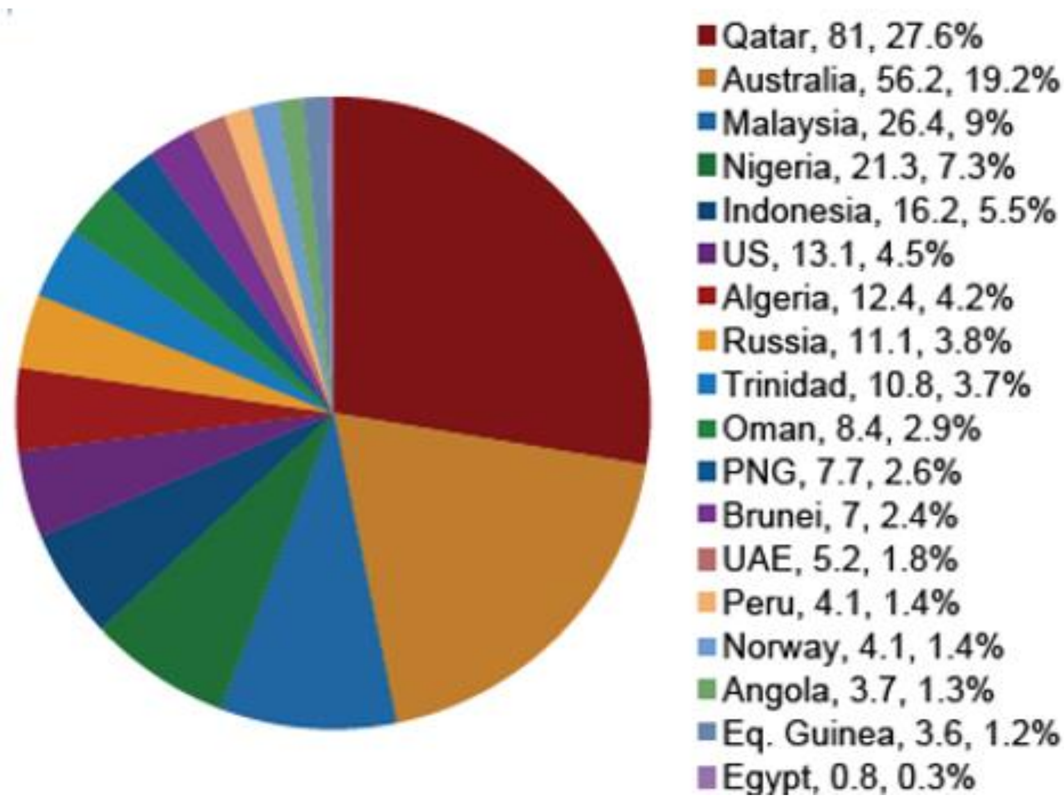

Fig 1: LNG export and market share by country (in MTPA)

Source: World LNG Report, 2018

Asian Pacific remained the largest importing region in 2017, taking in just over half of global supply at 50.3%. This is the fourth straight year of declining market share for the region, which is reflective largely of the rise of imports into Asia, led by China, and a recovery in European imports. Demand in Asia-Pacific continues to be led by Japan (84.5 MT), with South Korea (38.6 MT) a distant second in the region [World LNG Report, 2018]. LNG trade volumes increased from 172.83 MT in 2008, 246.55 MT in 2011, 249.36 MT in 2014 and 293.1 MTin 2017 [Clarkson, BP, 2018]. Qatar became the world's biggest exporter of LNG in 2006. Qatar is the source of 25 percent of the world's LNG exports as of 2012. By 2013, investments in U.S. export facilities were increasing, these investments were prompted by a large price differential between natural gas prices in the U.S. and those in Europe and Asia and the growing shale gas production in the United States. In 2016, Cheniere Energy became the first company in the United States to receive permission and export LNG (gCaptain, 2017).

2.1.8 Forces Driving the Renewed Interest in LNG

I. Environmental Concern

The issue of global warming has dominated all discussion relating to human existence on earth today. Huge quantities of natural gas exist in the form of natural gas hydrates, which are reservoirs in which natural gas is trapped within ice cages. These materials have strong links with climate change; they have the potential to magnify or remedy climate change depending on how they are handled. These materials are only stable at low temperatures and methane (95% natural gas) is twenty times worse than carbon dioxide as a greenhouse gas. Non-exploitation is thus not an option because with the present increase in atmospheric temperature due to climate change, these materials will soon start melting and methane will be released uncontrollably into the atmosphere. The resultant global warming will enable the release of yet more methane. This cyclic run-away scenario is better only imagined (Igboanusi, 2007). As a result of this scenario, the current increase in the consumption of natural gas is encouraged.

It is certain that the proper handling of natural gas hydrates is one of the challenges that nature has presented to our generation. This challenge is unique not just because it presents us with a bonus of energy supply if we succeed and thrusts us into an irredeemable cycle of climate change and natural disasters if we fail. It is unique because it presents itself at a time when our appetite for energy and our addiction to climate change enhancing activities warrants that it must be solved in this century if life on earth is to remain as we know it (Igboanusi, 2007).

II. Electricity Supply

As a result of the combined-cycle Gas turbines (CCGT), the power sector is increasingly showing interest in further use of natural gas for electricity generation. When compared to coal-fired steam and nuclear power plants, the CCGT power plants have significantly lower investment cost as well as higher power generating efficiency, shorter construction time and higher operational flexibility. This may be the reason why the US has chosen CCGT or gas turbines for up to 90% of their future constructed power generators (Shively and Ferrare, 2005). As the full life service of coal-fired stations begin to end and get phased out, the percentage of natural gas stations will increase significantly. Looking at this from the other round, this causes a problem since even the highly efficient CCGT generators are cheap only at gas price below $5 per million BTU and the high price variability in gas makes prices of coal more attractive at higher prices. Therefore, the future growth of gas as fuel for power generation highly depends on the market's ability to stabilize the highly volatile gas prices. One advantage is that as gas is used more and more for power generation, its consumption volume compared to its number, ability to hedge price volatility as well as its more predictable demand nature, with only surges in demand during the summer months, could mean that they will be what is needed to weigh down large fluctuations in gas prices. This will also depend on the industry's ability to increase its flexibility and open market trading (Lazaridis, 2007).

III. International Acceptance of Natural Gas.

Many countries now are in the quest for more energy and are considering adding natural gas in their energy mix. Among the countries entering into this exercise in a very big way are India and China, this they do in order to satisfy their growing thirst for energy. Among the countries to be included in this category are the Philippines, Singapore and New Zealand. All these countries basically demand natural gas towards there industrial and electricity generation uses with very small planning for other uses like residential and commercial. In the same vain, both China and India are relatively experiencing expansion in their car industry, indicating interest in adapting their public transport services towards cleaner fuels which will lower emissions especially within the cities. These gas needs are projected to be covered through major pipeline projects from Iran and Russia to India and china respectively (Shively and Ferrare, 2007).

Apart from countries in Asia, a whole lot of other countries in the world are showing interest in gas; among the other countries in the race are South American countries, previously dependent on oil and coal. These countries have lately pushed to attract investors in funding the large capital intensive infrastructure required in order for import and distribution of natural gas. Most of these countries are confronted with the problem of not being too close to major natural gas supplies and require extra funding for either offshore pipelines or LNG import facilities. Among the countries in South America working towards this include Jamaica, Puerto Rico, Chile and Mexico. Most of these countries mainly lacked investors as these markets are unable to show long term economic stability required for establishing cash flow security.

The investment climate is however changing as more projects are proposed (Lazaridis, 2007). Some countries like Mexico have found the easy solution of creating import terminals by co-operating with US for terminals which will serve both but be ideally situated in Mexico. These new countries entering into the business of importing natural gas have increased the expected number of players in the market and thus provide liquidity market which in turn lowers investment risk and as a consequence attract further financing.

IV. Cost Reduction on LNG Chain.

The latest developments in technology has made it possible for the cost of exploration, liquefaction, LNG tanker, re-gasification to be reduced significantly contrary to what it used to be, say ten years ago. The liquefaction cost reduction has been due to a number of factors. With more activity and more design constructors, plants have benefited from greater competition and higher productivity. The maturing of the industry with diversified supply source has led to less concern for building in redundancy – commonly called 'gold plating' – to ensure operating reliability. Substantial improvements have also come from increasing plant sizes and the resulting economies of scale. Expansion by means of one modern 4 MMT liquefaction train can cut the costs of liquefaction by about 25% compared with the two 2 MMT trains that were common ten years ago. Tanker costs have come down as well. Perhaps more of this improvement has been the result of greater activity and the resulting competition among shipyards for business. But increased tanker sizes have also improved economics, although the scale improvements are not as marked since the size increases have been less dramatic. A new 140,000 cubic metre tanker could probably cut costs by about 5% relative to the 125,000 cubic metre tankers of ten years ago (Jensen, 2004).

V. The Stranded Gas Phenomenon

This is another factor that has led to the higher interest in LNG. It is the emergence of concern for ‘stranded gases. At one time, companies searching for oil in international concession areas treated a gas discovery as a ‘dry hole’ and abandoned further effort in the area. Now with the possibility of major oil discoveries narrowing in many areas and with a mounting inventory of gas discoveries, companies are much more willing to concentrate on gas development possibilities (Jensen, 2004).

2.1.9 Natural Gas Production

The projected trends in the regional gas production generally reflect the relative size of the reserves and their proximity to the main markets. Production grows most in volume terms in the Middle East and Africa. Most of the incremental output in these two regions will be exported, mainly to Europe and North America. Output also grows quickly in the Latin America, where Venezuela emerges as an important supplier to North America. Output is expected to grow less rapidly in Russia, despite the region's large reserves: much of that gas will be technically difficult to extract and transport to market although, Europe has been projected to remain largely dependent on Russian pipeline gas. There are also doubts about how much investment will be directed to developing reserves in the transition economies. While Asia is projected to import a large amount of the traded LNG, other developing Asia sees slower growth, as Indonesia struggles to develop its reserves for export to other countries in the region. (IEO, 2017). According to world energy outlook, NON-OECD countries production is projected to be double of OECD counties production in 2040, (World Energy Outlook, (2016).

2.1.10 Natural Gas Consumption

The worldwide Consumption of natural gas is projected to increase from 120 trillion cubic feet (Tcf) in 2012 to 203 Tcf in 2040 (IEO2016). The consumption of natural gas grows in both the OECD and non-OECD from 2015 to 2040, but growth is greatest in non-OECD countries which have expanding industrial sectors and electricity demand because their infrastructure requires higher financing and has higher demand for safety, highly technical labor and quality, compared to other competing fuels such as oil and coal. The consumption of natural gas in non-OECD countries is projected to grow an average of 1.9%/year from 2015 to 2040 in contrast to 0.9%/year in OECD countries. The share of world natural gas consumption in non-OECD countries increases from 53% in 2015 to 59% in 2040 (International Energy Outlook, 2017)

Natural gas accounts for the largest increase in world primary energy consumption by energy source. Among other resources abundant natural gas resources and robust production contribute to the strong competitive position of natural gas. Natural gas remains a key fuel in the electric power sector and in the industrial sector. Natural gas is an attractive choice for new generating plants because of its fuel efficiency in the power sector. Natural gas also burns cleaner than coal or petroleum products, and as more governments begin implementing national or regional plans to reduce carbon dioxide (CO_2) emissions, they may encourage the use of natural gas to displace more carbon-intensive coal and liquid fuels, (IEO, 2016).

Natural gas continues to be an attractive fuel for the electric power and industrial sectors in many countries. Nearly 75% of the projected increase in total consumption between 2015 and 2040 are accounted for by these two uses. Because of low capital costs, favorable heat rates, and relatively low fuel cost natural gas-fired generation is attractive for new power plants. Natural gas-intensive industries, such as chemicals, refining, and primary metals, expand over the period of 2015–2040particularly in non-OECD countries driving industrial demand. The International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI, which limits the sulfur content of marine fuels, and the growing spread between oil and natural gas prices are projected to lead to a greater use of liquefied natural gas (LNG) as a bunkering fuel towards the end of the projection. In 2015, Non-OECD member countries accounted for just over one-half of the world’s total natural gas use, and OECD countries accounted for the remainder. In the IEO2017 reference case, natural gas consumption in the non-OECD countries grows almost twice as fast as consumption in the OECD countries. Natural gas demand in the non-OECD countries accounts for about 72 percent of the total world increment in natural gas consumption over the projection period (IEO, 2017).

World Natural gas consumption rose by 96 billion cubic metres (bcm), or 3%, the fastest since 2010(BP, 2018), although only North America, Asia Pacific and Africa recorded above average regional growth. The US accounted for nearly half of the world's gas consumption growth, driven by cold winter weather and strong demand for power in the power generation. Natural gas accounted for nearly all the growth in the US energy consumption. Consumption growth was driven by China (31 bcm), the Middle East (28 bcm) and Europe (26 bcm). Consumption in the US fell by 1.2%, or 11 bcm. EU consumption declined by 1.6% the second consecutive decline in the face of warm winter weather (BP, 2018).

2.1.1 Natural Gas Prices

Natural gas prices rose and fell with that of oil before the 1980s. This is due to the negotiation of gas contracts being linked to crude oil (or oil products), more especially in International Energy Agency (IEA) regions. Both gas and oil market has been yearning for the unbundling and liberalization of network assets years after the inception of oil price linkage to natural gas. The delivery of accurate up-to-date information on the price of natural gas, called "hub pricing" is an efficient creation of ways to coordinate multiple players in the gas industry in order to make the NYMEX possible. The linking of oil to natural gas makes natural gas a tradable commodity. For natural gas both physical trading and derivatives trading occur, with the latter dominating by 10 to 12 times the value of the former [NaturalGas.org].

In terms of gas pricing, an international pricing regime that characterizes the oil market does not exist for natural gas. Where oil has an international pricing in terms of Brent Crude and WTI, the LNG market has separate regional markets as indicated by the frequent considerable deviation of prices across the globe, and the relationship in prices among these regional markets has lessened since 2009. The most important regions are North America, the U.K, the European Continent and Northeast Asia. The more noticeable abnormality of market prices in recent years is a result of the two different pricing systems in conjunction with market circumstances that are emphasizing pricing system differences and a limited market access for arbitrage. The U.K. and North America have both developed a short term market, while the European Continent and Northeast Asia regions still rely on long-term contracts. The European Continent and Northeast Asia prices are usually linked to the oil-indexed pricing system while the U.K. and North America prices are based on the gas price indicators like National Balancing Point (NBP), where prices are determined in a competitive process between multiple natural gas suppliers (i.e., gas-on-gas based prices), (BP Statistical review, 2018).

According to Makholm and Olive (2016), the reason for the non-existence of international gas price is the following;

1. The cost of liquefying natural gas to LNG, cost of shipping LNG to the regasification terminal and the cost of regasification is extremely higher than other commodities and can be as high as 150% of the competitive US gas sales price.
2. The regulations of the major industries outside the U.K and North America effectively prevent competitive entry of new supply. This is because of gas prices outside the U.K. and North America are still tied to the oil price rather than the supply and demand of natural gas.

Since the regional prices are partly independent of each other, a trader can ship LNG from a region where the price is high to a region where the price is low and make profit on the difference, excluding shipping costs, (Nikhalat-Jahromi et al., 2017).

Just like other commodities, natural gas price is inherently volatile. Since the reflection of market demand and supply is price, an investor making an investment decision could use the volatility of natural gas hub price as an indicator for decision making; for example, when it is reasonable to make more investment in natural gas storage and when to withdraw. In North America the hub system is increasingly becoming dominant and over 40 principal centers gas is now traded across the North American continent. The Henry Hub in Louisiana is the best known, and it is the NYMEX gas future contract reference point of gas. Natural gas spot market development is being permitted by Such innovative financial instruments, this guarantees that the underlying issues of demand and supply are reflected by the gas price, and not only that of oil prices, issues such as the level of industrial or commercial demand, pipelines, hydro levels, temperature, availability of power plants, oil prices, gas storage levels, are also included. However, this does not indicate that gas pricing cannot trail oil prices, to the level that they are interchangeable; change in the price of one will certainly have an effect on the price of the other. Nevertheless, it should be noted that, while the government still regulates the prices of storage services and transportation, the prices of gas still remain deregulated at the wellhead and at the bulk or wholesale level remains. It is debatable whether the deregulation of such service is desirable.

At some points it appears as if gas and oil prices are inversely related and that is an interesting aspect. Before 2007, a rise peaking in natural gas prices is accompanied by a dip in crude oil prices, once it hit 2007, the reverse is true, and also, a familiar peaks and dips at times through 2008-2009 was witness. The high competitiveness of natural gas relative to oil is indicated by the inverse relationship in price (Asche et al., 2017).

2.1.12 Trends in Gas Prices in North America

Consumers' access to resources and prices/cost are intended to be lowered by the liberalization. Prices have Nonetheless, gradually been increasing since the 2000s in the case of North America. Definitely the volatility in natural gas price has also been on the increase Not only so, there has also been increased volatility in natural gas prices (historically the price volatility of crude oil has always been 20% lower than that of natural gas), (CME Group, AdilaMchich, 2018).

The underlying powers of supply and demand of natural gas should first be understood in other to understand this combined phenomenon. Keeping aside Some common forces of demand and supply, natural gas market has some integral unique features, to which has an effect on its price structure:

1) To smoothen the tension between the low average marginal costs and high fixed cost, certainly balance needs to be in order to ensure short term competitiveness without jeopardizing long term investment incentives
2) Natural monopoly tends to exist on the large economies of scale related with the system of pipeline transmission. Natural gas prices spot market may not be favorable in this sense as long term contracting can be stifled by it, hence investments.

3) Wellhead price is generally being tracked by the price of natural gas (the natural gas price as a commodity), cost of local distribution and cost of transportation for long distance.
4) The entire energy market complex structure in each region influences the natural gas market in each region, by providing potential prospects and gas infrastructure for its future expansion;
5) The fixed variable costs of natural gas are usually large (startup capital, infrastructure, etc. being fixed cost, transmission and associated costs being variable).
6) Natural gas dominates no exclusive end-user market. Rather it tends to compete in every main use with other fuels Instead, either petrochemical, domestic heating, industrial, power generation, etc.
7) Generally, there exist low income elasticity for the demand of natural gas;
8) Different elasticity of demand exists for different end users of natural gas - generally the least responsive to a change in price are the residential/commercial consumers due to their inability to access viable substitutes.

These indicate that a series of regional markets has the price of natural gas dependent on the regulations in place and the nature of infrastructure. As a matter of facts, oil producers are less exposed to the risk of disruption than gas suppliers. Temporary supply shortages in the case of oil, can be dealt with by transferring oil (by railroad, truck, plane or tanker) to the emergency region. Furthermore, the requirement for gas cannot be constructed in a hurry because these are fixed installations which are highly costly. As a result, dangerous risk of not being able to access gas exist for all gas users that are not situated in the immediate locality of an LNG terminal, a pipeline hub or a gas field. This cannot be ignored as it is a competitive drawback.

Nevertheless, as different users have different supply needs, the degree to which such temporary supply shocks are “dangerous” should not be exaggerated. For example, heavy industrial users normally have the ability to substitute coal or heating oil, so there is no need for entirely protecting them from supply shocks by using a contract. Contrary to this, they even might decide not to be protected from supply shocks by a contract because they will need to pay the “premium risk”. Power generators with shifting requirements, on the other hand need greater security in supply, the residential/public service/commercial consumers without substitution ability still remain the most venerable group. Higher prices are paid generally by commercial consumers to enjoy protection through priority services and statutory distributor storage requirements, (U.S Energy Administration, 2018).

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In principle, one can say that achieving an efficient outcome is not actually prevented by the supply risk associated with natural gas. More payment will eventually be made by those who need more supply security. However, as oil becomes increasingly scarce in the long run and we look to natural gas as a viable option, in the commercial sector efforts should be made to make natural gas more competitive through reduction of the supply risk, and thus the premiums paid by the consumers, (Annual Energy Outlook 2019).

Gas resources are more than sufficient to meet projected increase in the consumption to 2050. Proven reserves amounted to 193.5 trillion cubic meters at the end of 2017 (BP Statistics, 2018). Were production to grow at the 2% annual rate projected in the reference scenario, reserves would last about 40 years. Close to 56% of these reserves are found in just three countries: Russia, Iran and Qatar. Gas reserves in OECD countries represent less than a tenth of the world total, (BP statistical review, 2018).

Worldwide proven gas reserves have grown by more than 80% over the past two decades. Global proved gas reserves rose slightly by 0.4 trillion cubic metres (tcm) or 0.2% to 193.5 tcm in 2017, which is sufficient to meet 52.6 years of global production at 2017 levels (BP statistical review, 2018). Much of this gas has been discovered while exploring for oil. In the recent years, the larger share of the reserve additions has come from upward revisions to reserves in fields that have already been discovered and are undergoing appraisal or development. As with oil, the gas fields that have been discovered since the start of the current decade are smaller on average than those found previously. The remaining recoverable gas resources, including proven reserves, reserves growth and undiscovered resources are considerably higher than reserves alone.

2.1.13 Demand for Natural Gas

Obviously, these days the availability of energy resources has become vital, while the rate of newly discovered energy resources is surpassed by the depletion's rate. Equally, natural gas prices are driven up by the globally increasing demand. Although there has been a slow-down on the economic recovery these days, this does not signify that there is no demand and growth coming the following years. According to (U.S. Energy Information Administration, 2016), the largest increase in world primary energy consumption is occupied by natural gas, therefore, natural gas is projected to increase from 120 trillion cubic feet (Tcf) in 2012 to 203 Tcf in 2040. Globally, 23.8% of primary energy consumption is accounted for by natural gas (BP Global, 2015). The main fuel in industry sector and in the production of electricity still remains Natural gas.

Increasing population and income drive the increased demand for energy, but that growth is hardened by deteriorating energy intensity (energy consumed per dollar of GDP). In the Reference case India and China are the two regions with the fastest projected growth in per capita income. But substantial declines in energy intensity in these countries decrease the amount of energy needed to meet demand in the future. Japan has an aging workforce and a deteriorating population that already has relatively high per capital income levels. It is also among the world's most efficient consumers of energy. The combination of the economic and demographic factors indicates the country has less potential to advance energy intensity in the future. Japan's energy intensity improves by 0.4%/year from 2015 to 2040, compared with the world average of 1.9%/year.

In 2040, the global economy is anticipated to recover and rise. More energy will be required as a result of this economic growth and improved standards of living. The transforming of China from an energy-intensive manufacturing country to a consumer-focused with less energy requirements per GDP/capita as well as energy efficiency improvements across all sectors contribute mainly to the economic expand with relatively low growth rates. It is clear the correlation among energy demand, population growth, and GDP development. The question now is how the sustainability growth of nonrenewable industry will be achieved. Every possible reserve should be recovered with maximum efficiency of materials and energy used for the extraction by reasonably seeing to the full utilization of drilling technologies. Both on domestic economic factors and those of global market the boundary line between oil and gas reserves and resources is highly related. The key point in extracting and providing the commodity is the price. Supplying commodities such as natural gas to the world market as well as successfully planning and implementing projects has its core issue as accurate economic forecasting models, (International Energy Outlook, 2017).

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Forecast of growth of global natural gas demand is put at 1.6% P. A. and among the hydrocarbon it is the only one with a growing share of global energy supply. It has been projected that largest growth is in Asian economies, followed by Europe, (BP Energy Outlook, 2017).

The key drivers for demand growth include the quest for cleaner source of energy. Environmentally, the cleanest hydrocarbon is natural gas emitting 30% less CO_2 per Btu than fuel oil, (EIA, 2017). Forecast to grow for the global GDP is at 3.4% P. A. that is almost twice in the next 20 years. (BP Energy Outlook, 2017).

As a result of shut-down of nuclear plants Japanese demand has grown after the Fukushima disaster. LNG is solely relied on by many Asian markets for their natural gas needs. Domestic production is expected to outstrip growth in gas consumption (5.4% P.A., 36 Bcf/day by 2035). In China, such that the expected rise in the share of imported gas in total consumption will amount to nearly 40% by 2035, up from 30% in 2015 (BP Energy Outlook, 2017). The largest projected increase in gas consumption is that of the electric power generation sector. Global energy consumption over the next 20 years will be for power generation and that will account for two-third of the increase as estimated by BP. Increasing demand for power generation is as a result of policies encouraging the closure of nuclear power plants by several European countries.

Due to energy security concerns there is also an increase in European demand for LNG. 39% of its natural gas for the EU is received from Russia and strategic objectives of diversity of energy supplies are supported by the diversity of supply through LNG imports. (European Commission) Italy, Spain, Lithuania, and Poland among other EU countries imported LNG from the Cheniere's Sabine Pass Louisiana plant in 2017. In the second and third quarters of 2017 the EU LNG share of imports reached 16% accounting for the highest in four years. (EU report, 2017)

Finally, as discussed earlier, LNG trade has been made more economic due to developments and investments in all segments of the LNG value chain, from natural gas production to LNG storage and re-gasification thereby increasing the demand for LNG.

2.1.14 US Demand of Natural Gas

The largest gas market in the world is the North American gas market with 942.8 bcm (billion cubic meters) consumed in 2017, or 25.7% of global gas demand. The demand for U.S gas has been rising steadily from 1980s. Natural gas locally, currently accounts for about a quarter of all energy in the U.S. 70% of newly built homes and 50% of existing homes are heated by It. Gas fired power plants makes up 88% of total new electrical power plants. (The EIA Annual Energy Outlook predicted, 2018).

In the Reference case projection, Natural gas grows the most on an absolute basis while on a percentage basis non-hydroelectric renewable grows the most. The most growth in natural gas consumption with expanding use is in the chemical industries for industrial heat and power; and for liquefied natural gas production area accounted for by the industrial sector. Consumption of Natural gas also rises significantly in the power sector as a result of the scheduled expiration of renewable tax credits in the mid-2020s. A combination of implementation of policies that encourage the use of renewable at the state level (renewable portfolio standards) and at the federal level (production and investment tax credits) and reductions in technology costs drives down the costs of renewable technologies (wind and solar photovoltaic), supporting their expanded adoption. Utilities in the United States of America are in the process of constructing a natural gas-fired power plant in Dresden Ohio. Likewise, Baxter International is also involved in many energy-related GHG-reduction activities, this involves the use of innovative technologies, for which a few examples are cogeneration and fuel switching from oil to natural gas. External pressure also come from investors who want to see these companies engaging in sustainable practices though some companies may be driven to energy efficiency and carbon friendly practices by profit motives. Non-profit organization acting on behalf of 551 institutional investors holding $71 trillion in assets under management and some 60 purchasing organizations like Dell, PepsiCo and Walmart are examples of the Carbon Disclosure Project. Major companies have been urged by the CDP to disclose their greenhouse gas emissions; this information is made available to the public through water management and climate change strategies, thereby creating for these companies a major incentive to engage in environmentally friendly activities.

The case that companies' business performances are actually affected by the adoption of sustainable strategies, i.e. terms under Corporate Social Responsibility (CSR) has been supported by a propagation of studies [The Economist; 2002]. Presently, the integration of concepts such as management quality, environmental management, brand reputation, customer loyalty, corporate ethics and talent retention are becoming the bases to define successful businesses [Lopez MV et. Al, 2007]. The Dow Jones Sustainability Index (DJSI) was as a matter of facts created to indeed reflect these qualities and investors are increasing using it to evaluate companies. The demand of natural gas is favored by such social trends.

2.1.15 Factors Influencing Short Term Vs Long Term Gas Demand

Natural gas short-term demand and subsequently the fluctuations in price in the U.S. are generally seasonal. During the winter time increase in the need for residential and commercial heating generally increases the demand of natural gas. Natural gas prices spike in Jan/Feb and dip in July/Aug as a result of this demand. The price ratio is about 2:1, and when one only considers the residential sector the ratio is even larger at 7.4:1. This cyclical demand is met by the Base load storage capacity. Gas is stored during the hot month and drawn from the storage during the cold period. Anomalies in the weather, such as abnormally cold winters, unfortunately, cause record price volatilities and could break down this system. During times of fuel switching demand shocks could also occur. There is a decrease in demand as several electric generation stations may change from using natural gas to using cheaper coal. The GHG emission credits, e.g. nitrogen oxide (NOx) are tortuously tied with the spot price of natural gas. One would precisely, expect the price of natural gas to increase with the price of NOx, as an increase in the cost of NOx intensive fuels such as coal and oil will occur due to increase in NOx price. A demand shock, such as the recent Financial Crisis could also be caused by the Economy-wide recessions, which caused leapt in the Henry Hub spot price close to $2 per MMbtu, in the early 1980s comparable to natural gas prices, U.S. Energy Information Administration, (EIA, 2018)

The price of natural gas could also significantly be impacted by other exogenous events. The California Energy Crisis, also known as the Western U.S is one example. 2001 energy Crisis, which instigated the price of natural gas in California to be artificially inflated, (Van Goor and Scholtens, 2014).

Long term determinants of demand are more significant to the future role of natural gas. These include the prospects of climate change legislation in the U.S., which is discussed later. Demographic change could also play a role. According to the

Work Progress Administration, recent demographic trend has inclined to warmer Southern and Western states, in which demand for cooling could increase. Other factors include technological advancements and energy efficiency regulations.

2.1.16 Demand Response to Changes in Natural Gas Prices

Consumers will react to prices as stated by conventional economic theory in the long run and for us what remains to explore is whether this happens in the market for natural gas. Over the past couple of years' energy prices has risen steadily, the tendency to lower ammonia and methanol output and switch production to sites near cheap sources of gas has been as observed. Nevertheless, since the North American prices are not indexed, a price spike/supply shock will decrease consumption, irrespective of whether the consumer buy spot prices or fixed price gas. The consumer will just stop buying if the sport price becomes too high in the case of the latter, in the case of the former the consumers might have to sell back to the market for a profit and thus interrupting his/her own consumption.

2.1.17 Natural Gas Supply

Owing to the world demand for energy, comes the supply of the product. Natural gas is commonly found in their reserves in countries where there are oil reserves; in these places, the value and demand for it is usually very low (GTI, 2006). So in order to add value to the product, it has to be transported to countries where there is high demand for it. Countries like; Qatar, UAE, United States, Nigeria, Russia, Saudi Arabia, Venezuela, Iraq, Norway, Turkmenistan, Uzbekistan, Kazakhstan, Netherlands, Canada, Egypt, China, Bolivia, Yemen, Peru, Equatorial Guinea, Angola, Algeria, Indonesia, Australia, Malaysia, Libya, Oman, Trinidad/ Tobago, and Brunei are the world major natural gas suppliers today. Current estimated reserves are around 193.5 trillion cubic meters (BP statistical review of world energy, 2018). Gas production rose by 2.4% in 2007. As was the case for consumption, the US accounted for the largest increment to supply, growing by 4.3%, the strongest growth since 1984. EU production declined by 6.4%, with UK output falling by 9.5%, the world's largest volumetric decline for a second consecutive year. A small decline in Russian production was more than offset by strong growth elsewhere in the Former Soviet Union. China and Qatar recorded the second and third-largest increments to production, increasing by 18.4% and 17.9% respectively. International trade in natural gas was weak in 2007, growing by 2.3%, less than half the 10 years' average.

2.1.18 Supply in the Us Market

The United States is the biggest gas market in the world with a total of 734.5 at the end of 2017, (BP statistics, 2018).

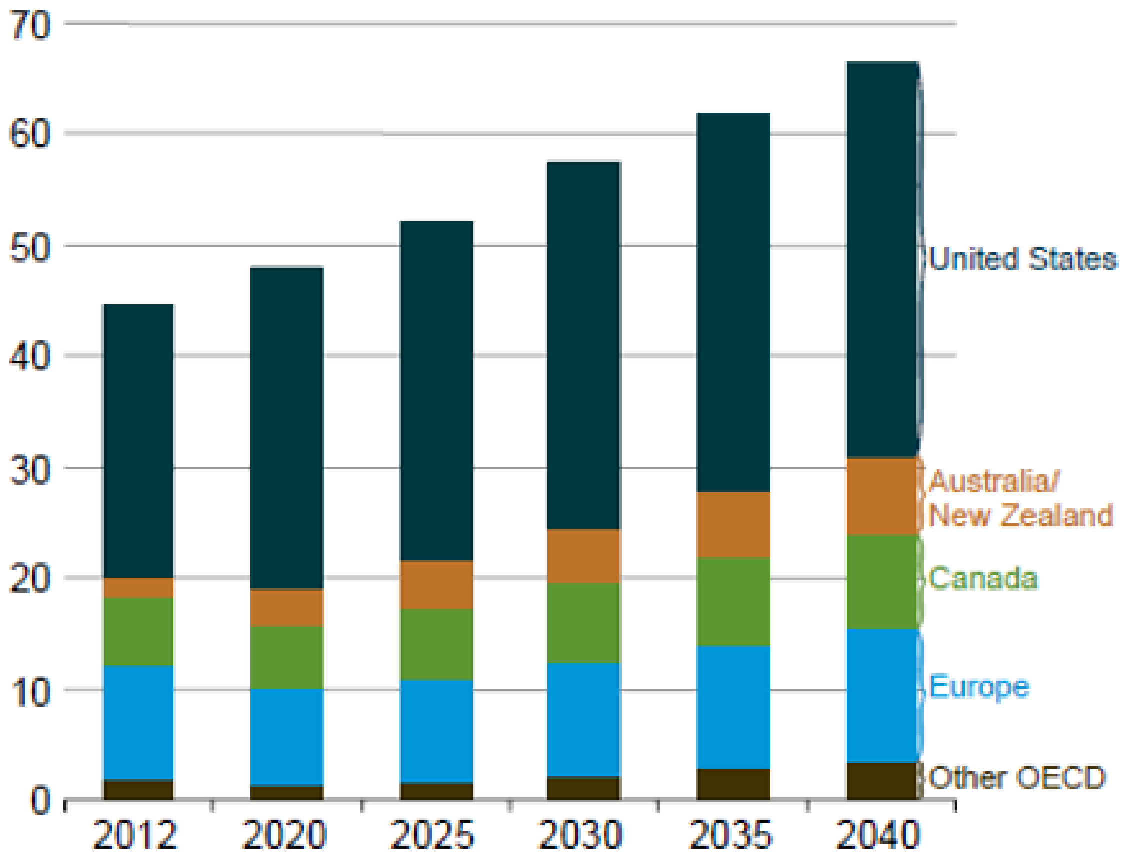

Fig 2: OECD natural gas production by country and region, 2012-40 (TCF)

Source: International Energy Outlook, 2016.

According to International Energy Outlook, Production of natural gas in the OECD Americas grows by 49% from 2012 to 2040. The largest producer being the United States, which is in the OECD Americas and in the OECD as a whole, accounts for more than two-thirds of the region’s total production growth from 24 Tcf in 2012 to 35 Tcf in 2040. Shale gas accounts for 55% of total U.S. natural gas production in the IEO2016 Reference case, tight gas accounts for 20%, and offshore production from the Lower 48 states accounts for 8% in 2040. Coalbed methane, Alaska, and other associated and non-associated onshore resources in the Lower 48 states accounts for the remaining 17% (International Energy Outlook, 2016).

As a result of new drilling technologies, such as horizontal drilling and hydraulic fracturing technology, which are unlocking substantial amounts of natural gas from shale rocks, in 2009, U.S estimate for gas reserves have surged by 35%. Between thin layers of shale rock, shale gas is trapped underground in bubbles. The United States holds far larger reserves than previously thought as shown by the report by the Potential Gas Committee, the authority on gas supplies. North America as believed by leading industry expert has more than 3,000 trillion cubic feet of proved natural gas reserve, enough to meet the current rate of U.S. consumption for more than 100 years [Wayne L, 2010.].

The possibility for the emergency of natural gas as a critical “transition fuel” that could be used to mitigate the cost of shifting into a clean energy economy is raised by these findings. Unconventional production is the single largest source of U.S. Natural Gas Supply, to be precise natural gas in tight sand formations, which by 2030 is forecast to accounts for 30% of total U.S. production. Production from shale formations however, is the fastest growing source.

2.1.19 Supply Implications on Price

From the 1990s to the early 2000s, the price of natural gases has been stable and lower than that of petroleum. This is because in the early 1980s (afterwards the start of deregulation of natural gas field price), a “glut was created as the supply available exceeded the market demand; this is termed the “gas bubble”. In 2002, the price at the wellhead for natural gas was 22% less in real terms than it was in 1985 [Fact Sheet: 2011.]. When the natural price is low more demand is encouraged, but for gas producers a discouragement is produced in finding more gas. Due to this, until supply and demand is approximately balanced the gas bubble eventually unraveled. This means however, rapid change in price will occur as a result of an unexpected shock to the supply and demand dynamics of natural gas, in the form of a tsunami or a new technology. In 1995, Barnett Shale of Texas discovery of hydraulic fracturing and horizontal drilling technologies represented such a shock.

In 2005 the U.S. shale deposits development began to be aggressive when the EIA reported that “technically recoverable” gas resources were 862 Tcf [U.S. Energy Information Administration; 2011]. In the early part of 2011, natural gas prices are hovering around the lowest since 2002. Natural gas futures in April weighed in at about $4.17 for a million Btu, in about 8 gal of gasoline was the amount of energy contained [Studebaker p. 2011]. Some of this of course, could be attributed to the recession, which has decreased the demand for gas; rising production from North American shale rock formation is believed by expert to have resulted to most part of it. This has some behavioral inferences for users of natural gas. A typical example, in February, trustees at Purdue University, home of the Boilermakers, voted to cancel a $53 million project to upgrade the Wade utility plant with clean coal technology. Instead, they plan to install a natural gas unit to replace the existing 50-year-old Boiler.

Moreover, with the uncertainty in the climate legislation of the U.S., natural gas seems more and more like a strategic choice. With a national cap and- trade legislation in absence, gas-fired plants are still cheaper, and shorter-term commitments are required, then plants fired by other “clean tech” fuels. In fact, according to the Energy Information Administration (EIA) most recent report, costs for combined cycle natural gas plants are expected at or below $1,000/kilowatt to stay stable and affordable, while nearly $5,300/kilowatt will be reached the future capital cost for nuclear plants [America’s Natural Gas Alliance; 2011]. EIA in the same report forecast substantial increases in cost of coal and wind-powered plants. Natural gas is not only a cleaner but more cost-effective when it comes to generating electricity, as provided by the EIA, electricity generated by natural gas will have the lowest cost in 2016, compared to coal, wind, and solar.

Greenhouse gases will be priced to reflect their social costs, i.e. global warming, health consequences, ecological damages…etc., in the alternative scenario that a nationwide cap-and trade legislation does pass, natural gas would also be cheaper than traditional, GHG-intensive fossil fuels. A win-win situation could occur by investing in natural gas. Of course, this is only a general analysis. Under certain assumptions and postulations of CO_2 prices, coal-fired power plants could be a feasible choice for some firms as shown by an article that appeared in Environmental Finance [Sandor L.R, 2001].

Far from undermining our conclusions, natural gas is still a very competitive fuel in most cases as shown by these calculations. For under the assumption that technology is constant and that there are zero emissions associated with coal extraction, which is unrealistic are these calculations made.

2.1.20 Key Players in the LNG Market

1. United States of America (USA): Mexico and other countries of the world imported LNG and natural gas from the USA. In March 2013, USA exported LNG to the Mexico (153 Mcf) and Canada (2 Mcf). Also, through the pipeline natural

Gas was supplied to the Mexico (6109802 Mcf) and Canada (970846 Mcf) in the same month (US Energy Information Administration, 2013)

Shipments from the United States went to more destinations as LNG exports increased. In 2017, U.S. exports of liquefied natural gas (LNG) reached 1.94 billion cubic feet per day (Bcf/d), up from 0.5 Bcf/d in 2016. U.S. LNG exports in 2017, reached 25 countries all of which originated from Louisiana’s Sabine Pass liquefaction terminal, (U.S. Energy Information Administration, Natural Gas MonthlyMarch 27, 2018).

Three countries namely; Mexico, South Korea, and China received shipments of more than half (53%) of U.S. LNG exports in 2017. Mexico received the largest amount of U.S. LNG exports, at 20% of the 2017 total (EIA, 2018). The growing demand for natural gas in Mexico, mainly from the power generation sector, and interruptions in the construction of domestic pipelines connecting to U.S. export pipelines led Mexico to depend on LNG imports to supplement imports of natural gas by pipeline. South Korea accounted for 18% of total U.S. LNG exports in 2017 and were part of long-term contracts between sellers Cheniere Energy and Shell and the Korean natural gas buyers—utilities KOGAS and KEPCO. U.S. LNG exports China accounted for 15% of the total which were sold mostly on a spot basis, with volumes in October, November, and December increasing as record-high LNG demand impelled China to seek additional LNG on the global spot market to supplement contracted volumes. In 2017 almost 60% of U.S. LNG was sold on a spot basis to more than 20 countries in the Caribbean, North and South America, Asia, Europe, and the Middle East and North Africa. Liquefaction capacity at Sabine Pass although fully contracted under long-term contracts to various buyers, U.S. LNG can be shipped to any market in the world as a result of the flexibility in those contracts' destination clauses (EIA, 2018).

Countries in Europe collectively accounted for the third-largest share of U.S. LNG exports after countries in Asia and North America (Mexico). The continuing expansion of U.S. LNG export capacity has resulted to the increase in LNG exports over the past two years. Two LNG projects—Sabine Pass in Louisiana and Cove Point in Maryland—have come online since 2016, increasing U.S. LNG export capacity to 3.6 Bcf/d. (EIA, 2018).

2. Qatar: The world's foremost LNG exporter is Qatar. In 2011, about 3600 Bcf of LNG was exported to the United Kingdom, Japan, South Korea and India. Nearly 15.7 MT LNG was exported to Japan and 10.8 MT to South Korea in 2012. About 63% LNG from Qatar was exported to Asian countries including Japan. Seven importing countries out of 26 (China, Japan, South Korea, India, Taiwan, Spain and United Kingdom) attracted 81% of total LNG on demand side. (US EIA Qatar, 2013; GIIGNLG, 2012). According to BP Statistics, review of world energy, Qatar holds almost 13% of total world gas reserves (880 Tcf) at the end of 2017. (BP Statistics, 2018). Qatar will maintain LNG export for next few years. Exporter competitors such as Australia, North America, Africa and Mediterranean push ahead with new LNG market and they will target Asian customers with new LNG prices (Qatar LNG to Asia, 2012). Qatar exported 82 million metric tonnes in 2017 placing it ahead of Australia, Malaysia and Nigeria. Shipment to Europe has fallen while Qatar's export to Asia has risen during the past few years. Qatar delivered 71% of its exports to Asia in 2018 as a whole through July, with total loaded volumes of 34 MMT in line with record highs set in 2013 during the aftermath of the Fukushima disaster (HIS Markit, 2019).

3. Australia: Australia is a leader in CBM-to-LNG development. Projected gas reserves are 3.8 Tcm including 400 Bcm of Coal Bed Methane (CBM) or Coal Seam Gas (CSG). LNG export projects is what that drives mostly the CBM production. Australia is the most growing LNG producer in the world. The LNG production was projected to reach 75.8 Bcm/year by 2016. This is the world's second largest LNG exporter after Qatar. By 2020 Australia is estimated to export

LNG with capacity between 60-100 Mtpa (Qatar LNG to Asia, 2012). From North West shelf Darwin LNG production capacity is 19.6 Mtpa (26.7 Bcm). Pluto LNG train production capacity is 6.5 Bcm. The 6.8 Bcm production capacity of Gorgon LNG will likely be complete by 2014. The world's first floating LNG terminal, Prelude LNG terminal started with capacity of 4.9 Bcm in 2017. Gladstone LNG project with capacity of 10.6 Bcm was projected to be expected competed in 2015 (International Energy Agency, 2011). Qatar LNG decreased by 3% while Australia LNG increased by 15% compared to October. Australia witnessed an increase in LNG export to 6.5 million tons during the month of November, 2018, thereby surpassing Qatar with export of 6.2 million tons in the same month. (LNG World News, 2018).

4. Russia: The largest gas supplier through pipeline is Russia (The Voice of Russia, 2012). Japan and Russia carried out a new LNG plant study. Vladivostok with producing capacity of 6.8 Bcm constructions began in 2017. Yamal LNG project plant consists of three production lines with each having a capacity of 5.5 million tons per year. The first production line started operation in December 2017 and the second one was launched in August 2018 (Xinhua, 2018). in February 2010, the project development schedule of Shtokman LNG project was postponed for three years due to a decrease in demand for gas in European markets. Gas production from the facility will now start in 2016. The first LNG production has also been postponed until 2017 due to changes in the targeted US LNG market (hydrocarbons-technology, 2018). In 2017, Russia produced 635.6 bcm of LNG and consumed 424.8 bcm.(BP Statistics, 2018).

5. Singapore: No domestic gas production exists in Singapore. Since 1992 natural gas was imported from Malaysia through pipeline. Singapore LNG Corporation (SLNG) built and operated its own LNG terminal with storage capacity of 4.1 Bcm. The Singapore Energy Market Authority has announced the third storage tank with capacity of 4.1 Bcm at the SLNG terminal in the 2010, (OECD/IEA, 2013). The gas consumption was 8.7 Bcm in 2010 and 12.3 in 2017 (BP Statistics, 2018)

6. Malaysia: The first major gas project in Malaysia started in 1983 was LNG in Bintulu. It was the first world scale LNG project, being a joint venture between PETRONAS, Shell Gas BV and Mitsubishi Corporation of Japan (Abdullah, 1998). Japan, Korea and Taiwan are the major importers of Malaysia’s LNG. Malaysia was the world’s second largest exporter of LNG in 2009. Nevertheless, Malaysia was positioned one step back in the world due to the declining gas recovery from existing fields and rising demand from country’s power plant, industries. Malaysia exported over (1 Tcf) of LNG in 2010 (10% of the world LNG export). Malaysia was the third largest LNG export country in the world in 2010 (OECD/IEA, 2013). Its objective is to be Asia's leading hub in LNG production and business. Table below presents the Malaysia's LNG export price from 1996 to 2008 the LNG price was increased. Due to the infrastructure development and re-gasification projects initiated by the PETRONAS the price was shown decline in 2009 (Kuncinas, 2013; Koh, 2013).

Malaysia is on one step nearer to becoming the world's largest LNG producer. At Bintulu Sarawak Malaysia, the largest LNG complex in the world was facilitated. The ninth LNG train was added to Bintulu Sarawak Complex on Borneo, as announced by PETRONAS in February 2012 (OECD/IEA, 2013). The offshore fields of Sarawak will produce the feed gas for the new train (Oil and Gas Journal, 2013.

By 2020 Multiple LNG users will be allow to store and trade the product through this terminal and will be the first independent LNG terminal in the Asia (PETRONAS Malaysia MLNG, 2013). To meet the increasing domestic gas market demand, PETRONAS Malaysia signed some of the LNG import agreements. In May 2011, the first agreement was signed with France's GDF Suez for 2.5 MT of LNG over the period of 3.6 years. The second agreement was signed with Qatar Gas for the LNG supply 1.5 mmtpa for over 20 years, started from 2013. Third agreement was signed with Australia for LNG supply 3.5 mmtpa (Malaysian Insiders, 2013; Kuncinas, 2013). In The Q3 2018, Malaysia's LNG exports were down by 30% year on year, to just over 5 mt representing a decline of 2 mt from Q3 2017 meaning 12% decline from the total imports of 2018 from the same period in 2017 (Interfax Global Energy, 2018).

7. Other countries: A new LNG project at the southern coast of Alaska with LNG producing capacity of 20 mtpa was planned to be built by the Japanese companies (The Voice of Russia, 2012). Indonesia is reducing LNG export from traditional LNG Trains due to increase in domestic demand. In 2012, the United Kingdom imported LNG 10.5 MT. It has four import terminals with total capacity of 38mtpa (Spomer, 2013). A projected gas reserves from Tamar and Leviathan field offshore Israel's coast will lead to develop their own LNG project. Israel need more time to become LNG exporter. Projected gas reserves from both fields are 240 and 450 Bcm (International Energy Agency, 2011)

2.1.21 Natural Gas Reserve

The largest natural gas reserves are found in the Persian Gulf (Iran and Qatar) and in Russia (all three together are in possession of around two thirds of the known reserves). In 2017, the Global proved gas reserves rose slightly by 0.4 trillion cubic metres (tcm) or 0.2% to 193.5 tcm as of 163.5 trillion cubic meters in 2007. This is sufficient to meet 52.6 years of global production at 2017 levels. The largest single contributor to growth was Israel (0.3 tcm), while the CIS region also added 0.2 tcm to reserves. The Middle East holds the largest proved reserves (79.1 tcm, 40.9% of the global total), followed by CIS (59.2 tcm, a 30.6% share) by region. The production of natural gas is most abundant in the United States of America, Canada and Mexico. In 2017, Qatar with more than one-fifth of the world's total export volume, it was the world's largest LNG exporter. Most of Qatar's LNG is imported by Europe with smaller volumes going to South & Central America and Middle East. (BP Statistics, 2018).

When possible, through widely spread pipelines natural gas is under high pressure quickly and efficiently transported. For final distribution the pipelines are altered and the pressure is lowered. As the conversion from oil and nuclear energy to natural gas gains momentum in Europe, International trade in pipeline gas is projected to grow. But it often happens that production regions are separated from consumption regions by oceans making the construction of pipelines difficult and expensive. So, most of the demand for natural gas has to be fulfilled by liquefying gas in the absence of pipeline infrastructure and supplying it as liquefied natural gas or LNG. Liquefying natural gas is a competitive means of transporting it even if there is a possibility to build pipelines as liquefying natural gas and for distances of more than 700 miles or in onshore pipelines for distances greater than 2,200 miles, shipping it becomes cheaper than transporting natural gas in offshore pipelines.

2.1.22 LNG Chain

When the distance between source and customer is too long, it is not economical to transport natural gas in its original form. Therefore, natural gas is then compressed into Liquefied Natural Gas by injecting at high pressure and reducing the temperature to about -163°C. Natural gas must be free from condensates, impurities and heavier hydrocarbons so it must be purified. At the temperature of -163°C the gas reduces to a liquid state completely which takes up about 1/600 in its gaseous state. Flashed vapors and boil off gas are recycled within the process (Mokhatab and Economides, 2006). The pressurized LNG is further sub cooled in one or more stages to facilitate storage at slightly above atmospheric pressure. LNG is converted to its gaseous state (natural gas) through a re-gasification facility at a receiving terminal where this energy source can be supplied through the pipeline.

The LNG chain consists of “value” or “supply” chain that involves four well connected and interlinked stages. They are; the exploration and production, liquefaction, shipping and then re-gasification at the final destination. At each stage, the natural gas is processed to add value to the product until the final destination (the customer) is reached.

1. Gas Exploration and Production

The first segment in the LNG value chain is exploration and production. The main operations at this stage is to initiate ideas about where the natural gas resources might occur (prospect generation), to the next stage of mobilization of the financial capital to support the drilling and field development, to the ultimate production. The exploration and production segment incorporates geologic risk- the chances that natural gas resources in a “play” (an area of interest) either do exist or exist in quantities or subsurface conditions that do not favor commercially successful exploration. Natural gas trade via pipeline and LNG helps to provide a diverse portfolio of supply options that can offset tight domestic supplies and soften impacts of higher prices during periods when the world demand for natural gas exceeds deliverable supply (Foss, 2007).

2. Natural Gas Liquefaction

This is the act of converting the natural gas as it occurs naturally in its standard temperature and pressure to the form where it can be economically transported through the LNG ship. During the liquefaction, contaminants found in the produced natural gas are removed to avoid freezing up and damaging equipment when the gas is cooled to LNG temperature (-162°C) and to meet pipeline specifications at the delivery point. The liquefaction process can be designed to purify the LNG to almost 100% methane. The liquefaction process involves the cooling of the clean feed gas by using refrigerants. The liquefaction plant may consist of several parallel units ("trains"). By liquefying the gas, its volume is reduced by a factor of 600, in other words, the LNG at -162°C takes up 1/600th of the space required for a comparable amount of gas at room temperature and atmospheric pressure. LNG is a cryogenic liquid, meaning it exists at very low temperature generally below 0°C. LNG is a clear liquid, with a density of about 45% the density of water. During liquefaction, receiving and re-gasification, the LNG is stored in double walled tanks at atmospheric pressure. The storage tank is a tank embedded inside a tank. The annular space between the two tank walls is filled with insulation (Foss, 2007).

3. LNG Shipping

The shipping of natural gas in the form of LNG is the main topic of discussion of this research. The LNG shipping is done with specially designed ships with cryogenic containment system. They are double-hulled tanker ships specially designed and insulated to prevent leakage or rupture in an accident. The LNG is stored in a special containment system with the inner hull where it is kept at atmospheric pressure and cryogenic temperature. There are three main type of containment system, they are; the spherical (Moss) design, the membrane design and structural prismatic design. There are other containment designs which account for a small fraction of the current fleet. They include ConocoPhillips Prism tank design and the Ocean LNG cylindrical tank both of which are designed to deal with the sloshing problems presented by semi filled tanks (Foss, 2007). The typical LNG carrier can transport about 125,000 – 138,000 cubic meters of LNG although lately more LNG ships with containment system with a capacity of up to 260,000 cubic meters are on order (Clarkson’s research institute, 2008).

4. LNG Re-gasification and Storage

When the natural gas in the form of LNG has reached its final destination, it could be used in various ways, for example as a transportation fuel for truck and bus fleets; in these cases, the LNG import receiving terminals will include facilities to dispense LNG into tanker trucks for distribution to central fuelling locations. Or LNG import terminals may be located with electric generation stations, allowing use of the cryogenic properties of the LNG to help cool the power plant. To return LNG to a gaseous state, it is fed into a re-gasification facility. On arrival at the receiving terminal in its liquid state, LNG is pumped at atmospheric pressure first to a double-walled storage tank, similar to those used in the liquefaction plant where LNG is stored at atmospheric pressure until needed. At that time, LNG is then pumped at higher pressure through various receiving terminal components where it is warmed in a controlled environment. The LNG can be warmed by passage through pipes heated by the direct-fired heaters, or pipes warmed by seawater, or through pipes that are heated in water. The re-vaporized natural gas is then regulated for pressure and then enters the pipe line to where it will be needed.

2.1.23 Transportation of Natural Gas

The transportation of natural gas refers to any movement or shipment of natural gas while in its liquid form which is called liquefied natural gas (LNG) and in its gaseous state. For effective and efficient movement of natural gas from the region(s) of production to that of consumption requires an extensive and elaborate transportation system. In numerous instances, natural gas produced from a particular well travels a long distance to reach its point of consumption.

There are several methods of exporting/importing natural gas from point of production to point of consumption these methods include; through pipelines, liquefied natural gas (LNG) carriers, gas to liquids (GtL), compressed natural gas (CNG), gas to solids (GtS), etc. There are two major methods of transporting natural gas; they are by pipeline and vessel. Where natural gas pipelines are not feasible or do not exist, liquefying natural gas is a way to move natural gas from producing regions to markets.

1. Transporting by Pipeline

The transportation system for natural gas consists of a complex network of pipelines, designed to quickly and efficiently transport natural gas from its origin, to areas of high natural gas demand. Natural gas flows efficiently through pipelines so it was a more preferred method of transporting natural gas. Most natural gas pipeline infrastructure takes the natural gas between liquefaction facilities and storage facilities, from storage facilities to tankers, and from tankers to re-gasification facilities. By this means much higher amounts of gas are able to be transported for the same volume flow. The downside is that natural gas pipelines are difficult and costly to construct. Natural gas requires a temperature of -163°C (-260°F) to stay in its liquid form(Gate Terminal, 2011), important insulation must be combined into liquefied natural gas pipelines in order to maintain this low temperature and ensure that it does not return to its gaseous form. This normally includes a combination of mechanical insulation like glass foam and a vacuum layer (PHPK Technologies, 2008). This complex insulation system makes LNG pipelines significantly more difficult and expensive to manufacture the standard natural gas pipelines.

The pipeline transportation network for natural gas consists of several interlinked segments, which are designed to deliver natural gas to customers quickly and efficiently on demand from point of extraction to destination where there is demand. The design and construction of these networks is based on careful analysis of expected demand. There are three major types of pipelines along the transportation route: the gathering system, the interstate pipeline system, and the distribution system. The Interstate pipeline system is similar to in the interstate highway system as they carry natural gas across state boundaries, and at times across the country. On the other hand, Intrastate pipelines transport natural gas within a particular state. The gathering system consists of low pressure, small diameter pipelines that transport raw natural gas from the wellhead to the processing plant. a specialized sour gas gathering pipe must be installed in the gathering system should incase natural gas from a particular well have high contents of sour gas (sulfur and carbon dioxide). The distribution system just like the Local Distribution Company, distributes natural gas to it consumer's door step. The optimal layout and size of mid-stream gas infrastructure, transmission, and distribution networks depends on the inconsistency of gas consumption and, importantly, the maximum level of gas consumption within a year (peak gas demand). The system capacity has to be large enough to meet sudden peaks in demand instantaneously; for example, during an unexpected on set of cold weather, where gas is used for heating. (IGU,2018)

2. Transporting by Vessel

LNG is shipped in specialized ocean-going vessels (gas carriers) between the export terminals, where natural gas is converted to liquid form, and import terminals, where LNG is returned to its gaseous state (re-gasification). At an import terminal, it is injected into pipelines for transmission to local distribution companies, industrial consumers for industrial uses, and power plants for electricity generation.

LNG is a clear, colorless, and non-toxic liquid which is formed when natural gas is cooled to approximately -163 ºC. The cooling process reduces the volume of the gas 600 times, making it easier and safer to store and ship. In its liquid phase, LNG will not ignite and it can be shipped safely and efficiently on specialized large ocean-going vessels called LNG carriers which are furnished with onboard, super-cooled cryogenic tanks or in moderately small volumes in ships using International Organization for Standardization (ISO)-compliant containers and on trucks, between the export terminals, where natural gas is converted to liquid form to the import terminals, where LNG is returned back to its gaseous state (regasification). After arriving at its destination, LNG is injected into pipelines for transmission to local distribution companies, industrial consumers for industrial uses, and power plants for electricity generation. LNG is a tried and true technology that has enabled safe transportation of natural gas to remote markets for over 50 years. LNG spill would not damage the ground or leave any residue as it evaporates, in water, it is insoluble and would simply evaporate, making water-spill cleanup unnecessary. LNG is not stored under high pressure and is not explosive. LNG vapors (methane) mixed with air are not explosive in an unconfined environment.

The majority of worldwide LNG exports take place between two or more continents, meaning that shipping LNG across the ocean is often required. This is done with the use of an LNG vessel or LNG ship, which transports large quantities of LNG between export and import terminals. The main type of LNG vessel that exists today among several types is referred to as an LNG tanker. The main components of an LNG tanker are the boiler and pump rooms, a double hull for added strength, bow thrusters, and the LNG storage tanks. Typically, an LNG tanker is built with 4 or 5 individual LNG tanks. LNG is shipped around the world in specially constructed seagoing vessels. The trade of LNG is completed by signing a SPA (sale and purchase agreement) between a supplier and receiving terminal, and by signing a GSA (gas sale agreement) between a receiving terminal and end-users. LNG is transported in specially designed ships with double hulls protecting the cargo systems from damage or leaks. There are several special leak test methods available to test the integrity of an LNG vessel's membrane cargo tanks.

Transportation and supply is an important aspect of the gas business, since natural gas reserves are normally quite distant from consumer markets. Natural gas has far more volume than oil to transport, and most gas is transported by pipelines. There is a natural gas pipeline network in the former Soviet Union, Europe and North America. Natural gas is less dense, even at higher pressures. Natural gas will travel much faster than oil through a high-pressure pipeline, but can transmit only about a fifth of the amount of energy per day due to the lower density. Natural gas is usually liquefied to LNG at the end of the pipeline, prior to shipping. Short LNG pipelines for use in moving product from LNG vessels to onshore storage are available. Longer pipelines, which allow vessels to offload LNG at a greater distance from port facilities are under development. This requires pipe in pipe technology due to requirements for keeping the LNG cold.

2.1.24 LNG Carriers

Since the first LNG carrier methane pioneer was built in the late 1950s; the LNG shipping industry has grown through a rapid and has increased in size, with the largest carriers today shipping more than 200,000 m^3 capacity. Approximately, 300 meters (m) (975 feet) long, 43m wide (140 feet) wide and has a draft of about 12 m (39 feet) is the dimension of a typical modern LNG ship. The cargo capacity of LNG ships varies, from 1,000 cubic meters to approximately 267,000 cubic meters, but the majority of modern vessels are between 150,000 m^3 and 200,000 m^3 capacity (or 180,000 m^{3}capacity for the case of the new Panama Canal). In some areas, such as Norway and Japan smaller LNG ships (1,000 – 25,000 cubic meters' capacity) also operate. LNG carriers are capable of speeds of up to 21 knots (oil tankers operate at 15-20 knots) in open waters. In the 2008, the cost of the largest LNG carriers was up to $280 million and but in 2009, the same size cost less than

$200 million today due to the fact that the LNG industry was been driven by both competition and innovation of new technology, to become more cost- efficient (DNVGL, 2018).

According to Alan Saachi, two main types of LNG carriers exist; these are carriers with spherical tanks and membrane type carriers.

1. LNG Carriers with Spherical Storage Tanks (moss type tanks), Norway in 1973 launched the first LNG carrier with spherical tanks known as the "Norman Lady" (87,600m^3), her storage tanks were made of 9% nickel-steel, the use of aluminum tanks quickly replaced quickly replaced quickly replaced that technology. Aluminum storage tanks were more resistant to burst, mechanical stress, and it was easier to molded/ bent into a sphere. The equatorial ring on which the tank "hangs" is the main characteristic of the spherical tanks. The greatest mechanical and thermal stresses are precisely on the "equator".

2. LNG Carriers with Membrane-type

During the 1960s, the membrane-type ships were developed, and both concepts use a thin flexible metal "membrane" which is in contact with the cargo. The characteristic of the system is of a sandwich where the cargo presses on the membrane; the insulation material presses on the membrane and in the end, everything leans on the ship’s inner hull. In offshore receiving terminals, the technology may also be utilized to function as floating storage and re-gasification units (FSRU). These facilities allow LNG terminals to be sited offshore. LNG ships with on-board re-gasification facilities are operating in Argentina, Brazil, the UK and the US.

The Moss System is capable of carrying the load at different levels without concerns of stability, while the Membrane System can only sail at full load or close to empty. The Membrane System utilizes the hull better, and can therefore carry more payloads compared to the Moss System with the same dimensions. Today, LNG carriers are being designed as the Membrane System because a majority of LNG carriers sail on long-term charters, where they fully load at one liquefaction plant and fully unload at the re-gasification terminal, (DNVGL, 2018).

All relevant local and international regulatory requirements including those of the International Maritime Organization (IMO), International Gas Carriers Code (IGC) and US Coast Guard (USCG) must be complied with by LNG ships. All LNG ships has double hulls. The cargo is carried near atmospheric pressure in specially insulated tanks, referred to as the cargo containment system, inside the inner hull. International codes govern the design and construction of gas carriers. The type of cargo that the ship will carry has additional international requirements set out in the codes which vary with them. All commercial vessels have to be registered in a country – the “Flag State”. Countries with more than one LNG ship in their registry include Bermuda, Algeria, Korea, the Bahamas, Australia, Brunei, Japan, Norway, France, Italy, Liberia, Isle of Man, Malta, the Marshall Islands, Malaysia, and United Kingdom. No inference can be drawn automatically from the supplier of the cargo, a ship’s flag of registry, or the nationality of the ship’s crew to a particular characterization of the importers. All countries implement IMO Rules including the International Safety Management (ISM) Code, the IGC, Certification and Watching (STCW) Convention and the International Convention on Standards of Training. Additional requirements over and above the international codes may be imposed by the government administration of the country of registry. A Classification Society is a non-governmental organization which forms a vital part of the shipping industry, and is often referred to as “Class”. It creates and upholds standards for the offshore structures, construction and classification of ships, according to technical rules, confirms that calculations and designs meet these rules, and conducts surveys of structures and ships during the process of construction and commissioning (BV,2010). Vessel in service are periodically survey by the Classification societies to ensure that they continue to comply with the rules and required codes. The ships are requiring to be “in class” by the insurance underwriters; without insurance the ships cannot trade.

LNG carrier's marine quality assurance (as well as other ships) is provided through the process of vetting, which in order to determine its acceptance for use assesses ship quality against a known standard. In relation to such international conventions and industry recommendations as IGC, Safety of Life at Sea (SOLAS) and International Convention for the Prevention of Pollution from Ships (MARPOL) ships are assessed. To all tanker types guidance detailed in the International Safety Guide for Oil Tankers and Terminals (ISGOTT) is pertinent and to gas carriers the Society of International Gas Tankers Terminal Operators (SIGTTO). The process of assessing the ship quality should include the assessment of operational standards of the vessel including the ship's physical condition, crew competency and training. Information on ship quality is gathered from many sources, including vessel inspections on behalf of market intelligence, owner assessments, ship companies, terminal and operational feedback, casualty data, reputation and questionnaires. The "Port State Controls" established by the Memorandum of Paris (1981) are recorded in the "Equasis" database available for worldwide access information which assist in making the vetting decision are provided in such port state control databases and Class reports. Generally, according to the Oil Companies International Marine Forum (OCIMF) standards or to their own standards to assess the ship conditions, operators perform ship inspections. Reports on the ship's technical and survey status are available through the OCIMF Ship Inspection Report (SIRE) Programme, via the ship's classification society, and through the ship owner.

2.1.25 The Fleet

At the end of 2015, total LNG fleet consist of 416 LNG carriers (IGU, 2018), considering only those above 30,000m^3 in payload. Most young vessels are built with a design speed of 19.5 knots plus a sea margin, which is because of the initial design of vessel Hilli and her sister vessels built in 1970s (DNVGL, 2018) and the design speed was optimized because of their high boil-off on a long contract and the storage capabilities. The relatively high speed is capable of being detained without a corresponding high external fuel consumption because the boil-off was used directly in the machinery for propulsion. The standard speed of 19.5 knots plus a sea margin which has been since used was pointless because advancement in technology has lowered the boil-off, which makes around 16-18 knots a more suitable speed. This is also the speed most LNG carriers sail in today. The majority of today's existing fleet have been built with a steam turbine powered propulsion system, while vessels built the last decade are mostly dual system or tri-fuel diesel electric system (DNVGL, 2018). Some of the newest vessels, built last year and early this year till date have installed the MEGI system (M-type, electronically controlled, Gas Injection) engines which reduce greenhouse gas emission with 22% compared to fuel oil (DNVGL, 2018). The reduced fuel consumption and emissions are a competitive advantage over the older part of the fleet.

1.26 The Capacity

According to the volume of tanker plus four-day production the capacity of LNG storage is based. Storage is the expensive item for LNG plant. During the year 2000-2010 majority of LNG tankers having capacity of approximately 140,000 m^3 were built. They carry the gas of 3.1 Bscf (87 million m^3) or 512,000 BOE. Super LNG tankers having capacity of 265,000 m^3 were designed for long trade from Qatar to United States of America. In order to meet the requirement of tanker load, most of the LNG plants are having two or more storage tanks (Choi, 2010). Long distance transport from one country to another by ship across ocean to markets and its local distributions is facilitated by the LNG physical properties. An advantage over the construction of long-distance pipeline is the Reduction of the LNG transportation costs using cargo ships. Where geological subsurface conditions are not suitable for underground gas storage LNG storage in the tankers is the solution. LNG storage in the tankers can reduce the cost of gas supply through long distance pipeline (Mokhatab and Economides, 2006).

2.1.27 Costs

The vessels are presumed to sail at a speed of 19 knots. The vessels are also assumed to have 160,000 m^3 loading capacity, and the Dual Fuel Diesel Electric (DFDE) Carrier’s machinery is fed by boil-off while the Steam Turbine (ST) Carrier burn a combination of HFO and boil-off to maintain 19 knots. The costs are divided into charter costs, fuel costs, canal costs and other costs. Charter costs are the payment to the owner for hiring the vessel, and fuel costs are assumed to be paid by the charterer the other costs include port costs, (Rogers, 2018).

It is seen that depending on the distance of the sailing, either the charter costs or the fuel costs are the main contributors. This holds for both DFDE and ST carriers. For the ST Carriers, with an older technology and much larger fuel consumption, the fuel costs are the governing cost when the sailing distance is long.

2.1.28 Pipeline Vs LNG Vessel

The traditional mode of transporting natural gas is through pipeline mainly due to the higher costs of other forms of transportation. But as demand increases and sources starts to get depleted, transportation distances between importers and exporters increase.

In places where the reserves are not in any form close to the market, so as to allow for pipeline transport, LNG vessels are used. Example of this is in Japan, where LNG transportation has flourished and account for more than 90% of natural gas consumption. Pipeline offers a rigid form of transport. Thus, if there is a need for the diversion of the natural gas or there is an increase in demand, LNG vessels provide a better alternative as they are more flexible.

Pipeline poses treats if there is any change in terms of contract between the exporting and importing country. A case where the supplying country turns off the tap for the controlling of the natural gas flow to the importing country with short or no notice, this will have a disastrous effect on the importing country, in which case LNG vessels offers a better option as the termination of supply in short notice could easily be catered for and alternative arrangements made. Also, on the long distance above 2200 miles, the cost of transporting natural gas is cheaper on LNG vessels if all parameters are kept constant.

2.1.29 Natural Gas Trade

A whole lot of factors have been pushing for further growth in the consumption of natural gas. Political movement; new technology, environmental friendliness among other things has made natural gas the choice of fuel for the future. As this develops it creates a lot of issues in the transportation sector as highlighted earlier, as the reserves will increasingly be further away from the consumer. Even relatively large producers, like the US are unable to produce all their natural gas requirements. In order to bring about equilibrium between the supplying and importing countries, a relatively complex network of pipeline and LNG vessel is created. Trade flows are on a contractual basis and may not correspond to physical gas flows in all cases.

2.1.30 LNG Trading Basins

The liquefied natural gas operates in two different markets (basins) due to geographical restrictions as well as the location of liquefaction and re-gasification terminals. They are the Atlantic basin and the Pacific basin. These basins rarely interact as the distances and the small number of countries involved in the LNG trade make it very hard. As such they have developed radically different market conditions with LNG playing a different supply role in each. The only common link between the two basins in the past couple of years is Middle East which is ideally situated between the two basins so as to be able to trade. As more countries get involved in the business of LNG trade, the interaction between these two basins will become closer.

2.1.31 Shipping Security

Through the use of strict operational procedures, putting a priority on safety and on well-trained, well-managed crews shipping safety and security risks are managed. Safety and security assurance are the key part of company hiring, training and operations practices. Due to the acts of terrorism in the US on September 11, 2001, IMO agreed to new amendments to the 1974 SOLAS (International Convention for the Safety of Life at Sea) addressing ship and port facility security. IMO adopted the International Ship and Port Facility Security (ISPS) Code in 2003. This code requires that vulnerability assessments be conducted for ships and ports and that security plans be developed. The aim of the ISPS code is to prevent and suppress terrorism against ships; improve security aboard ships and ashore; and reduce risk to people (including passengers, crew, and port personnel on board ships and in port areas), and to vessels and cargoes. Cargo vessels 300 gross tons and larger, including all LNG vessels, as well as ports servicing those regulated vessels, must adhere to these IMO and SOLAS standards.

For ships, IMO requirements include:

i. Ships must develop security plans and have a Ship Security Officer;

ii. Ships must be provided with a ship-security alert system. These alarms transmit ship-to-shore security alerts to a competent authority designated by the

Administration, which may include the company identifying the ship, its location and indicating that the security of the ship is under threat or has been compromised;

iii. Ships must have a comprehensive security plan for international port facilities, focusing on areas having direct contact with ships; and

iv. Ships also may have certain equipment onboard to help maintain or enhance the physical security of the ship.

For port facilities, IMO requirements include the following:

i. Port facility security plan;

ii. Facility Security Officer; and

iii. Certain security equipment may be required to maintain or enhance the physical security of the facility.

For both ships and ports, security plans must address the following issues:

i. Monitoring and controlling access;

ii. Monitoring the activities of people and cargo;

iii. Ensuring the efficacy of security communications procedures and systems, and their ready availability; and

iv. Completion of the Declaration of Security. A Declaration of Security (DOS) is a declaration which addresses the security requirements that could be shared between a port facility and a ship (or between ships) and stipulates the responsibility for security that each shall take.

v. Security plans also address issues such as: port of origin, port of destination, control of ship movements, cooperation with shipping authorities and appropriate internal and external communications.

In addition to the security measures listed above, in the US the USCG requires additional security measures based on a location-specific risk assessment of LNG shipping including among other things:

i. Inspection of security and carrier loading at the port of origin;

ii. On-board escort to destination terminal by USCG "sea marshals"; and

iii. Ninety-six-hour advance notice of arrival (NOA) of an LNG carrier.

Since the first cargoes of LNG were shipped on a regular commercial basis in 1964, over 56,000 shipments have been made without a single incident of LNG being lost through a breach or failure of the ship's tanks. The LNG shipping industry has an excellent safety record (GIIGNL, 2010).

Out of the three major grounding incidents, none resulted in loss of cargo. The robust design of the ships and cargo tanks and the LNG industry's extraordinary attention to safety details have collectively served to prevent the release of cargo and to facilitate this noteworthy safety record.

The entire LNG shipping process is replete with sophisticated operational and safety systems in addition to the aforementioned safeguards for the LNG ships. Ship's course, speed and position (as well as that of nearby vessels) are monitored continuously using use communications technology, global positioning and radar by the ship. Additionally, at the very outset of the loading process and at that point initiate the constant procedure of checking for leakage; comprehensive safety systems begin monitoring the precious (LNG) cargo. Such checks start at the liquefaction plan when the gas is loaded into the ship's pre-cooled cargo tanks as a refrigerated liquid at atmospheric pressure via a closed system from insulated storage tanks. In a modern membrane LNG ship, the cargo containment system consists of a primary barrier, a layer of insulation, a secondary barrier, and a second layer of insulation. Therefore, the secondary barrier will prevent leakage if there should be any damage to the primary barrier. The insulation spaces are filled with nitrogen and are continuously monitored for any sign of leakage. The tank detection equipment is so sensitive that it can detect leakage through a hole the size of a pinhead. The LNG is kept fully refrigerated by allowing a small amount of cargo to evaporate during the voyage to the import terminal. This is referred to as boil-off gas (BOG); in addition to keeping the LNG cold, it provides a source of clean fuel for the ship’s engines

2.1.32 The Shipping Market

The global natural gas market development is dependent on natural gas reserves and production in combination with demand, and the ability to meet demand with supplies from other regions and oceanic basins, the latter of which is exclusively traded as LNG (Leidos, 2014). The global economy produces goods through industrial activities which are require to be transported via ships. The drift in a particular sector of the economy can possibly encouragement the general pattern of demand, for example the change in price of natural gas could lead to changes in the demand for sea transport of that commodity (natural gas). The difference in the distance that a cargo must be transported also have as a result on the change of the final sea transport demand calculated in ton-miles (which is more accurate than in deadweight tons of the vessels). (Collins 2000)

The LNG market is facing the problem that the actual extent of shale gas reserves is still unknown. Large reserves of shale gas, potentially could have adversely affect the current dynamics within the LNG industry, (Global LNG trade & Trends 2030, 2013). The sea transport of LNG, similarly to other cargo transits by the sea is determined form supply and demand. The supply of tonnage and the demand for sea transport are the two pillars composed from a series of sub-elements. Thus, the interaction of supply and demand set the market for that particular sea trade.

Table 2: Shipping Market; Demand and Supply

Demand side	Supply side
The world economy	World fleet
Seaborne commodity trade	Fleet productivity
Average haul	Shipbuilding production
Random shocks	Scrapping and losses
Transport cost (freight rate)	Freight rate

Source: Maritime Economics (Martin Stopford, 2008)

Based on the table above, from the side of demand for sea transport there are five (5) main variables:

i. The world economy

ii. The seaborne commodity trades.

iii. The average haul.

iv. Random shocks.

v. The transport cost.

On the supply of sea transport there are five (5) major factors:

i. The world fleet.

ii. The fleet productivity.

iii. The shipbuilding production.

iv. The scrapping.

v. The freight rates.

The interrelationship between these variable in the shipping market model is shown in the figure below. This model is composed of three components which combines the demand and supply be controlling the cash flow flowing from one sector to another, these components are; A (demand), B (supply), and C (freight market).

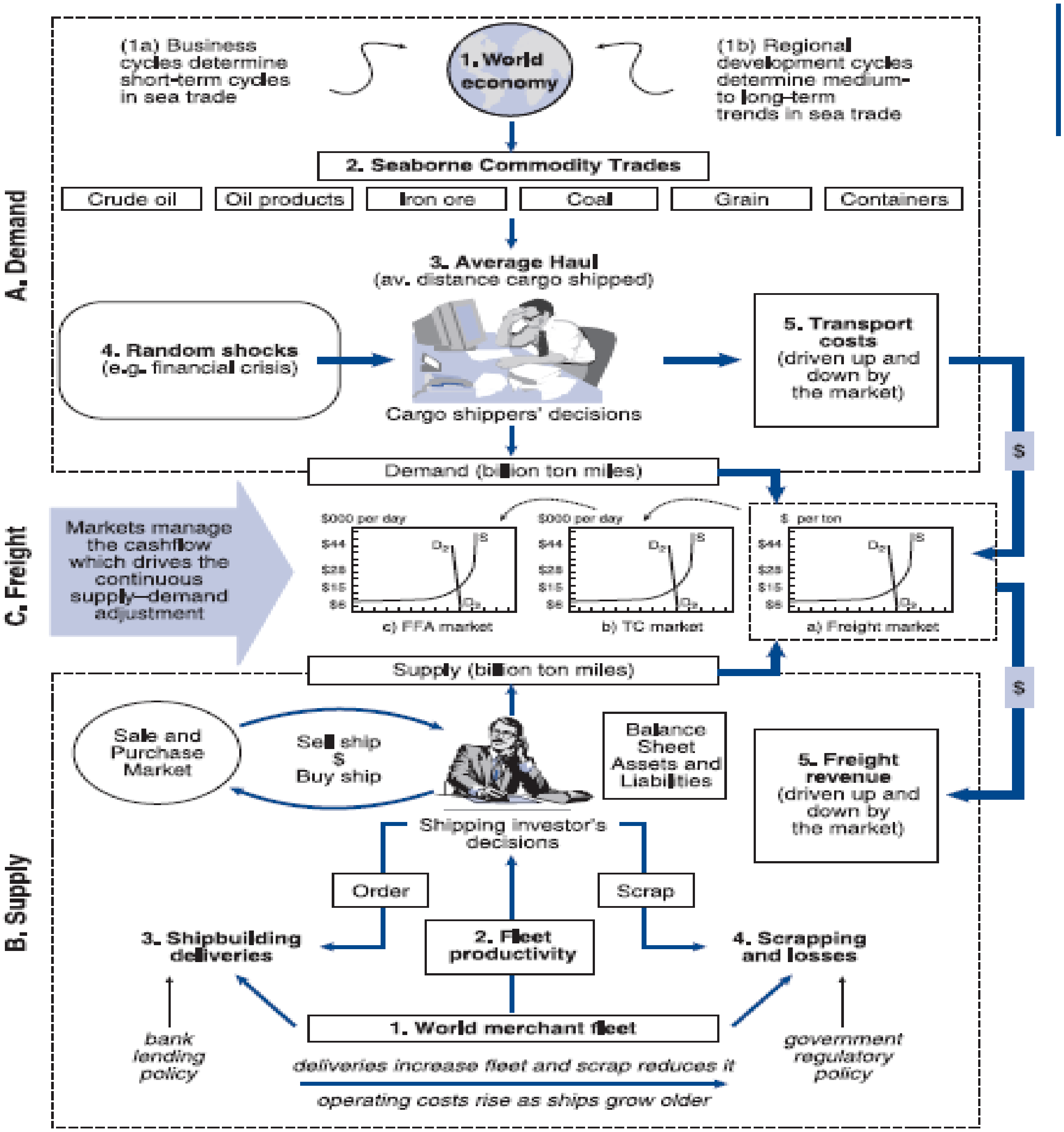

Fig 3: The shipping market supply and demand model

Source: Martin Stopford, 2008

1. Demand

The world economy has the most important and significant influence on ship demand, and may change the demand for sea transport through business cycles and trade development cycles (Stopford,2002). When there is a delay in decision making and the implementations of those decisions, there would be a dangerous effect in the market. For example, during a thriving market period when new ships are ordered with a delivery time of 5 years, the market may go into recession before it reaches the time for delivery. When this happens, there would be an even greater surplus of tonnage capacity in the market. Time-lags outcome is more dangerous than cyclical recessions and booms (Stopford, 2009).

One of the most important causes for short-term instabilities in the demand for sea transport is the world economic cycle. The economic cycles, just like the shipping cycles does not follow any specific path. Another very important factor affecting the demand for ship is the average distance of the haul. This shows that the average length in miles of carrying one ton is calculated by dividing the total ton-miles by total tons of the cargo shipped. The transportation cost by sea is another significant factor for transporters deciding to ship cargo. The transportation costs over the last century has been reduced because larger; more efficient and more effective shipping services have been developed while improving the quality of shipping services (Stopford, 2009)

2. Supply

There are four major decision makers who control the supply of sea transport they are; charterers, the financing institute, ship-owner and the law makers. The world merchant fleet is the most influential factor affecting the supply of sea transport. In the long run the growth of merchant fleet would be dependent on the deliveries and scrapping of vessels. The element of flexibility in the supply side of the model is as a result of fixed current fleet size which makes the ship productive. The fleet productivity is measured in ton-miles and depends upon four tools; deadweight utilization, port time, loaded days at sea and speed (Stopford, 2009)

Freight incomes affect the supply of sea transportation greatly, both in the long-term and in the short-term run. In the long-term, the instability in freight revenue is what controls the time to scrap and the time to order new vessels as it adds to investment decisions of the decision-makers, based on business decisions from shipping companies it is likely that only a part of that fleet to continue operation as a transport mode. Disagreeing, in the short term, the merchant fleet represents the constant transport capability; freight revenues inspire decision-makers to regulate the tonnage capacity in the market (Stopford, 2009). Some vessels could be laid-up or transform into storage platforms (FSO). Generally speaking, the word fleet can be increased from new ship building projects as well as to be decreased from scrapping. (Collins 2000).

3. Freight Rate Mechanism

The freight market links the Supply and demand together through the balance of obtainable ships and cargo in the market, ship-owners and shippers discuss and try to establish a freight rate which best imitates this; when there is a surplus of ships the rates are low and when there is a shortage of ships the rates are high (Stopford, 2009).

The two main key-factors to the development of the Asian LNG industry were the increasing demand and price of natural gas. The point of liquefaction and transportation of natural gas in huge volumes across the oceans via LNG vessels has stretched out the market and at the same time lower storage and operating costs from technological developments and economies of scale, have opened up the domestic market into global domain. (Shell International Gas Ltd, 2010).

Freight rate is a very critical part of shipping market model it practically connects supply to demand for sea transport. When there is a shortfall of vessels supply the freight rates increase giving the ship owners stronger negotiation power in the market. The cash flows which end up at ship owner’s bank accounts could influence the behavior of the other market players such as the charters or port operators as well as the ship owners themselves who often invest that money to new buildings and then on the other hand, when there is surplus of available vessels, the freight rates decreasing and the ship owners in many cases struggle to cover the ship’s operating costs. Thus, they turn to sell some vessels in order to gain the necessary funds. The price of vessels decreases and the scrapping agencies offer relatively high prices in order to attract additional tonnage for demolition. Furthermore, the low freight rates change the performance of the fleet mainly from speed adjusting (lower speed) or laid-ups.

Eventually the balancing in the market and the freight rate levels is the most important economic proofs of the market model and it is related to the business decisions from the ship-owners, as well as the general psychology of the market players. Hence, as the behavioral aspect is important for the market trends, it is almost impossible to have an accurate simulation using mathematical forecasting models. The general shipping model as it is presented before illustrates how complex the shipping market is. The demand for sea transport is volatile, and adjusts very quickly in the global economics changes. In contrast the supply is maladaptive to changes on demand. As Martin Stopford mentioned, «The supply is like a turtle who tries to catch the rapid which is the demand» (Stopford 1988)

Based on the above, it can be concluded that the short term changes on freight rates are resulting from the demand as the supply of sea transport is inelastic in the short term. (Metaxas 1971). The most important determinant of sea transport demand is the global economy. It was calculated that about 80-85% proportion of world trade in terms of cargo transported was executed via sea. It is also proven that the fluctuations in shipping market follow the general pattern of the economy's cycles. It is an expected outcome as the demand for sea transport is a derived demand, coming from the world economy and sea trade. (McConville 1999)

The circles of shipping market, exactly as those of economy are coming from the combination of endogenous and exogenous factors such as weather (physical phenomena), political and socioeconomic events, technological improvements, wars, etc. The analysis of shipping circles is very interesting and complex at the same time. It is obvious that a complete study of shipping market must include all those important exogenous events; it is very difficult to translate those phenomena into economic terms and use them into an integrated forecasting model. It is equally important to note that the sea transport demand is influenced from the sea trade and the related sea routes. In short term, the seasonality of some cargos is related to ships demand fluctuations whereas, in long-term, factors such as the variations in cargo demand, differentiation of import-export locations, industry locations and charters policy could influence the demand for sea transport. Additionally, the demand for sea transport is dependent also on the distance that the cargo must be transported.

The impact of average haul has been appeared many times before. For instance, several times during the last decades when the Suez Canal was closing, the distance between Middle East and Europe almost doubled leading to higher freight rates especially for oil tankers. Moreover, the supply of vessels is depending generally from four decision making lobbies: ship-owners, charters, banks and regulatory organizations. The ship-owners take the decisive decisions as they choose when to place an order to the ship yards for new buildings or when to scrap an older vessel. Also, the regulations and legislation influence the supply for sea transport. For instance, MARPOL rule of 2003 promoted the phase-out of single hull tankers. In addition, the total transportation capability which is provided from the global fleet is depending on the fleet productivity which includes factors such as: vessels speed, total covered distance and time sailing with ballast.

2.1.33 Pricing Mechanism

There has been a recent trend towards LNG prices indexing to natural gas benchmarks with less dependence on global oil benchmark appreciation clauses for physical LNG delivery contracts. The entry of the U.S. as a substantial exporter of LNG will further this trend. International Gas Union (IGU, 2016) shows the share of European import contracts indexed to oil has decreased from over 90% to less than 40% in 10 years (IGU, 2016) and newer contracts are much more likely to be indexed to natural gas. The same trend holds to a lesser degree in Asia. This change towards gas-indexed pricing for LNG may put pressure on U.S. LNG exports, because U.S. natural gas has less of a pricing advantage against other natural gas supplies than it does against oil.

2.2 Theoretical Framework

2.2.1 The Shipping Market Cycle

Every industry experiences some kind of market cycle whereby everything that happened in the past finds a way of repeating itself so does the shipping industry, this cycle is called the shipping cycles. Cournot a French economist recognized the secular variations that are independent of the periodic variations and also distinguished the long term cycle from the short term cycle by identifying three different components of a shipping cycle which are; long-term cycle, short- term cycle and finally seasonal cycle.

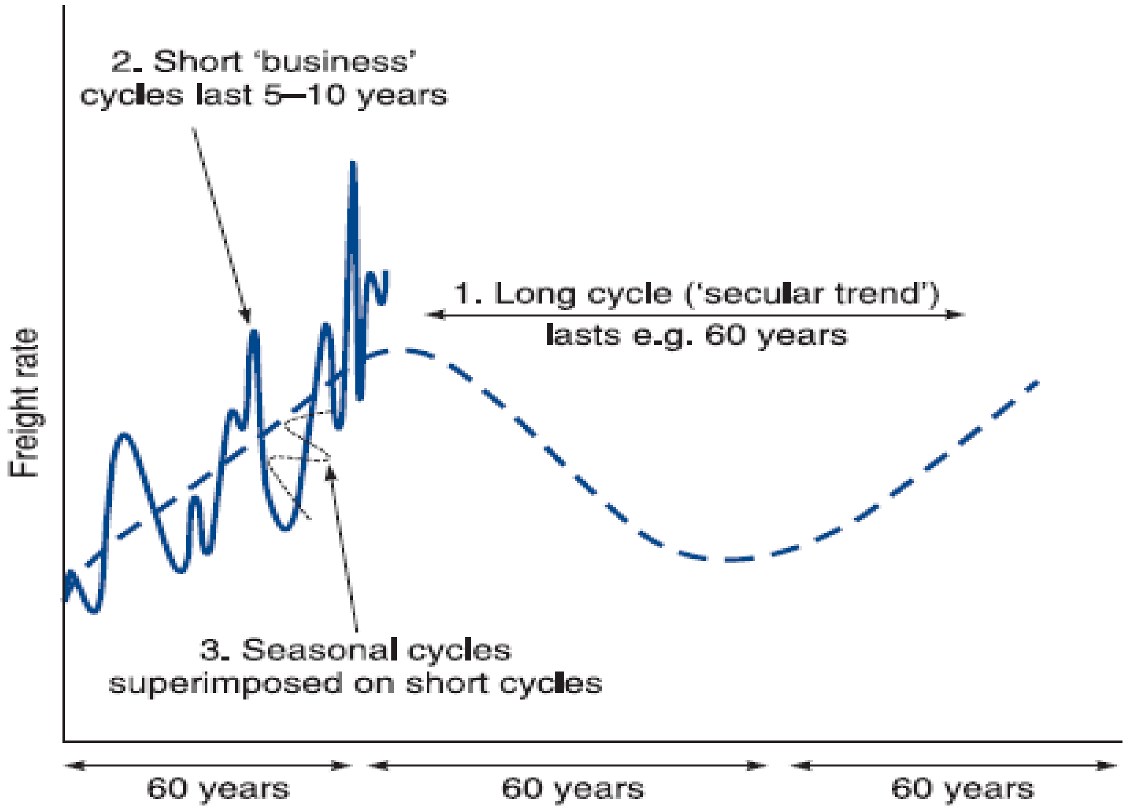

Fig 4: Seasonal, short and long cyclical components

Compiled by Martin Stopford from various sources

The long-term shipping cycle are driven by technical, economic or regional change. This theory was developed by the Russian economist, Nikolai Kondratieff who argued that in the major Western countries, between 1790 and 1916, there were three periods of slow expansion and contraction of economic activity, averaging about fifty years in length. The short-term cycle, also known as the business cycle is the one that corresponds more closely to most people's idea of a shipping cycle. They swing up and down, and a complete cycle can last anything from 3 to 12 years. The purpose of the short shipping cycle is to coordinate supply and demand in the shipping market, a short cycle typically is made up of four stages which are;

Stage 1 – Trough; here is a clear sign of surplus shipping capacity, freight rate grows nearer to the operating cost, old ship prices fall to scrap price leading to many demolition sales, there is usually little ordering and then shipping companies are left with no other option than to sell modern ships at prices below their book value in other to raise cash as banks are reluctant to lend. Troughs may last six months or six years.

Stage 2 – Recovery; here the freight rate goes above operating cost as the demand and supply moves towards equilibrium, second-hand prices increases as liquidity improves although market opinions are still in doubt but gradually growing confidence.

stage 3 - Peak; this peak period depending on the pressure of supply and demand may last for a few weeks or several years and the longer it lasts the higher the earnings generated and higher liquidity ratio. There is usually heavy ordering, few demolition sales, five-year-old vessel may cost the same as new building, the freight rate goes over three times the operating cost (sometimes ten times) and finally market opinions become implausibly positive.

stage 4 -Collapse; this phase occurs when supply over takes demand and freight rates fall hastily as freight rate falls operating speed of ship are being reduced and the least eye-catching vessels have to wait for cargo, at this stage liquidity still remains high and there are little sales of ships as owners are reluctant to sell their ships at a discount rate to the recent peak prices. The market opinion is confused, changing with each meeting in rates and unenthusiastic to accept that the peak is over.

For as long as there are fluctuations in supply or demand there will be cycles. There is no simple formula for forecasting the shape of the next stage, or the next cycle. Market collapses may be reversed before they reach the trough and sometimes the market gets stuck in the middle ground between trough and recession.

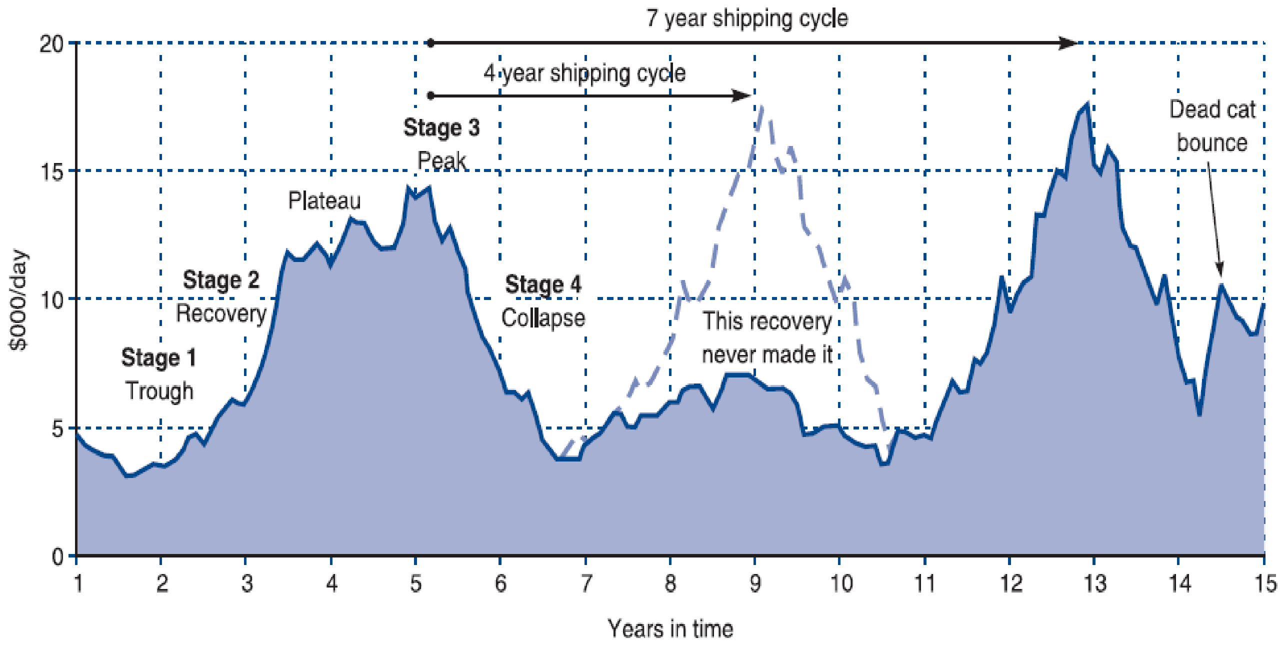

Fig 5: Stages in a typical shipping market cycle

Source: Martin Stopford

2.2.2 Adam Smith’s and David Ricardo’s Theory of International Trade

In Adam Smith’s and David Ricardo’s trade theory, they elucidated the basis for trade. In 1776, a book ‘Wealth of Nations’ by Smith was published and in this book he elaborated on the advantages of trade between countries. He also added that countries should only produce products of which they have absolute competitive advantage over to other countries and those of which they cannot produce they should import. This means that; when a country let’s say “country A” produces a product say “max z” at a lower cost per unit than any other country, that country (country A) has automatically gained absolute competitive advantage in the production of that product over other countries. In conjunction to the theory of trade by Smith, Ricardo added his own contribution saying it doesn’t matter whether or not a country has absolute advantage, there is always a basis for beneficial trade (Pugel, 2007). A demonstration of this was presented in the late 18th century / early 19th century explaining the principle of comparative advantage which states “A country will export the goods and services that it can produce at a low opportunity cost and import the goods and services that it would otherwise produce at higher opportunity cost” (Pugel, 2007, pg. 35).

In Ricardo’s new theory “Inter-Industry Trade”, it is seen that trade also happens between equal countries and within equal sectors (Pugel, 2007). This trade is not as a result of comparative advantage, but rather the term economies of scale can be used to explain this trade theory and the fact that customers want a variety of similar products. When the variation of the products in the market size is increased, the customers are free to choose between varieties of similar but not identical products.

2.2.3 Theory of Demand and Supply.

According to Adam Hayes, demand and supply are the most fundamental concepts of economics and they are the backbones of any market economy. Demand is referred to as the quantity of a goods or services that a buyer is willing to buy at a certain price and its relationship with price is known as demand relationship. Supply represents how much the market can offer that is the amount of a certain good a producer is willing to supply at a certain price and its relationship with price is known as the supply relationship. Therefore, price is a reflection of supply and demand.

1. The Law of Demand

The law of demand states that, as long as all factors remain equal, the higher the price of a commodity, the lesser the demand for that commodity. This is to say, the higher the price of natural gas, the lower the quantity of natural gas demanded. The graph below shows that the demand curve has a negative slope as it moves downwards from left to right.

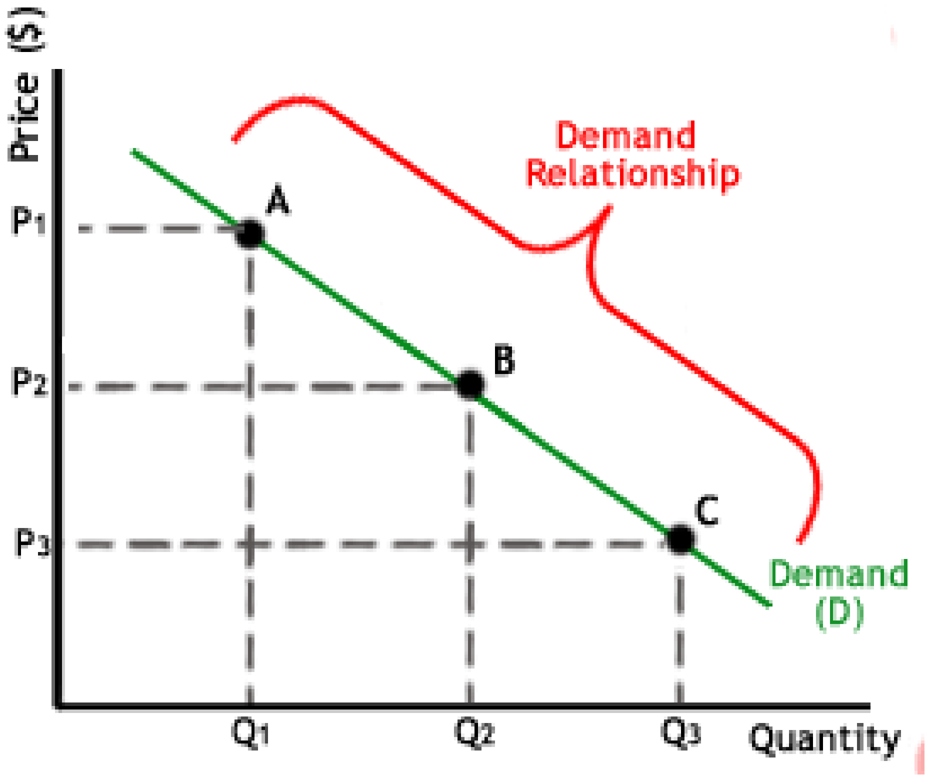

Fig 6: Demand relationship between quantity and price.

A, B and C are points on the demand curve. Each point on the curve reflects a direct correlation between quantities demanded (Q) and price (P). So, at point A, the quantity demanded will be Q1 and the price will be P1, at point B, the quantity demanded will be Q2 and the price will be P2, and at point C, the quantity demanded will be Q3 and the price will be P3. As mentioned earlier, the demand relationship curve shows the negative relationship between price and quantity demanded. The higher the price of a commodity the lower the quantity of that commodity demanded, and the lower the price of that commodity, the higher the demand for that commodity.

2 The Law of Supply

The law of supply illustrates the quantities of a commodity that would be sold at a certain price. In the case of supply, the supply relationship to price shows an upward slope that is a positive slope which implies that the higher the price of a commodity, the higher the quantity of that commodity supplied.

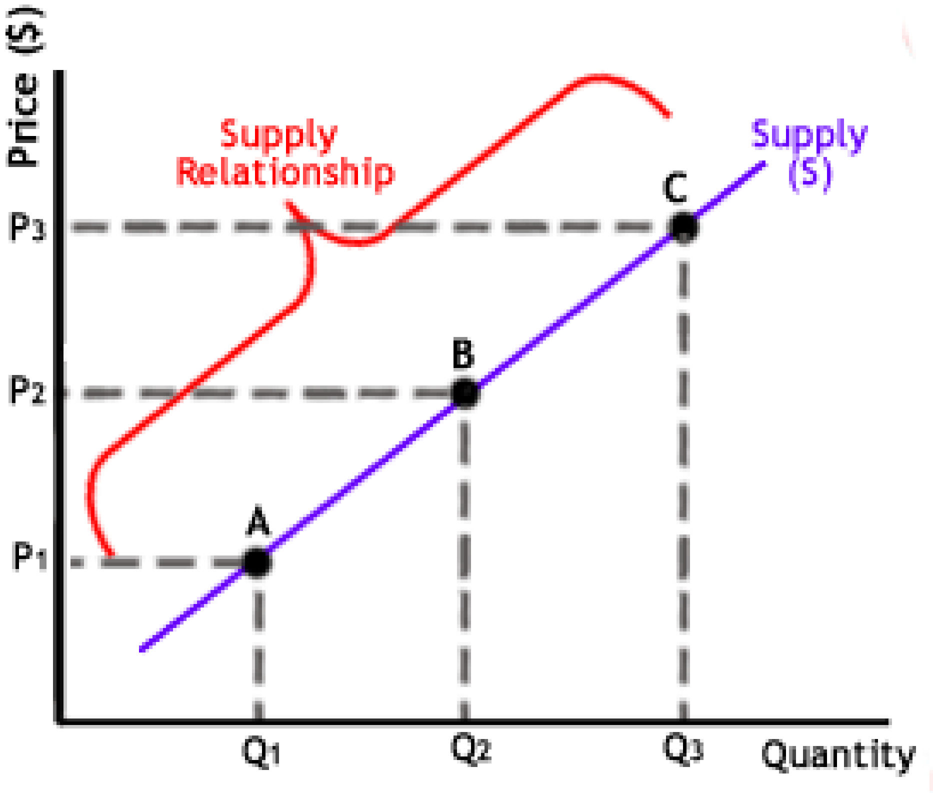

Fig 7: Supply relationship between quantity and price.

A, B and C are points on the supply curve. Each point on the curve shows the relationship between quantity of a commodity supplied (Q) and the price of that quantity supplied (P). At point B, the quantity of the commodity supplied will be Q2 and the price of that commodity will be P2, at point B, the quantity of the commodity supplied will be Q2 and the price of that commodity will be P2, at point C, the quantity of the commodity supplied will be Q3 and the price of that commodity will be P3. Shown from the graph above it is seen that the supply has curve is characterized by a positive slope which entails that as the price increases so does the quantity supplied.

Based on the above theories, demand and the supply of sea transport is inelastic in the short term, (Metaxas 1971) and the most important determinant of sea transport demand is the global economy. It was estimated that about 80-85% proportion of world trade in terms of cargo transported was executed via sea. It is also proven that the fluctuations in shipping market follow the general pattern of the economy’s cycles and the demand for sea transport is a derived demand, coming from the world economy and sea trade, (McConville 1999).

The circles of shipping market are coming from the combination of endogenous and exogenous factors such as weather (physical phenomena), political and socioeconomic events, technological improvements, wars, etc. The analysis of shipping circles is very interesting and complex at the same time. It is obvious that a complete study of shipping market must include all those important exogenous events; it is very difficult to translate those phenomena into economic terms and use them into an integrated forecasting model. It is equally important to note that the sea transport demand is influenced from the sea trade and the related sea routes. In short term, the seasonality of some cargos is related to ships demand fluctuations whereas, in long-term, factors such as the variations in cargo demand, differentiation of import-export locations, industry locations and charters policy could influence the demand for sea transport. Additionally, the demand for sea transport is dependent also on the distance that the cargo must be transported.

Also, the regulations and legislation influence the supply for sea transport. In addition, the total transportation capability which is provided from the global fleet is depending on the fleet productivity which includes factors such as: vessels speed, total covered distance and time sailing.

2.2.4 The Law of One Price

The economic Law of One Price states that over time, the prices of a commodity in a competitive market will converge to a single price, assuming there are no transport costs, no tariffs, quotas or economic barriers between supply and demand locations. Contained in this law is the ability to non-discriminately trade between locations, allowing arbitrage to reduce price differences between locations to the differences in transportation costs. Stigler and Sherwin, 1985, defines the extent of the market and measures market integration saying if a single price exists over several spatially distinct markets, it implies that these markets are integrated as a single market. Ravallion in 1986 stated that market integration can only be viewed as basics to understanding how a specific markets work. Identifying the non-stationary behavior of commodity prices, Engle and Granger in 1987 extensively employed co-integration and error-correction models (ECM) to test the law of one price and market integration on international commodity markets. Earlier studies conducted on the law of one price discovered that the law of one price almost never holds in the short run and as such the oil market provides an excellent example of price convergence. As seen in the figure below, oil prices move together among locations with price differences that are primarily due to differences in transportation costs. In contrast, natural gas prices exhibit a lack of convergence, in which price movements in one region do not necessarily follow price movements in other regions. This begs the questions of why global natural gas prices have not converged, and what changes are needed for price convergence.

The key factors that have reduced the ability of arbitrage to enable the convergence of global natural gas prices are: the presence of different dominant pricing systems in different regional markets, and limitations on access to the arbitrage opportunities that must be exploited for price convergence. Access to arbitrage opportunities is limited by the prevalence of restrictive terms in long term contracts; supply chain limitations; and national policies that limit imports and exports.

Both historically and currently, the high investment risk associated with the high capital costs of certain natural gas supply chain segments has been mitigated through long term contracts with destination restrictions that legally bind both parties to price and quantity, and in many cases, effectively prevent opportunistic behavior (i.e., the possibility of arbitrage). Further, the pricing mechanism of oil indexation has, and continues to be incorporated in long term contracts in a manner that reduces the LNG supplier exposure to natural gas market-based price risks. As such, the barriers to nondiscriminatory market access posed by multiple pricing systems and restrictive long term contracts have origins in the capital-intensiveness of this industry, which for certain supply chain segments is substantially more capital intensive than in the oil industry.

In recent years, the number of natural gas market players has increased and spot market volumes have grown. This increases the opportunities for new trading partnerships, and enables a more liquid market with reduce risks associated with any particular trade arrangement. These shifts notwithstanding, investors still face substantial risks, and as a result, the well-established risk mitigating strategies employed in long term contracts and oil indexed pricing systems have been slow to change.

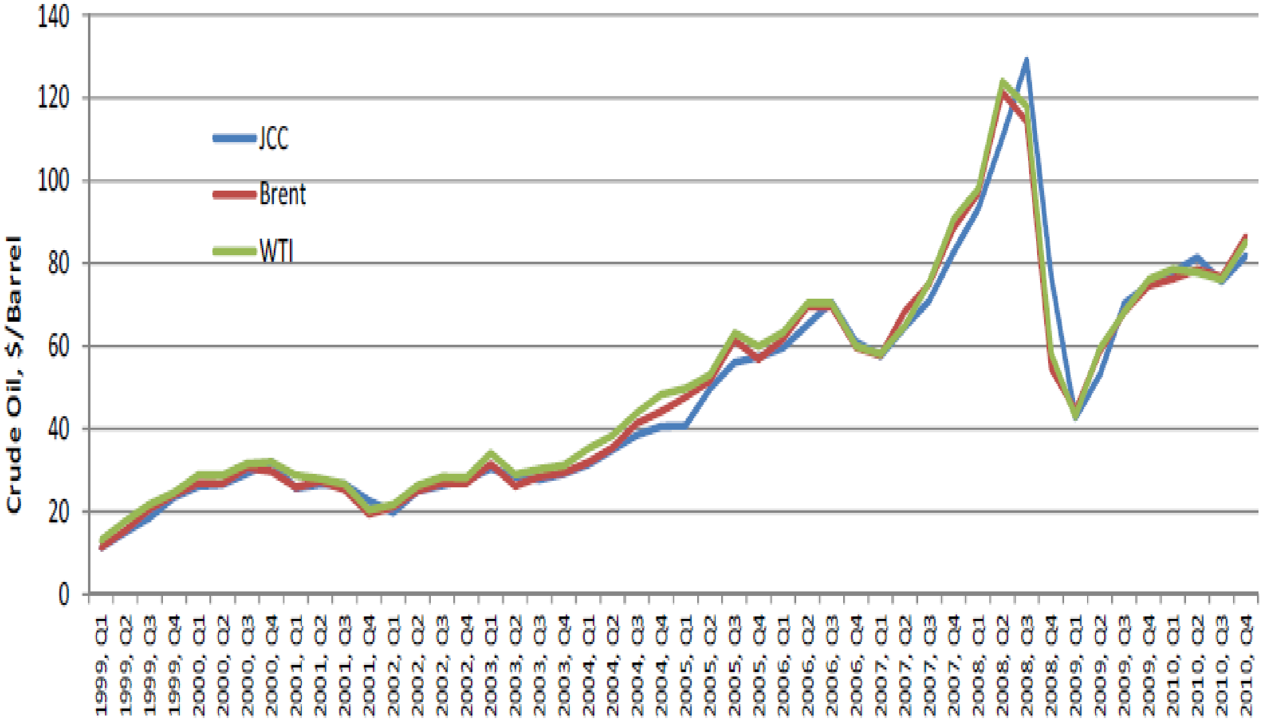

Fig 8: Global crude oil prices, Japan (JCC), Europe (Brent), and US (WTI), 1999 to 2010

Source: EIA, Gas Strategies, 2010

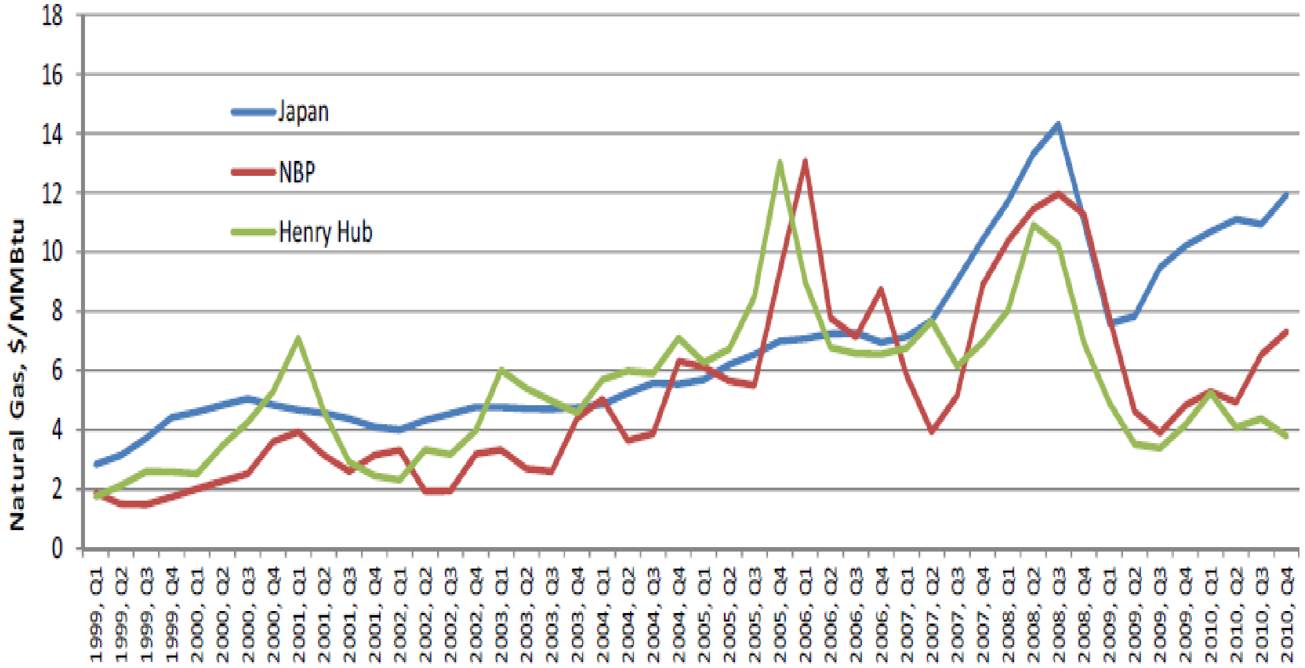

Fig 9: Global Natural Gas Prices, Japan, UK (NBP), and US (Henry Hub), 1999 to 2010

Source: EIA, Gas Strategies, 2010

2.2.5 Theory of Economic Rhythm

This theory proposes that economic occurrences behave in a recurring manner and cycles of almost the same intensity and duration and these economic occurrences tend to reappear. According to this theory, the available historical data have to be analyzed and find the trend. This trend obtained from the historical data is projected into the future either on a graph sheet or with a mathematical trend equation. If the occurrences are cyclical in behavior, the trend should be adjusted for cyclical movements. It is usually very difficult to predict irregular variations; therefore, rhythm method should be mixed with other methods to avoid inaccuracy in forecasts. However, it must be remembered that business cycles may not be strictly constant and the very assumptions of this theory may not be true as history may not repeat itself.

2.2.6 Theory of Action and Reaction Approach

This theory was developed based on Newton’s ‘Third Law of Motion’, which states that “for every action there is an equal and opposite reaction”. When this is applied to the business, it implies that if there is a gradual disintegration in a particular field of that business, there is bound to be a negative impact on that business sooner or later. This theory looks at a definite stage of business activity as normal and the forecaster has to estimate the normal stage carefully. According to this theory, if the price of commodity goes beyond the normal level, it must come down also below the normal level because of the increased production and supply of that commodity.

2.3 Empirical Review

Dimitrios (2013) developed both simple and multiple linear regression models to determine the capacity of the global LNG fleet based on seven factors, which includes: Global GDP, Oil Prices, Shale Gas, EU Policy, Natural Gas Consumption, Natural Gas Prices and LNG Fleet Capacity but only 5 of them were used with exemption of Shale Gas and EU policy. The idea was based on four (4) rudimentary stages which are; the correlation between global GDP and Oil prices, the determination of natural gas consumption, the determination of natural gas prices, and the determination of total capacity of LNG vessels. In achieving this, he subjected the collected data to a regression analysis (using simple and multiple regressions) and also analysis of variance to examine the importance of the results. From the analysis, he discovered that Global GDP per capita and political events are two sea transport factors that control the oil and gas prices worldwide and natural gas consumption; and hence, the demand for sea transport and vessels capacity.

Sydney and Richard (2002) in their review work on ways to transport natural gas energy from countries which do not need the gas for domestic use did a comparative analysis between the different methods of transferring natural gas from a region of less use to a region of higher use. In their work, they identified and discussed briefly the various modes in which natural gas is transported which includes; pipelines, liquefied natural gas (LNG), gas to liquids (GtL), gas to commodity (GtC), gas to wire (GtW), compressed natural gas (CNG), and gas to solids (GtS), i.e. hydrates. The different market risks involved in the transportation of natural gas from the point of production to a point of consumption were also discussed by the authors. From the research, they concluded that although transporting natural gas in other modes such as GtW, GtL and GtC has potential but the cost involved in investment is on the higher side leaving transportation of natural gas to be by just pipeline and LNG.

Sylvie et al. (2003) did a work on the challenges of further cost reductions for new supply options. They opined that it is already known by so many other researchers that natural gas is expected to be the ruling source of energy in the near future due to its economic and environmental favorable factors. The demand for natural gas is expected to grow more rapidly in regions such as Asia, China and Latin America whereas regions such as OECD North America, OECD Europe, and the Former Soviet Union remains the largest natural market with the Former Soviet Union and the Middle East accounting for more than two-thirds of global gas reserves. They reviewed the international gas trade and the economics of pipeline and LNG transportation which ended up in LNG being the most preferred method of transporting natural gas as the factors affecting pipeline are more than that of LNG and LNG’s flexibility compared to pipeline. They observed that the new technologies involved in the transportation of natural gas which include; CGN, GtS, GtL etc, in a highly competitive export market will reduce the supply cost and major cost reduction is expected particularly in high-pressured long-distance pipelines.

Beenstock and Vergottis (1993) developed a demand and supply model that considered the endogenous variable that make up the freight rate includes spot and time charter. This model represents not just demand and supply but also the equilibrium conditions in the shipping markets. The econometric Modeling of World Shipping is mainly concerned with different factors that are linked directly to freight rates or the ship markets. These factors include; the time charter rates, ship building, freight rate, speed, prices and scrapping. These elements also include the freight demand, prices of the fuel, operating, ship building and lay up costs. The ships are taken as capital assets and their demands alter with the return expected on other assets. It also regards the objectives and restraints that the participants in the market have to face and examines responses to the change taking place in the environment; this is done through the methodological approach. Furthermore, the responses of the shipping market to predictable and unpredictable changes in the external factors were also studied by the authors. For instance, prices, freight rate, ship building and scrapping are likely to exceed their equilibrium value to meet up the demand and bunker price shocks. It reflects that the market may respond to the predictable and unpredictable shocks which has similar effects in the long run but has different response in the short term (Beenstock&Vergottis, 1993). Basically, the theoretical explanation involves only one ship type, but the model itself provides a differentiation of the tanker and dry sector. The insignificant particulars are omitted so that the essential interactions between these markets can give rise to the fluctuations and co-movements in ships rates, prices, fleet and the other aforementioned factors.

Monika (2009) studied the development of new technologies for shipping natural gas by sea. The author was of the opinion that transport capability for ship orders intended for liquefied natural gas (LNG) shipping has witnessed concurrent increase in recent years while evaluating different alternatives method of transport (liquefied gas, hydrate form and compressed gas) and considering characteristics of their technology with respect to temperature and pressure, design etc. The author added that despite complexity and high cost of liquefied gas, it is the most profitable transport method in long-range transport, whereas CNG and NGH transport technologies are suitable for transportation of medium and small amounts of gas over short distances, up to 3000 Mm, hydrate form of transport is still in research phase and researches were being made by some universities on development of design and production technology of ships for natural gas transport.

Tomás and Nelson (2009) in their study of Natural gas transport tried to assess a means of applying the various method for transporting natural gas present and future which include gas to liquids (GTL), natural gas hydrate (NGH), compressed natural gas (CNG), liquefied natural gas (LNG) and pipeline, taking into account their processes and underlying economics (investment & material requirement) in Columbia. They suggested that only pipeline was feasible compared to other methods due to the high cost on construction and usage, there is a need for non-pipeline technologies that can capture stranded gas. They observed that gas transporting infrastructure development in Colombia will depend on the new legislations and natural gas transportation (large scale) options.

Princewill (2011) designed a transportation model for the transmission of natural gas using a pipeline network from izombe flow station to Owerri city in Imo state. In the analysis of the proposed network some factors were actually considered which includes; nature of gas to be transported, length of the network, type of terrain to be crossed and the maximum elevation of the route. He conducted his design using wey-mouth equation, gas demand/supply forecasts based on the population census, pipe-phase and economics analysis with some assumptions. The author calculated the Network configuration, pressure drop estimation, estimation of operation and capital cost, yearly revenue, yearly expenditure and Optimum Pipeline Diameter using data on Stoichiometric properties of the gas from Izombe, Chemical composition of the gas and population of Owerri. The author designed a network with city gate stations away from populated area and compression regulation station for the regulation of gas pressure at the dense area of the state for distribution of gas. The design considers only one case of static design which deals with a transmission network whose layout were assumed to be fixed.

Raju et.al (2016) investigated the volatility of new ship building prices in LNG shipping. They tried to analyze the volatility of new LNG vessel building prices taking into account the average ship building prices for capacity between 160-173,000m^3 to be delivered between 2016 -2019. Using GARCH & EGARCH to analyze the data for modelling new LNG ship building price volatility, he made use of 126 observations in the form of monthly prices from April 2005 to August 2015 in the time series. Though the GARCH model captures the volatility clustering, it doesn’t capture the leverage effect if it is positive or negative. In order to capture leverage effect EGARCH models was applied. From their results the significance of persistent negative shocks or the volatility asymmetry indicates that the ship owners are more likely to be affected by the negative news as compared to the positive news and that the volatility is increasing drastically when there is a big reduction in the prices compared to an equal increase in the price. This implies that the volatility spill over the mechanism is uneven. Results of the study also indicate that the future of high volatility is associated with low returns and high future expected return.

David (2011) did a general review on the global market for liquefied natural gas with emphasis on the significant investments in LNG production and the projects under construction in Australia. According to him, while LNG investments face a variety of risks, the use of long-term contracts affords a significant degree of protection, particularly in terms of volumes. He concluded that with trade segmented between regions and subject to a variety of pricing arrangements, the LNG market is not as globalized as some other energy commodities. Australia has emerged as a major Centre for LNG investment and as a result it’s projected to become the second largest LNG supplier globally during the next decade.

Victor et. al (2013) highlighted the impact of global trend in natural gas development on the Nigerian gas market. They considered three major factors that will have a strong effect on the natural gas market in the nearest future to include; soaring gas prices in Asia, the boom in unconventional gas production in the United States and new gas fields increase in liquefaction facilities. They identified that the Nigerian gas resource has been grossly underutilized due to inadequate gas master plan and poor infrastructure in the country. They observed that with the boom in unconventional gas development in some countries of the world especially the United States who is currently a major destination of the Nigerian gas, recent discovery of large natural gas resources in deep water Rovuma Basin in Tanzania and the deep-water Area-1block in Mozambique, known to hold enough gas to supply France, Germany, the UK and Italy as well as the introduction of new players in Western and Eastern Africa, the revenue generated by the sale of Nigerian gas might deteriorated as a result of these new emerging markets.

Marina and Mirjana (2008) on the challenges facing the LNG carriers in the 21stcentury, focused on the recent economic boom in LNG shipping and sought to address the questions about the safety, crewing, technologies and capacities of LNG tankers in the future. The trend in fleet development 1965-2006, LNG fleet capacity in November, 2007 (greater than 100,000m^3& less than 100,000m^3 with their age, range, number & capacities, idle & active ones), analyses of supply and demand for LNG shipping capacities, estimated cost of building new vessel, consumption and production, safety issues, management in LNG shipping companies such as employment of the tankers- talking about contract terms, short and long, spot market forecast to increase in LNG trading, flexibility of some long term contracts to accommodate short term were analyzed . They observed that the expansion of the LNG fleet and the erection of new terminals could lead into the employment of not properly trained and not so accurately selected personnel although both shipping companies and terminal operators assure that quality and safety are crucial aspects of their operation and both attributes can *only* be amplified

Romeo et al. (2017) analyzed LNG carries present and future. They observed that the peculiarities of liquefied gas and the unique feature of each type of gas specialized transport ship relative to oil tankers in other to achieve a comparative study of both the qualities and vulnerabilities, from an operational perspective. Using a descriptive research, they considered the trend in the volume of liquefied gases transported by sea worldwide from 1990-2012, the growth in fleet of specialized gas vessels form 2015-2016, in dwt and Compared the degree of danger on gases and petrol product. According to them, analysis on the evolution of the volume transported by sea of liquefied gases worldwide from 1990-2012 showed a steady growth of over four times and the main difference between tankers carrying liquefied gases and oil tankers and chemicals is that the liquefied gas storage system on board vessels are usually compact separated from the structure.

2.4 Gap in Literature

In the course of this work, we observed carefully and come into conclusion that the demand for vessels is a derived demand and as such depends on the uses and demand for LNG and its price. So many researches have been done in this area of study but none was done directly on the determinant for demand in vessels via demands for LNG and prices. And also no work was done on the determination of the vessel capacity (Volume) that will optimize return on investment for Vessel investors. In this study, we intend to develop two models namely; the multiple linear regression models that will reflect the current trends in LNG market and forecast the future of LNG market. This will help investors to make an informed decision on vessel investment. Again, we also intended to develop a linear programming model that will maximize profit on investment and vessel volume that will yield optimal profit for vessel investors. This kind of work has not been done by other researchers in this area of study.

CHAPTER THREE

METHODOLOGY

3.1*:* Description of study area

Research Methodology entails all conventional methods and techniques of conducting specific research work with the intention of arriving at a conclusion. The selection of the proper research method is very important for a successful dissertation. The main choice for every researcher is whether qualitative or quantitative approach should be used as well as the nature of the data (primary or secondary). Essentially, the procedures by which researchers go about their work of describing, explaining and predicting phenomena are called research methodology, (Kothari, 1985).

3.2*:* Sources of Data

The researcher obtained the data for the study from the following sources:

1. Data for natural gas production and consumption was gotten from BP Statistical Review of World Energy, June 2020, 2011 and 2002 edition.
2. Data for natural gas price was gotten from BP Statistical Review of World Energy, June 2020 edition

3. Data for global GDP per capita was gotten from World Bank national account data and OECD national account data files, 2020.
4. Data for LNG trade volume was gotten from Clarkson Research data, 2020.
5. Data for geographical variables were obtained from word distance database.
6. Data for LNG fleet capacity was gotten from Clarkson research Institute. 2020 (2003-2020), IGU World Gas LNG Report 2020 edition,
7. Data from 2003-2020 for LNG fleet capacity NLNG Limited.
8. Other data were collected from annual abstracts of port statistics, NPA.

3.3*:* Method of Data Collection

We used secondary method of data collection to collect data for this study. The data was collected from the secondary sources such as journals and LNG publications on the global market for LNG, in addition to those sources stated in section 3.2 above. Such a data is called secondary data because it has been collected and compiled by another person or organization other than the researcher.

3.4: Method of Data Analysis

In this section, the method applied to achieve the aim and objectives of the study was stated vividly. The methodology was divided into two sections corresponding to two models developed in finding solution to the demand for vessels in the LNG market and to identify significant policy variables. Each section gave specific details on how the solution was achieved. The various steps were briefly discussed below.

The first model to be developed in the first section is the Gravity regression model. The gravity regression model fits the study because we have various factors influencing demand for natural gas shipping trade between Nigeria and her trading partners. Apart from satisfying other requirements for the application of the model, each of the variables are independent of the other, thereby eliminating the effect of multicollinearity. The solution to multiple linear regressions in this thesis involves two stages: The first stage was concerned with the development of the model and determination of the parameters of the model. We will test the significance of the parameters of the model and determine the fit adequacy of the model. The second stage is concerned with the fitting of the model to determine the trend lines and to make inferences about the future market in LNG.

3.4.1: Development of the Gravity Model

The gravity model provides evidence of the relationship between distance and the magnitude cum intensity of bilateral trade flow between two Countries, regions and and/or domains. The original gravity model suggests that the magnitude of bilateral trade flow between two trading regions and/or Counties (F_{ij}) is directly proportional to the product of their economic size measured by the Gross Domestic Product (GPD) population mass and inversely proportional to the square of their distance apart (D_{ij}). Starting with the basic gravity model for trade, Jose et al; (2012 and Schlaich et al; (2020) posit that:

$$F_{ij} = G * \frac{MiMj}{D_{ij}^{2}} ------------------------ (3.1)$$

Where:

F_{ij} = spatial interaction induced magnitude of bilateral trade flow from origin Country (i) to destination Country (j)

G = constant term, M_i = GDP *(population mass)* represent economic size of origin Country (i)

M_j = GDP *(population mass)* representing economic size of destination Country (j).

D_{ij} = distance between the two airport locations.

Evidently, distance is seen from the above equation to influence magnitude of bilateral trade flow, othe*r factors other than distance are* also known to affect bilateral trade flow, *e.g.*: transportation cost (freight), population, exchange rate, etc. According to Baier and Bergstrand (2009), for econometric applications, it is traditional to specify that:

$$F_{ij} = \beta 0 * \frac{Mi^{\beta 1} Mj^{\beta 2}}{\left(D^{\beta 3}_{ij}\right)\mu_{ij}} ---------------------(3.2)$$

Where: μ_{ij} = error term.

Where β_0 = constant term, β_1, β_2, β_3 = coefficient of terms.

Traditional General linear Model (GLM) estimation involves taking natural log of both sides as shown:

$$\mathrm{In}(F_{ij}) = \beta_0 + \beta_1 \mathrm{In}(M_i) + \beta_2 \mathrm{In}(M_j) - \beta_3 \mathrm{In}(D_{ij}) + \mu_{ij} ---- (3.3)$$

3.4.2: Development of the Log-Linear Gravity Model

A multiple linear regression model is of the form

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \varepsilon_i \qquad \ldots \qquad (3.4)$$

Where Y_i are the observed values of the yield (prices ₦) of the LNG, it is also called the dependent variables. β_0 is the universal constant, an intercept on Y-axis, otherwise known as the general mean. β_i; i = 1, 2, . . . , n, is the parameter measuring the mean effect of demands *(trade volumes)* for LNG X_i. If β_i; i >1, we have multiple linear regression, (Arua et al., 2000). Then ε_i is the random error associated with the price Y_i. And X_i is called independent or predictor variables (various demands for LNG). We are aware that there are some errors to be minimized in the development of model and this inform the choice of multiple linear regression model where the error is minimized while estimating the parameters of the model. Since the parameters of interest in this work exceed one, we chose the matrix approach to the least square estimation for the derivation of the estimators of the parameters β_i.

Assumption:

Normality: All the variables in the model are normally distributed, that is, $\varepsilon_i \sim N(0,\ \sigma_e{}^2)$; $x_i \sim N(0,\ \sigma_x{}^2)$ and $y_i \sim N(\mu_y,\ \sigma_y{}^2)$.

Independence:

All the variables in the model are independently distributed, that is CoV$(\varepsilon_i\ , \mathrm{x_i}) = 0$; Cov$(x_i\ , \mathrm{x_j}) = 0$; Cov$(y_i\ , \mathrm{y_j}) = 0 \quad \forall\ \mathrm{i} \neq \mathrm{j}$

Constant Variance (Homoscedasticity)

Var$(\mathrm{x_i}) = \sigma_x{}^2 \forall i$; Var$(\varepsilon_\mathrm{i}) = \sigma_e{}^2 \forall i$; Var$(\mathrm{y_i}) = \sigma_y{}^2 \forall_i$,

To derive all we needed in the estimation of the parameter, we resort to matrix approach and vector notation.

The model:

$$Y = X\beta + \varepsilon \tag{3.5}$$

$$\varepsilon = Y - X\beta \tag{3.6}$$

Squaring the error and summing both sides, we have

$$\begin{aligned}
&\varepsilon'\varepsilon = (Y - X\beta)'(Y - X\beta) \\
&\sum \varepsilon'\varepsilon = Y'Y - Y'X\beta - \beta'X'Y + \beta'X'X\beta \\
&S = Y'Y - 2\beta'X'Y + \beta'X'X\beta
\end{aligned} \tag{3.5}$$

Minimizing the error sum of square, we take the derivative of both sides with respect to β_i

$$\frac{\partial S}{\partial \beta} = -2X'Y + 2X'X\hat{\beta} = 0 \tag{3.7}$$

Equation (3.6) is called the set of normal equations, and solving the equation, we have

$$X'Y = X'X\hat{\beta} \tag{3.8}$$

Pre-multiplying equation (6) by $(X'X)^{-1}$, we have

$$\begin{aligned}
&(X'X)^{-1}X'Y = (X'X)^{-1}X'X\hat{\beta} \\
&(X'X)^{-1}X'Y = \hat{\beta}
\end{aligned} \tag{3.9}$$

where

$$\hat{\beta} = \begin{bmatrix} \hat{\beta}_0 \\ \hat{\beta}_1 \\ \vdots \\ \hat{\beta}_n \end{bmatrix} \tag{3.10}$$

Hence, the fitted model is

$$Y = X\hat{\beta} \qquad (3.11)$$

Writing equation (3.9) in a scalar form, and since we have six predictor variables, we have

$$Y_i = \hat{\beta}_0 + \hat{\beta}_1 X_1 + \hat{\beta}_2 X_2 + \hat{\beta}_3 X_3 + \hat{\beta}_4 X_4 + \hat{\beta}_5 X_5 + \hat{\beta}_6 X_6 \qquad (3.12)$$

Equation (10) is the fitted trend line and will be used to examine the future demand for LNG and hence the demand for vessels.

Hypothesis

$H_0 : \beta_i = 0$ Vs $H_1 : \beta_i \neq 0$; Take $\alpha = 0.05$

H_0: simply means that there is no significant difference in the parameters. On the other hand, H_1: simply means that there is significant difference in at least one of the parameters.

Analysis: We shall use Stata Statistical package to analyze the data presented in section four.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Study Data/Results

In this chapter, we will present the data employed for analysis and subsequently test the hypotheses governing this study. Two statistical methods of shall be employed namely: descriptive and inferential statistics. The descriptive statistics present descriptive summaries or frequency distribution of the data set in the study. The inferential statistics will be employed for testing the hypotheses in the study. These are as discussed in the sections that follow. In table 4.1, we observe the means and standard deviation of data set on volume of natural gas trade (dependent variable) in (billion cubic feet) between Nigeria and her trading partners. Other independent variables include: population mass of the Nigeria and trading partner countries, geographical distances between Nigeria and trading partner countries, international natural gas prices per cubic metres, bilateral trade agreement (dummy variable taking values of 0 or 1). Other variables in the table include: transport infrastructure index (proxied by logistics infrastructure index) and shipping freight rates. According to the Gravity model theory, these are the variables postulated to determine the level of natural gas trading between Nigeria and her trading partners.

Table 4.1: Descriptive Statistics of Variables in the Gravity Model

Variable	Obs.	Mean	Std. Dev.	Min	Max
Tot_trade (bcm)	609	4,021.229	12,828.08	0	87,395.91
Pop_Mass (km.sq)	820	69.32955	168.3912	176.2	1,554.244
Geo_dist (km)	820	4.070867	2.156028	1.519	14.01
Nat_gas_prices ($)	820	7.299668	20.83062	0.00007	1.71E+02
trade_agr (dummy)	820	19.16714	15.48185	3.35038	120.241
Transp._infr (index)	820	4.426336	2.560066	1.519	27.247
freight_rate ($)	820	790,595.8	2,022,535	7	1.71E+07

Source: Author data analysis, variables in their natural logs.

In table 4.2, we find the distribution of Nigeria's trading partners by continents. Thus, the continents listed can be taken as proxy of shipping routes for analysis of transport demand. The frequencies are indicative of number of times countries within these trading blocs traded with Nigeria. However, the volume of trade involved can be understood in figure 4.1

Table 4.2: Distribution of Nigeria's Natural Gas trading Partners by Continents

Continents	Freq.	Percent	Cum.
Africa.	204	26.19	26.19
North America (USA)	41	5.26	31.45
Asia	123	15.79	47.24
EuroAsia	124	15.92	63.16
Europe	246	31.58	94.74
S.Amer	41	5.26	100
Total	779	100	

Source: Author data analysis

In figure 4.1, we note that United States of America and Eurasian countries imported natural gas from Nigeria than the rest of other countries in the trading blocs under discussion.

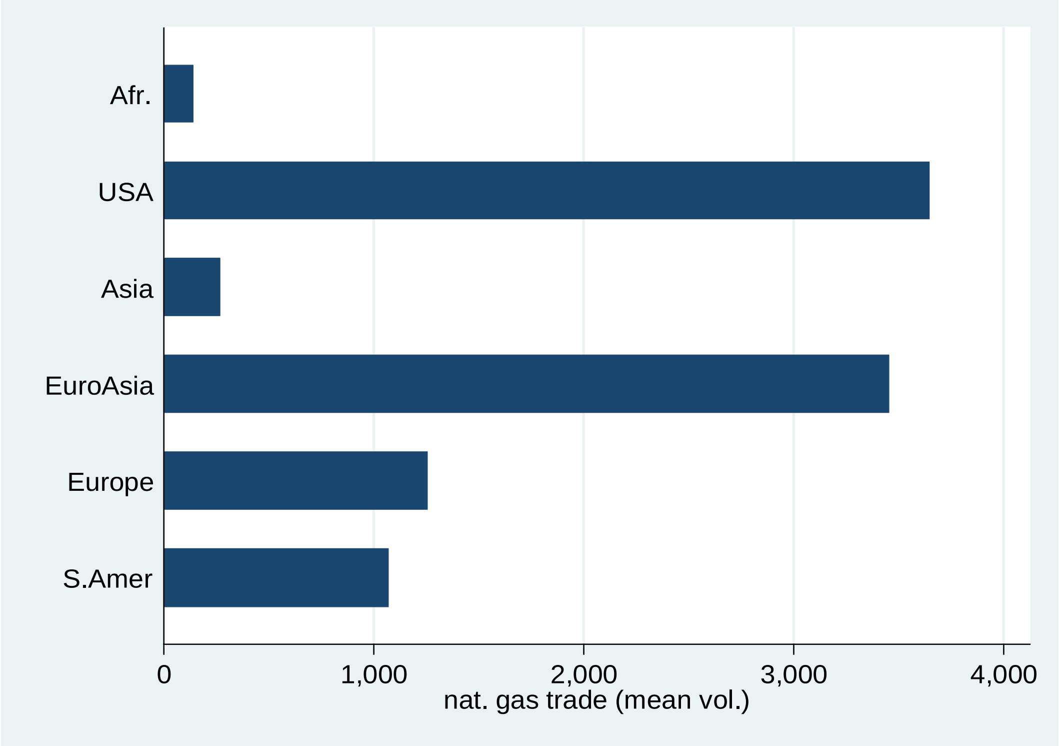

Figure 4.1: Distribution of nat. gas trade vol. between Nigeria and trade partners by continents

Table 4.3 provides further aggregations of countries involved in Nigeria's natural gas trade during the study period. The frequency column indicates the number of times particular countries traded with Nigeria. However, the bar chart (figure 4.1) depicts average volume of trade in billion cubic metres and provides more information indicative of demand for shipping capacity.

Table 4.3: Major Importers of Nigeria's Natural Gas by Continents

Trading Countries	**Freq.**	**Percent**	**Cum.**	**Continent**
Ghana	41	20.1	20.1	Africa
South Africa	41	20.1	60.29	Africa
Tunisia	40	19.61	79.9	Africa
Egypt	41	20.1	100	Africa
United States	41	100	100	USA
Singapore	41	33.33	33.33	Asia
Taiwan	41	33.33	66.67	Asia
Thailand	41	33.33	100	Asia
Russia	41	33.06	33.06	EuroAsia
Tunisia	1	0.81	33.87	EuroAsia
Turkey	41	33.06	66.94	EuroAsia
Ukraine	41	33.06	100	EuroAsia
Germany	41	16.67	16.67	Europe
Romania	41	16.67	33.33	Europe
United Kingdom	41	16.67	50	Europe
France	41	16.67	66.67	Europe
Poland	41	16.67	83.33	Europe
Spain	41	16.67	100	Europe
Brazil	41	100	100	South America

Source: Author, field work

Figure 4.2 shows the trends in global natural gas trade from years 2003 to 2020. Thus, from the graph, we note a rising trend in demand for natural gas across countries from the year 2003 to year 2017 when there was a drop to 2,800bcm from 3,500bcm recorded in the year 2017. However, the demand peaked in 2018 and rose to 3,500bcm in year 2020. It is expected that this trend will continue in the short run given the positive and significant R-squared value, see equation below:

$$y = 44.178x + 2735.6 \quad \ldots \quad 4.1$$

$$(R^2 = 0.5207)$$

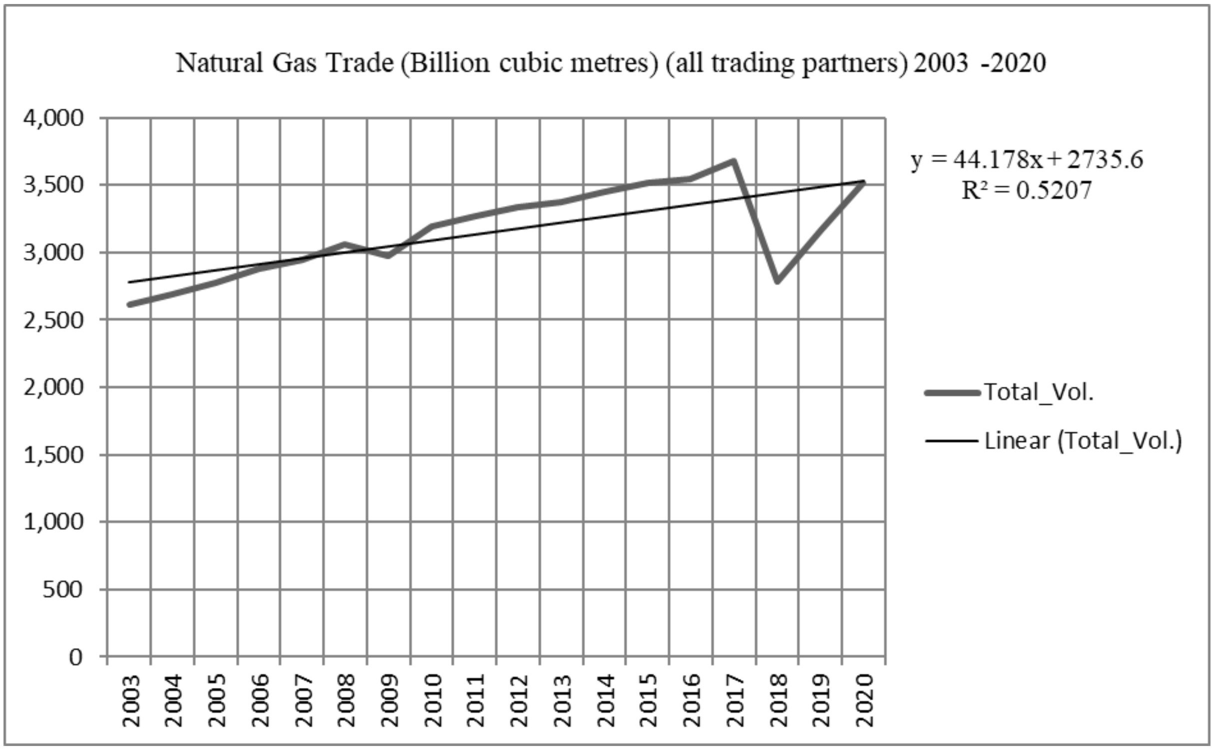

Figure 4.2: Trends in Natural Gas Trade (Billion cubic metres) (all trading countries) 2003 -2020

In figure 4.3, we note the trends in Nigeria's output of natural gas from the year 2003 to year 2020. Thus, from the graph, there has been a steady rise in demand for Nigeria's natural gas from year 2003. The demand dropped significantly from 2017 to 2018 and peaked again to 2020. The trend coefficient is 1.145 and is positive, see equation 4.2. This outcome implies a positive outlook for Nigeria's natural gas shipping trade.

$$y = 1.1145x + 23.779 \qquad \ldots \qquad (4.2)$$

$(R^2 = 0.453)$

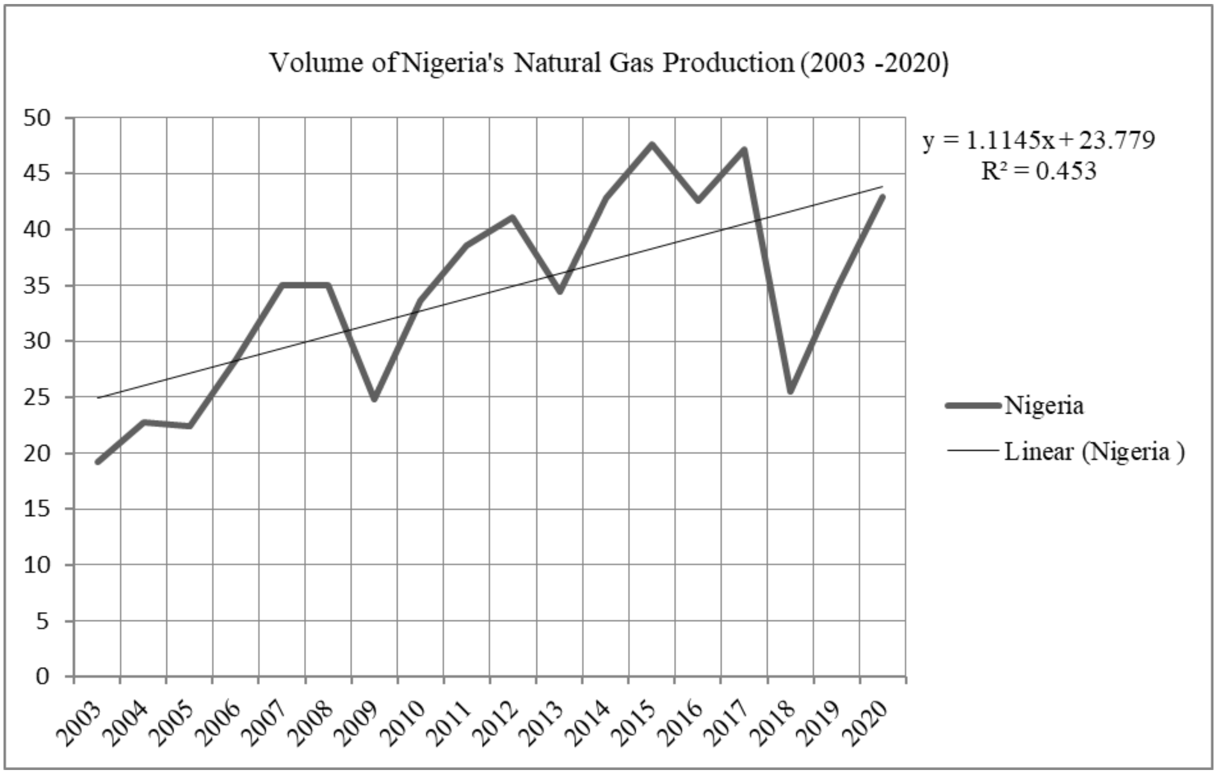

Figure 4.3: Trends in Nig. Natural Gas Trade (Billion cubic metres) 2003 -2020.

In figure 4.4, we observed the rising trend in demand for shipping tonnage from years 2003 to 2020. By inspection, it can be observed that Nigeria’s contribution to global shipping capacity is minimal. This outcome suggests that more investments in LNG fleet are needed for Nigeria’s gainful participation in natural trade in terms of freight revenue earnings.

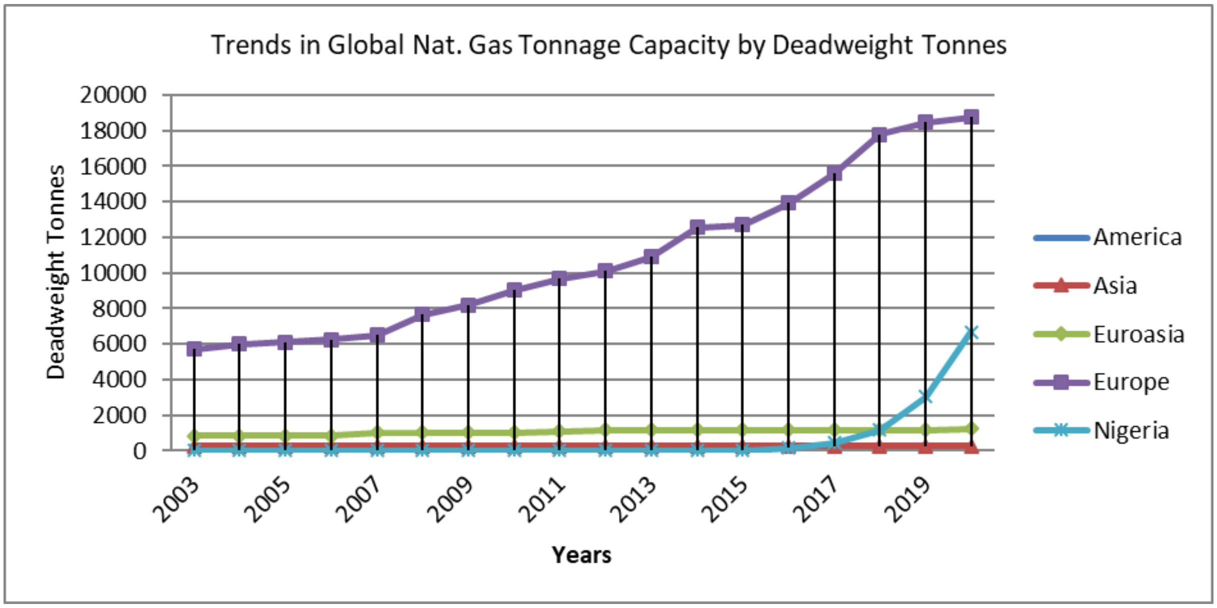

Figure 4.4: Trends in Deadweight tonnage of LNG Fleet; Nigeria vs. Trading Blocs

4.2 Discussion of Results/Test of Hypotheses

Table 4.4 depicts the results of gravity model of Nigeria's natural gas shipping trade. The model shows significant variables (factors) that affect Nigeria's natural gas shipping trade with other trading partners. The continental dummies represent major trading partners. Those with significant p-values may be interpreted to mean clusters of nations with most significant trade volume with Nigeria during the study period. By inspection, all the signs on the coefficients appear to conform to apriori expectations. The following variables (factors) are significant determinants of natural gas shipping trade between Nigeria and other trading partner nations;

these are namely: population mass, geographical distance, trade agreement (bilateral or multilateral), and transport infrastructure quality.

Table 4.4: Determinants of Liquefied Natural Gas Trade & Trading Partners

lnTot_trade	**Coef.**	**Std. Err.**	**t-stat**	**P>t**	**[95% Conf.**	**Interval]**
lnPop_Mass	0.955	0.428	2.23	**0.026**	0.115	1.796
lnGeo_dist	-232.721	81.614	-2.85	**0.005**	-393.023	-72.419
lngas_price	0.000	0.000	0.08	0.932	0.000	0.000
lntrade_agr	42.534	17.612	2.41	**0.016**	7.940	77.127
lnTransp_infr	-255.448	76.300	-3.35	**0.001**	-405.312	-105.584
Continental Dummies						
USA	3,360.056	278.887	12.05	**0.000**	2,812.280	3,907.833
Asia	21.704	216.849	0.10	0.920	-404.221	447.629
EuroAsia	3,090.082	213.347	14.48	**0.000**	2,671.036	3,509.128
Europe	904.810	172.406	5.25	**0.000**	566.179	1,243.442
S.Amer	786.413	357.271	2.20	**0.028**	84.680	1,488.146
_cons	1,514.848	376.008	4.03	0.000	776.312	2,253.383
Model Fitting Information						
No of obs. = 579.						
F(10, 568) = 63.460						
Prob. > F = 0.000						
R-Sqrd. = 0.593						
Adj R-Sqrd. = 0.583						

Source: author, data analysis. Dependent Variable: total trade vol. Sig. p -values in bold

The generalized log-linear model summarizing the determinants of Liquefied Natural Gas Trade & Trading Partners is given as follows:

$$\begin{gathered} lnTot\_trade = 1{,}514.848 + 0.955lnPop\_Mass - 232.721\, lnGeo\_dist + 0.000 \\ lngas\_price + 42.534\, lntrade\_agr - 255.448\, lnTransp\_infr \end{gathered}$$

The result from table 4.4 reveals that the model for our study is well fitted (F-statistic= 63.460). The Goodness of fit tests namely the R^2 has a value of approximately 60%. The F-statistic has a value of 63.460 with a significant p-value of 0.000. The fit statistics show that the model possesses sufficient explanatory powers and can therefore be adopted for testing the hypotheses governing the study. Using size of coefficients, we can rank the major determinants of natural gas shipping trade as: quality of transport infrastructure (-225.448), geographical distance (-232.721), trade agreement (42.534) and population mass (0.955). These coefficients are in their natural logs and can therefore be interpreted as elasticities.

The model has a relatively appreciable goodness of fit with the various determinants (population mass, geographical distance, price of natural gas, trade agreement and transport infrastructure quality) accounting for coefficient of multiple determination of 59.3%. This was moderated by the Adjusted R-squared to 58.3%, indicating that there are other variables other than our explanatory variables that might also impact on the dependent variable. It implies that there are other determinants of LNG shipping trade which the study was not able to capture. The model above shows that the LNG shipping trade has a positive impact on the population mass, price of gas and shipping trade agreement among trading partners.

Objective 1

The effect of population mass on Nigeria's LNG shipping trade is positive and it is statistically significant with a p-value of less than 0.05 (0.026). Hence we reject the null hypothesis implying that there is significant effect of population mass on Nigeria's LNG trade (volume) with trading partners. The higher the population mass, the greater it impacts positively on LNG shipping trade in Nigeria. Hence size of a country's population has direct relationship with goods and services produced and consumed and hence positively impacts on international trade; in this case natural gas trade.

Objective 2

The impact of geographical distance of Nigeria's LNG shipping trade is negative but statistically significant at $p = 0.05$ (with a p-value of 0.005). We reject the null hypothesis, thus geographical distance does significantly affect Nigeria's LNG shipping trade. The geographical distance variable has a negative sign which is consistent with the Gravity model theory. Thus, there is an inverse relationship between trade volume and geographical distance as it acts as impedance to trade flows.

Objective 3

The effect of price of natural gas on Nigeria's LNG shipping trade shows a positive trend. Though with a coefficient of 0.000 and not statistically significant at p-value = 0.05. We accept the null hypothesis that International price of natural gas does not significantly affect Nigeria's LNG shipping trade. Hence the price of gas has zero effect on the LNG shipping trade.

Objective 4

Here we examine the impact of trade agreement among trading nations on LNG shipping trade. From the gravity model, trade agreements also influence trade volumes positively as barriers are taken care of in trade contracts with a p-value of 0.016 which was statistically significant at 0.05 level of significance. We reject the null hypothesis implying trade agreement (bilateral/multilateral) does significantly affect Nigeria's LNG shipping trade.

Objective 5

Transport infrastructure quality which was proxied by logistics performance index, has a negative impact on Nigeria’s LNG shipping trade although its coefficient was statistically significant at 0.05 level of significance (with p-value of 0.001). We reject the null hypothesis, thus transport infrastructure quality affect Nigeria’s LNG trade with other nations. The negative sign may imply comparatively inadequate LNG handling infrastructure in Nigeria.

Objective 6

In terms of most significant trading blocs, the United States of America, Euroasia, Europe and South America are considered the most important trading routes for her natural gas trade. In terms of most important trading blocs or shipping routes, the most important are namely: The United States of America (3,360.056), EuroAsia (3,090.082), Europe (904.810) and South America (786.413). We reject the null hypothesis, hence there are significant LNG shipping routes showing intense transport demand.

4.3 Discussion of Findings

The findings from data obtained for this study, we find that there are prospects for growth in natural gas shipping trade which Nigeria is a participant to. This assertion can be ascertained from trend graphs of global natural gas trade volumes and LNG shipping fleet for the years 2003 to 2020. Again, a separate graph of Nigeria's natural gas production (figure 4.3) also shows a rising positive trend signifying positive future trade outlook. We also identified the most important trading/shipping routes for Nigeria's natural gas trade. These were found to be USA, Euroasia (made up of Russia, Turkey, and Ukraine), Europe (mainly Germany, United Kingdom, France Spain and Poland) and South America (largely Brazil). Accordingly, Strengthened trade relations must be fostered with these nations in order to increase our trade volumes with them. In terms of policy variables that influence shipping trade according to the Gravity model, we found the following as significant, namely: quality of transport infrastructure (-225.448), geographical distance (-232.721), trade agreement (42.534) and population mass (0.955). The distance variable serves as proxy of all other factors (though not included) that may serve as barriers to international trade. Transport infrastructure quality variable requires the federal government's intervention. This is because there is not enough facilities to handle LNG powered vessels in Nigeria. The demand for clean shipping has necessitated deployment of LNG powered vessels by some trading nations. Presently, we do not have platforms for providing bunkers for LNG carriers calling offshore. The trade agreement variable is indicative of our LNG contracts. This may require more robust fulfilment of all obligations to reduce all barriers and improve trade.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1. Summary

In this thesis, we developed a model for Nigeria natural gas trade with other nations as a framework for improvement of our shipping trade, revenue earnings and development of merchant marine. We explored the trends in global demand for natural gas trade, demand for shipping tonnage and associated determinants of natural gas trade. We found the significant factors affecting natural gas shipping trade and the most significant trading routes showing intense demand for sea transport. These were namely: quality of transport infrastructure (-225.448), geographical distance (-232.721), trade agreement (42.534) and population mass (0.955). All the variables are in there natural logs and therefore can be interpreted as elasticities. The most important and significant trading routes or blocs were found to be USA, Euroasia (made up of Russia, Turkey, and Ukraine), Europe (mainly Germany, United Kingdom, France Spain and Poland) and South America (largely Brazil). The trends in Natural gas production, global production were found positive and significant indicating bright future prospects. However, it was found that the LNG shipping tonnage capacity of Nigeria does not compare favorably with global trends. This outcome has policy implications for more investments in LNG fleet. Presently, Nigeria relies on charters to make up for shortfalls in shipping tonnage demands.

5.2. Conclusion

The results from our empirical analysis have broad policy implications for our LNG shipping sector. Nigeria is a maritime nation and produces natural gas for exports and domestic use. The nation has been earning substantial revenue through LNG exports and shipping. However, the gains so far can be maximized in terms of revenue, merchant marine development and job creation. Our national LNG fleet lags behind global outputs. This calls for policy interventions to promote more acquisitions to match the rising demand for LNG tonnage. To further promote trade with our trading partners, our transport infrastructure quality (especially that of bunkering facilities for LNG vessels) should be provided. Our trade contracts must be followed to every obligation in order to reduce impediments as this has been found to promote trade. Thus, the present work has provided a framework which policy administrators can apply to improve LNG shipping trade, revenue and our merchant marine. Adopting these will also have multiplier effects to the economy of Nigeria especially in terms of employment for seafarers and other shipping professionals.

5.3 Recommendations

1. Policies should be made or the already existing ones be reviewed to encourage indigenous ship owners to invest in LNG vessels. The CABOTAGE law already in place should serve in this case but pay more attention to natural gas vessels.

2. Nigerian government should look out for ways to further partner with foreign ship building companies to increase our indigenous shipping capacity. The partnership could be BOT, BOO or any other condition.

3. Manpower development for LNG vessels should be a priority for the Nigerian government, so that when our indigenous shipping capacity increases, enough manpower will be available to meet up the increased shipping capacity.

4. Nigerian banks in partnership with foreign bank should be encouraged with the right policy to finance the acquisition of LNG vessel. In the same way, during the disbursement of Cabotage Vessel Financing Fund (CVFF), priority should be given to acquisition of LNG vessels.

5. Our LNG infrastructures should be developed, just like the train 7 is currently under construction at Bonny Island in Rivers State, is a welcome development if we will increase our LNG shipping capacity.

6. Nigerian Maritime Administration and Safety Agency should give a soft Landing (in the form of registration, dues and charges) to investors who want to invest in Natural gas shipping.

7. We recommend for future studies the modelling of constraints to natural gas trade involving gasification and re-gasification stations as the scope of the present work did not cover them.

5.4 Contribution to Knowledge

The present work has applied a model that explains trade between and among nations to model Nigeria's natural gas trade. Much of empirical works concentrated on forecasts of natural gas trade based on time series data. In this research, we have introduced some economic and geographical variables to understand trade between Nigeria and her trading partners. We have identified quality of transport infrastructure and trade relationships/contracts as determinants of natural gas shipping trade. There is paucity in research on application of gravity model in modelling natural gas shipping trade especially in developing countries like Nigeria. In terms of methodology this research is a novel contribution to trade literature.

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