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Factors Determining LNG Throughput at the Port of Rotterdam

By

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Abstract

Global and regional LNG trade has evolved significantly over the last twenty years; owing its growth to the diversification of supply and the increased flexibility it provides in cargo movement, LNG seems destined for sustained growth over the next decade and so. This research aims at discovering the main factors that affect the throughput volumes at the Port of Rotterdam. Followed by a literature review on seaport throughput determinants and forecasting models, as well as an overview of the global and regional natural gas sectors, the paper deploys a multiple regression model in order to statistically indicate the variables that have the largest effect on throughput volumes at PoR. The level of economic prosperity and welfare indicated by GDP, as well as the rather low coal prices that function as substitute to natural gas, are proven to be the strongest determinants of LNG volumes handled at the Port. Moreover, a forecast is conducted in a monthly basis indicating the rather stable economic situation in Europe that has also laid its effect on LNG, since additional investments in regasification and liquefaction infrastructure in Europe, are not planned in the near future.

Contents

List of Tables

List of Figures

List of Abbreviations

NG: Natural Gas

LNG: Liquefied Natural Gas

Y-o-y: Year over year

OECD: Organization for Economic Co-operation and Development

TTF: Title Transfer Facility

IEA: International Energy Association

IMO: International Maritime Organization

GDP: Gross Domestic Product

NWE: North West Europe

PoR: Port of Rotterdam

PA: Port Authority

WTO: World Trade Organization

EU: European Union

GATE: Gas Access to Europe

MMT; Million Metric Tons

MTPA: Million Metric Tons per Annum

1 Introduction to Thesis

1.1 Introduction

Natural gas is one of the most rapidly-growing energy sources in the world. Over the last decade, the consumption of natural gas grew by an average of 5.4% per year; (Clarkson, 2013) supported by substantial reserves, competitive pricing and a cleaner environmental record comparing to alternative energy sources such as oil and coal, nowadays natural gas constitutes one quarter of the global primary energy consumption.

Coal, oil and natural gas make up the so called "Big Three" that generate the majority of the world's primary energy during the last two decades. Between the years 1990 and 2012, consumption of natural gas has grown at an average rate of 2.4% year-over-year (IEA, 2013), almost twice the growth of oil consumption in the same period. Several studies and forecasting agencies expect consumption of natural gas to continue to rise, with the Energy Information Association projecting growth in demand for the next three decades that accounts for 1.7% y-o-y (IEA, 2013), while demand for oil and coal are expected to grow less in the same period. Still, governmental initiatives to reduce global carbon emissions originating from carbon intensive coal is most likely to boost-up demand for natural gas, as the burning of the latter emits almost 45% less carbon dioxide less than coal and 30% less than oil (IEA, 2013). The applicability of natural gas ranges from heating, to power generation to industrial uses; therefore, due to the expected global economic growth, demand for natural gas is expected to rise in both OECD and non-OECD countries like China and India, unlocking unattainable resources and liberalizing the market, an effect that will stipulate both natural gas and LNG trades.

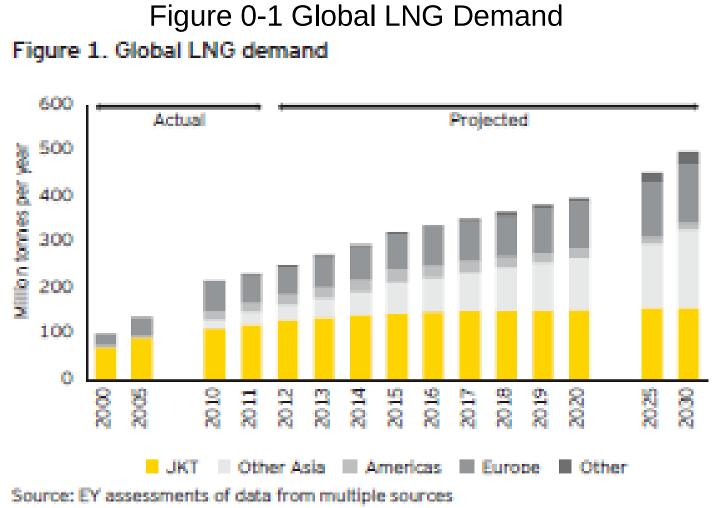
Undesirable climate change leading to human health issues has made societies much more conscious of their environmental footprint and have created a large sense of responsibility for its consequences. After the implementation basically of the Kyoto Protocol that entails mitigation of carbon emissions to heavy industrialized regions (e.g. G20 plus developing countries), major energy consuming countries have moved towards substitution of higher carbon fuels such as coal and oil, by lower carbon emitting ones such as natural gas.

In order to transport natural gas across water, a certain procedure must first take place; the gas must be filtered and then liquefied by being cooled down at -260^{o} Fahrenheit. This procedure allows for enhanced economical transportation, as the volume of the product shrinks about 600 times. Transportation is being conducted using special carriers called LNG carriers that keep LNG cool through the voyage, before the liquid gas reaches its destination and gets re-gasified at designated plants. (IEA, 2013)

Before the deployment of the LNG technology, the transportation of natural gas was only limited to movement via pipeline. The development of LNG changed the nature of the product evolving it into an internationally traded commodity. The introduction of LNG goes back to the 19th century when the first practical compressor and regasification machine was built in Germany. The first tanker shipment goes back to 1958 and took place from

LA to UK aboard the experimental vessel, Methane Pioneer (Clarkson, 2013). Today the industry has made big steps of growth, as worldwide there are 26 export or liquefaction terminals located in 17 different countries and 60 import or regasification terminals spread across 20 different countries. In addition to the existing capacity, there are over 50 marine terminal projects in 15 countries that are either under construction or waiting for approval to initiate constructions. (Clarkson, 2013) Despite the fact that costs related with the LNG supply chain have declined over the past few decades thanks to technological improvements, it can be still less expensive to move natural gas via pipeline than LNG carriers. The problem of moving “stranded” natural gas to distinct locations of demand, therefore lies within its capital intensive, expensive and technologically sophisticated supply chain. In detail, the supply chain is “built” from the following five procedures; the extraction of gas from the gas field, its transportation through pipeline to the liquefaction plant where it can be temporarily stored until it is being shipped, the regasification process and storage, and finally the distribution to the market. Natural gas liquefies at -162 ^{o} Celsius at atmospheric pressure, reducing its volume up to 600 times compared to its gaseous state. Hence, transportation and storage are performed by using cryogenic tanks before the liquid is being re-gasified and distributed to the market. (IEA, 2013) It is worth mentioning that by taking a look at the typical costs of the supply chain, the largest share consists of the development of the gas field and extraction procedures as well as the building of the liquefaction plant. On the other hand, shipping, re-gasification and marketing, all share an equal part of the remaining balance. Demand for LNG is expected to grow significantly through the following decade; industry analysts and observers forecast an annual growth of around 5% to 6%. (EY, 2013) After 2020, demand growth is expected to continue, but at a slower pace, as markets will mature and subsidies currently given to non-OECD markets will be removed. Nevertheless, demand for LNG globally may be double in 2030 compared to the present situation which accounts to 250 million metric tons. (EY, 2013)

Figure 0-1 Global LNG Demand



Source: (EY, 2013)

Global demand for natural gas is growing at fastest rates than supply rates. According to the IEA, consumption of global energy sources has doubled during the last forty years and it will keep growing in the future; projections show that energy consumption in 2030 will be 50% higher than 2006 (IEA, 2013). Main drivers of this growth include emerging economies such as India and China in addition the European Union and the United States.

In 2014, the expectancy for the industry is the continuous growth in demand for LNG from non-OECD Asia (China, India Indonesia, and Taiwan) which consists the “backbone” of global LNG trade. Japan has new gas-fired power generation due to start this year, a fact that will add significantly to demand. In Japan although, it has been asserted that some nuclear capacity will return after the Fukushima accident in 2011 (BGgroup, 2014). However, this will have minor impact on demand for LNG, as it is planned to replace coal and oil products. In China, increase in LNG imports is likely to take place due to the new terminal imports that will ensure long-term supply agreements. In Europe and Middle East, several countries such as Poland Lithuania, Egypt and Jordan are planning to commence imports this year. (BGgroup, 2014)

In the maritime industry, the International Maritime Organization (IMO) is pushing for the replacement of the existent fuel to LNG. The major concentration of operating vessels in the North Sea, Baltic Sea and English Channel has resulted in the reduction of sulfur content from 1% to 0, 1% by 2015 (IEA, 2013). Countries in the region such as Norway have implemented certain regulation that exempts carriers from high emission taxes. The cost of low-sulphur bunker oil is the same for LNG, therefore LNG can capture a significant part of global marine fuel demand.

1.2 Relevance of the Thesis

The main mode used for natural gas transportation still remains the pipeline; however, LNG volumes traded over the last two decades have increased at a rate of 40% (Clarkson, 2013) more than pipeline trade, and at the same time almost three times the rate of global natural gas consumption. Due to large distances between sources of supply and locations of demand, capital costs related to the construction of pipelines as well as geopolitical factors preventing their use between countries, lead to the conclusion that LNG carriers will remain the pre-dominant means of transportation for a large part of global natural gas demand. Global LNG trade has been driven by substantial increase in liquefaction and regasification capacities as well as persistent differential in pricing between different regions, therefore importing and exporting countries as well as the number of individual trade routes have increased significantly. Nevertheless, natural gas transportation by LNG carriers offers faster response to market developments such as new sources of demand and supply or substantial changes in the price of LNG in certain regions, characteristics that pipelines lack of.

Pipelines consist an effective way to transport natural gas on land. However, pipeline gas supplies have flaws; they are very capital intensive, they have depth and length restrictions and they customers are bound to the existing network, since pipelines have a permanent fixture leading from the gas field to a particular consuming area. Nevertheless, a significant part of future trade growth is expected to take place in the water. In fact, since 2010, LNG trade has experienced a growth at an annual rate of 7.5%, while pipeline has grown at a rate of 4% and domestic natural gas production at 1.8%. (IEA, 2013) Planned or proposed gas pipelines can deteriorate current or potential demand markets in Europe and Asia. Projects such regarding gas pipelines from Russia, the Caspian and Central Asia into Europe such as the Nabucco, the South Stream pipelines into central and southern Europe as well as the TAPI and the Russian Altai pipeline into China clearly create questions and doubts about the future of LNG trade. However, not all of these projects will become online in the end.

Forecasting natural gas consumption is essential for the formulation of a country's energy policy; it is also one of the most important policy tools deployed from decision makers in all major consuming regions. (Gang Xu, 2010) Long term forecasting of cargo flows is also of significant importance for ports in terms of strategic planning and investment decisions. Therefore, valid estimations may prove their usefulness in all these organizations. (De-Langen, 2012) argues that despite the fact that throughput predictions are essential for governments, port authorities, terminal operators and all the rest port users, academic research is quite poor. Regarding the case of Rotterdam, forecasting models will play a key role in the future business plans and strategies of the PA. Especially after the corporatization of the port, the PA bases its investment decisions on carefully selected business cases; a recent example is the development of Maasvlakte 2. Therefore, we can safely assume that valid future estimations play a key role on the ability of potential investments to proceed. PA's by acquiring a reliable insight of the future are able to respond effectively to market fluctuations and challenges, while at the same time gain a competitive advantage over ports in the same region.

As mentioned before, demand for natural gas will increase firmly in the coming decade especially in regions where sources of supply are smaller or are being exhausted in a higher rate. In Europe, the depletion of natural gas in the North Sea is a stimulant, therefore LNG imports into northern Europe are expected to increase. On the other hand, there is a number of projects designated to increase natural gas pipeline capacity into Europe such as the Nord Stream, a trans-Baltic pipeline that carries natural gas from Russia to Germany being operational since 2012 and the Trans Adriatic Pipeline which will be operational after 2018, bringing central Asian natural gas to Western Europe via Turkey and the Balkans (avoiding Russia), for export to Italy. Nevertheless, if all potential projects were operational, there would still be demand left unsatisfied. North Sea countries such as the Netherlands and the United Kingdom, have already initiated procedures to replace their elderly owned "fleet" of coal-fired power stations, as carbon reduction solutions must be found; hence the growth in LNG imports can only continue.

The Netherlands has established a strong gas industry during the last 50 years, possessing considerable expertise in all areas of the gas supply chain, thus nowadays comprising a global center for R&D and use. Since the Groningen field was discovered in 1959, the Netherlands has become a strong player in the market for natural gas by using its dense network of pipeline infrastructure to supply gas to a large part of Northwest

Europe. However, as the demand for gas in the region is rising, production is declining; the security of gas supply therefore remains of great importance for EU members. Hence, in addition to the need of using existing gas reserves in an efficient manner, imports coming from nearby regions such Russia and Norway as well as traditionally large supplying ones like Middle East and Africa, are becoming vital. In 2012, the country imported 1.25 million m^3 of LNG volumes via the Netherland's first import terminal for LNG in the Port of Rotterdam (Clarkson, 2013); the GATE terminal (Gas Access to Europe) is a joint venture between Gasunie and Royal Vopak which commenced its operations in 2011. The terminal is meant to connect the Northwest European market to the global market of LNG, stimulating competition and security of supply by being able to handle up to 12 billion m^3 (with possibility of further expansion to 16 billion m^3) (Gate Terminal, 2014) and accommodate the world's largest LNG vessels, the Q-maxes.

1.3 Purpose of the Research

The purpose of this paper is to identify and analyze all the factors that affect the throughput of LNG in the Port of Rotterdam. In addition, the study develops a formula by which LNG throughput can be forecasted for a single year period. In other words, the research will be able to examine the independent variables that can effectively predict the throughput of LNG. All in all, the relationship between the dependent variable (LNG throughput) and the independent variables is being analyzed by using a multiple regression model, with the outcome pointing out the factors that are highly correlated with the throughput of the Dutch port. Finally, after the equation is being formulated, current values of all predictors are placed at the forecasting formula, with the final result representing the LNG throughput for the port of Rotterdam until the end of the current year (2014). Regarding the main hypothesis of the thesis, the area of investigation will be the volume of LNG imports coming into Europe via the port of Rotterdam, given the projected increase of demand in the whole European region. The main research question that will be answered is: *"How will the expected growth in demand for natural gas in Northwest Europe, affect the throughput of LNG in the Port of Rotterdam?"*

In addition to the main research question, there are other issues that must be given an answer, aiming to provide a deeper understanding to what the paper wishes to achieve. Although they derive from the research hypothesis and their answer may seem obvious, the following sub-questions provide an overview of the research's objectives:

Which are the economic factors related to the natural gas and LNG market?

Which are the trends affecting both markets?

Which are the variables going to be used, with the highest predicting value?

2 Literature Review on the Role of Seaports & Port Throughput

The following literature review, aims at describing the role and development of ports, as well as its functions through different segments. Moreover, a review on forecasting models is been conducted aiming to identify a potential list of general forecasting variables that can be used specifically to the Rotterdam case.

For a large time-period of research, the role of ports has been asserted according to the utility of a port per se, rather than within the context of Port Authorities or port governance framework of whatever form. (Robinson, 2010) describes ports purely as morphological places equipped to facilitate the necessary relation between ships and land. The recognition that ports should be considered as shipping nodes brought up the utility of ports as operating systems; a place that handles cargo coming from ships with operational efficiency. Moreover, the underlying importance of an economic perspective led to the realization of ports as administrative units with a clear function and structure of either public sector agencies or corporations. Corporatization despite its effects on governance structure, reflects the nature of a legal framework under which the former was achieved; that is an environment of effective legislation. Therefore the role of the sea-port can be said to describe not only the geographical location in which ships and cargo are being handled within an efficient administrative policy environment, but also the added value that they provide to shippers and third party service providers.

During the last two decades a significant number of Port Authorities have amended their governance structure and therefore their strategy, evolving from public administrative organizations entrenched under national guidance, into self-governing and commercially operating entities. Goss (1990) discusses a number of different strategies that can be implemented by Port Authorities, given the several forms of competition that sea-ports may attract. He describes the “public sector strategy” as a governance model that includes Port Authorities taking over all port related functions. On the other hand, the “competitive strategy” is based on a careful reproduction of competition circumstances in which efficiency is being taken seriously into account in operations such as cargo handling, franchising, short-term leasing etc. The paper therefore, provides us with the insight stating that according to the circumstances by which each port operates, there is a suitable governance model that should be implemented. Regarding the Port of Rotterdam, due to the competitive environment in which it operates, the selection of the appropriate model is of vital importance not only for the attractiveness of clients and cargo but for the existence and usefulness of the port as a shipping node.

Ports have always considered to serve as natural sites for transshipment with a purpose to transfer goods from one mode of transport to another; they provide the link between maritime and inland transport. Nowadays, ports play an integer role in the management and coordination of material and information flows and consist an important part of the entire supply chain. Therefore, aligning the scope and objectives between players within the port community will guarantee reliability and good productivity levels. According to Heaver (2006), development of global trade, together with containerization, increased vessel size and restructuring in the industry (e.g. mergers and alliances) have stipulated the popularity of hub-and-spoke systems. Hence, transshipment traffic becomes increasingly significant in the determination of port competitiveness. For port authorities, these developments mean that competition has intensified and ports need to strengthen their attractiveness in order to survive.

De Langen (2004, 2008) developed the concept of port clusters; he used the concept of clustering to provide a different approach on the role of port authorities, as cluster managers. De Langen and Haezendonck (2001), define port clusters as separate but inter-connected organizational networks that consist of entities that operate in different sectors and are situated at the vital part between the sea-leg of industrial and commercial activities. Port authorities are presented as self-sustained, regional operating but not profit maximizing organizations that are well established and are able to make investments with overall benefits. In this aspect, we can infer that the role of the port authority is beneficial for the port as a whole as well as for the regional economy, since investments that take place in ports may also have an effect in the whole economic performance of the country. Hence, ports may also likely consist of sources that stimulate a country's financial and social welfare.

Moreover according to De Langen (2008) maximizing throughput volumes is also a strategic goal and is used as a primary performance indicator for ports. Kenyon (1970) identifies reasons regarding inter-port competition in the US to be related with containerization of ocean cargo freight, various categories of hinterlands, infrastructure expansion methods (e.g. railroad mergers), and differential in efforts to facilitate business by ports. He suggests that overall competitiveness between ports i.e. port competition, must be determined in individual cargo categories such as containers, liquid bulk, dry bulk etc. A common strategic goal of port authorities is considered to be port competitiveness. Port authorities also facilitate trade and create employment contributing to regional and national economic growth. Moreover, the dominant variable that can affect port performance and port competitiveness is considered to be the cargo throughput flow according to De Langen (2008).

Developments in information and communication technology, rapid changes in the market, as well as economic and political integration, constitute fundamental changes in the environment of ports. Ports have seized to operate as independent transport nodes and are now part of intermodal networks. With competition taking place not by ports individually, but between complete supply chains, ports must take more under consideration the quality of their hinterland services. Notteboom and Rodrigue (2005) present a significant role of the port authority in the hinterland referring the context of port regionalization. Hinterland accessibility has become a powerful driver of port competitiveness. They discover two important determinants for the competitiveness of a port; that is port performance (competition on service provided to carriers) and the ability of a port to serve hinterland markets in an efficient way. They furthermore assert that as terminal handling is being "commoditized" and is now available in every port, more pressure is being placed on ports to serve the hinterland. Therefore, by improving the quality of hinterland transport service, port authorities stipulate the international competitiveness of the port. Hinterland distribution is becoming more important as it also creates relationships between market players and shipping nodes and also consists of a stimulant for physical investments. The excellent hinterland network that the Port of

Rotterdam acquires has therefore led to the construction of additional terminals such as the LNG import terminal in Maasvlakte 2.

According to Kreukels and Wever (1998), direct and indirect networking with nodes and market players is probably the most important role of ports in the regionalization phase, since gaining competitive advantage is becoming more and more a matter of expanding beyond the port boundaries. Finally, it is asserted that port authorities can play a determinant role in the deployment of core competencies such as economies of scope, by contributing in the development of inland freight distribution and intermodality. In the same line of approach, Chlomoudis and Pallis (2004) develop the concept of the smart port authority, focusing on the aspect of enhanced coordination from the side of port authorities towards all relevant stakeholders within the port cluster. According to Bichou and Gray (2004), globalization and pressures deriving from the environmental side have brought several changes in the operational and commercial environment of port authorities; nevertheless, increased attention paid on the importance of network integration by ports and port actors on the accountability of the port authority have resulted in a change of perspective about their role. Notteboom and Winkelmans (2001), discover that developments in logistics have altered the strategic scope of Port Authorities, leading beyond of that of a traditional facilitator. In their work they emphasize on port networking (i.e. the establishment of partnerships with overseas, inland or neighboring ports) as an enhanced role for port authorities. The impact of foreign direct investments made by multinational companies, is substantial for the competitive position of ports and several stakeholders involved; competition between terminal operators, shipping lines, energy companies etc. situated in the proximity of the port is rising. Dooms et al (2013) refer on the significance of international strategies from the side of port authorities; they built a case specifically for the port of Rotterdam and its recent development in terms of establishing its position outside the country's borders. Hence, the international strategy of the port is being analyzed beyond the traditional scope, mostly paying attention to commercial representations abroad and participation to trade missions. The paper emphasizes on the changing environment that ports operate and the impact that they create on international trade, transport and shipping. European ports therefore must be ready to adopt the changes in the market environment and play the role of a successful actor in the supply chain.

The economic development during previous decades has affected positively the growth of world trade; consequently, an increase occurred in seaborne trade as well. The potential growth of future maritime trade in the EU, as well as the impact upon the major European ports is being investigated by Grossman et al (2007). However, the economic crisis implications upon seaports were examined by Pallis and De Langen (2010) resulting that the decline in throughput which ports faced at that period was mostly related to industrial activity, not GDP development.

2.1 Forecasting Studies

Projections regarding volume throughput that are made in a long-term horizon are considered to play a significant role in a port's development plans. Nevertheless, these estimates are also of vital importance for port authorities, terminal operators, and generally port users but also for governments and international organizations as well. However, there is not a big variety for this kind of scientifi research; the existing ones are based mostly on econometric models that deploy the dependent variable (in this case cargo throughput) as a constant relation to the independent variables like social welfare and the growth of international trade.

De Langen et al (2012), conducted a research that was part of the port of Rotterdam project called Port Vision 2030; they examine the competitive environment in which the port of Rotterdam operates, presenting port competition in the Hamburg-Le Havre range being affected by port major characteristics and hinterland connectivity. The research provides a forecasting model for the major sea-ports of the area adding validation of commodity specific trends to the previous literature. Commodities handled in ports mainly consist of raw materials; import flows that are mainly connected with industrial production. It is also stated that an important factor that determines demand uncertainty in throughput, is economic development. Results show that in all scenarios deployed, total throughput is expected to rise (including LNG volumes), however at lower rate than the previous two decades. Furthermore, De Jong et al (2004) present a number of forecasting, simulation policy and project evaluation models. More specifically he refers to freight transport models that are suitable for national and international transportation, rather than regional levels.

Meersman et al (2014) in their forecasting research on container throughput within the Hamburg-Le Havre range, they state that the main determinant of port throughput is the volume of maritime traffic. More specifically, this traffic is mostly driven by levels of economic activity and trade. Therefore, the core of throughput forecasting usually is determined by evaluating the relationship between port throughput and economic activity and trade. The most frequently used indicators are GDP and international trade flows (imports-exports).

Peng and Chu (2009) present a model combination for forecasting container throughput on Taiwan's three largest sea-ports. He specifically refers to the way trigonometric models are used in order to exhibit seasonal variations. In the case of regression modelling, the author refers to the use of seasonal dummy variables that are used according to the time-horizon chosen for the research.

Veenstra and Haralambides (2001) contribute to the literature on forecasting seaborne trade flows by using a Vector time-series model with multiple variation in order to produce long-term forecasts for bulk commodities. The specific method uses trade flow matrices illustrating the major routes and has the ability to provide estimates with small degree of errors. Results show that co-integration exists between commodities as, indications lean towards a homogenous market, since prices in different routes are moving closer.

Moreover, Glen (2006) performs an analysis of quantitative techniques for forecasting models in the attempt to examine the bulk shipping market; his focus is mainly caught by freight variability, the use of different ship types and the introduction of financial derivatives into modelling. In another research De Langen (2003) examines the variables of demand for container transport. He examines variables related to trade volume and transport flows such as the GDP, value density of trade and export quotes for economies.

Seabrooke et al (2003) conducted a research trying to estimate the general cargo throughput of the port of Hong-Kong for a period of ten years. Several macroeconomic factors such as regional competition, macroeconomic conditions in the country, market power by firms operating within the port and the economic restructuring of China as well as its entrance in the WTO, are main determinants of cargo throughput volumes in the port. Specifically, independent variables used include trade value of imports and exports, GDP and population rates.

The following table illustrates the important findings retrieved by the literature review, regarding the variables that are going to be deployed on the formulation of the Rotterdam throughput case model:

Table 2-1 Findings of Literature Review

Authors	Dependent Variable	Independent Variables	Sample	Methodology
De Langen (2003)	Demand for Maritime Transport of Containers	GDP, value density of trade, export quotes etc.	-	Various methods
Pallis & De Langen (2012)	Cargo Throughput for Hamburg – Le Havre range	Raw Materials, Liquid Bulk, Dry Bulk, GDP growth,	Hamburg-Le Havre Range 2008 base wear forecast	Qualitative Analysis (TRANS TOOLS, Expert judgments
Meersman et al (2014)	Container Throughput	GDP, International Trade Flows (imports-exports)	Hamburg-Le Havre Range	Econometric Models
Peng & Chu (2009)	Container Throughput	Use of Dummy Variables for Seasonal Variation	Three Largest Ports In Taiwan	Trigonometric Regression Model
Veenstra & Haralambides (2001)	Bulk Commodity Trade flows	Crude oil, iron ore, grain and coal	Fearnley's Publication: World Trade Routes 1962-1995	Multivariate Auto regression Time-series
Seabrooke et al (2003)	Cargo Throughput in Hong-Kong	Several macroeconomic variables– GDP, Population, Trade flows	Annual Data 1983-2001 Hong Kong	Regression Analysis

Glen (2006)	Overview of Bulk Shipping Market	Freight variability	Existing Relative Literature 1991-2006	Introduction of financial derivatives

3 Natural Gas and LNG

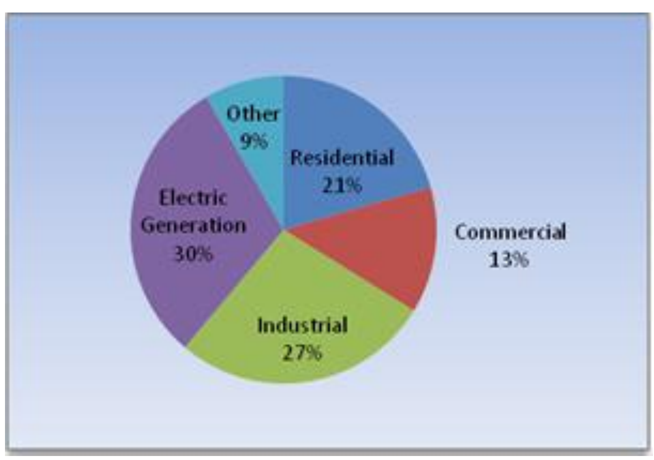
The aforementioned research questions consist basic steps of our analysis; the paper aims at presenting a holistic picture of the natural gas and LNG industry accompanied by an annual forecast of throughput in the port of Rotterdam. Hence, in order to be able to answer the main research question the appropriate literature review must be performed.

3.1 An Overview of the Global Natural Gas Sector

Natural gas as an energy source can be mainly used for domestic reasons such as electric power generation, heating and cooking. It can also be used as a petrochemical feedstock as it is a valuable compound in the manufacturing process of plastic and other important organic chemicals. Nevertheless, during the last decade it is also considered being the cleanest fuel for transportation modes such as vehicles and ships. In order to be able to use unconventional gas for the aforementioned reasons, a certain processing is required; that is purification i.e. the removal of materials that detain the use of gas an industrial fuel, followed by the separation from valuable chemical ingredients that can be used individually as stand-alone fuel or industrial gases (e.g. propane, helium and ethane) and finally liquefaction, a procedure that increases the density of the gas and enhances its storage and transportation.

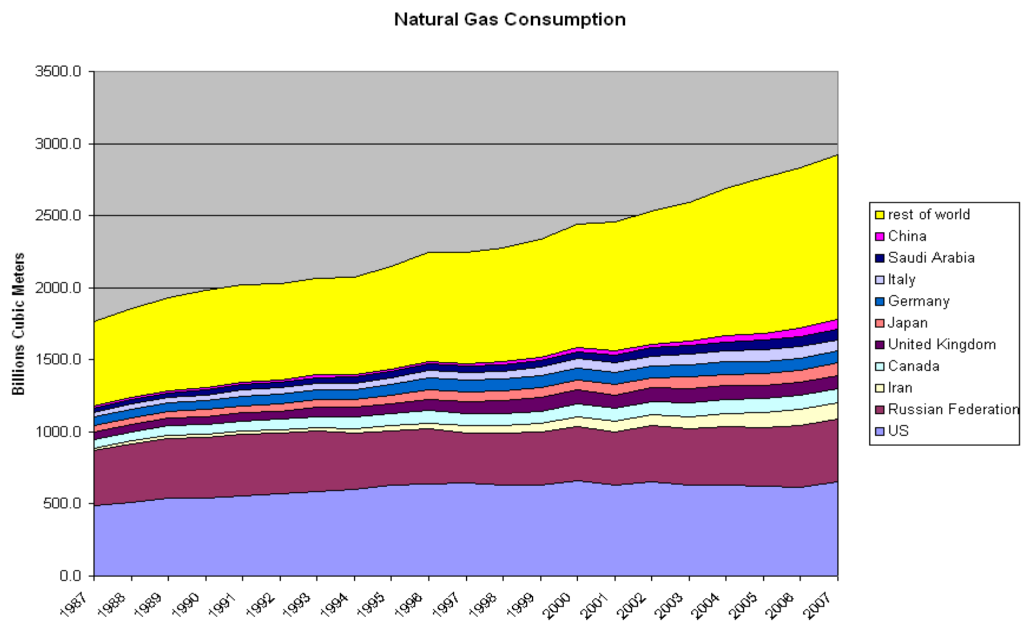
According to the International Energy Association, the global natural gas demand is expected to grow by 64% over the next 30 years; that is, from 113 trillion cubic feet in 2010 to 185 trillion cubic feet in 2040. (IEA, 2013) This fact is partly driven due to increasing consumption in non-OECD countries in the sector of industrial procedures, generation of electricity and transportation, thanks to its lower carbon intensity compared to coal and oil. (Trefis Team, 2013)

Figure 3-1 Natural Gas Consumption Utility



Source (IEA, 2013)

Figure 3-2 Natural Gas Consumption per Region

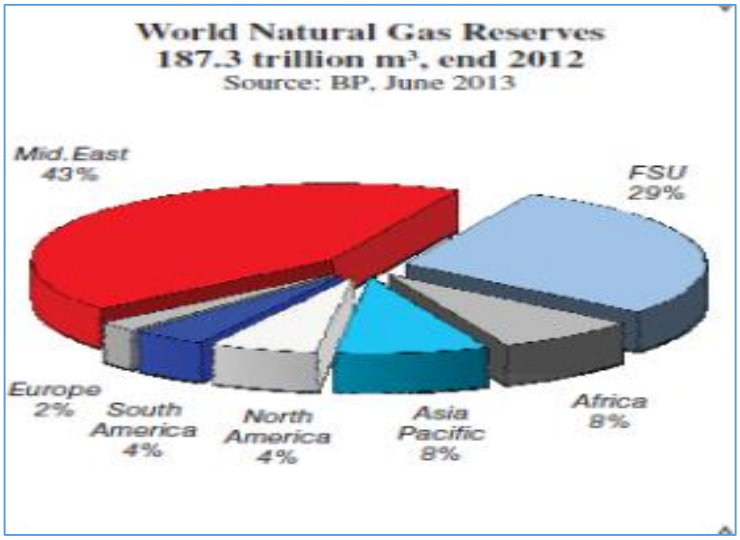


Source (IEA, 2013)

The major exporting LNG countries include Qatar, Algeria, Indonesia, Malaysia Nigeria and Oman whereas the most significant importing countries are Japan, South Korea, the US and some European Countries. LNG trade volumes have followed a growth path during the last decade; from 140 MT in 2005, 200 MT in 2010 and 300 MT in 2012. (IEA, 2013)

Conventional natural gas can be generally found in deep reservoirs associated with crude oil, or in the form of a hydrocarbon mixture consisted mainly from methane, a various amounts of alkanes and a small percentage of carbon dioxide, nitrogen, and hydrogen sulfide, commonly known as dry gas. Natural gas reserves are unevenly spread around the world; the Middle East is the leader owning 43%, followed by regions of the Former Soviet Union (FSU) which accounts to 29%, (Clarkson, 2013) while Africa, the Asian Pacific and Europe have the lowest share.

Figure 3-3 Global NG Reserves



Source: (Clarkson, 2013)

Global demand for natural gas is expected to increase significantly since more countries are gradually adopting cleaner fuels in order to meet future economic growth and minimize the impact of oil-based energy costs. This growth is partly driven due to the growing use of natural gas in electricity generation, industrial operations, and transportation. The underlying reason is that natural gas has much lower carbon intensity in comparison to coal, a fact which is favored by governments planning to reduce their greenhouse gas emissions. Natural gas emits 43% less carbon emissions than coal and 30% than oil. Many of the most rapidly growing gas markets are situated in Asia and particularly in China and India, the Middle East and South America, economies which struggle to maintain living standards by initially improving air quality. (Kamalakannan, Madhavan, 2012) For countries that lack of indigenous resources and delivery infrastructure, LNG is considered to be a fast and cost effective way to introduce natural gas into their energy mix. Currently, there are 25 LNG importing countries. With volumes having doubled between the period of 2006-2010, LNG has become an increasingly important means for transporting natural gas across countries. (Kamalakannan, Madhavan, 2012)

The share of LNG compared to total natural gas trade has grown significantly from 28% in 2008 to 32% in 2012; (Clarkson, 2013) according to research, his fact is attributed to the growing reliance of Asian-Pacific countries that currently capture 80% of global LNG trade (IEA, 2013). Wood (2012) refers to the significant part of demand for LNG in the Asia-Pacific region that is mainly caught by heavy industrialized countries like Japan and South Korea. Despite the fact that these two countries capture only 5% of global natural gas consumption, their import rates of LNG account for 50% of total volumes traded. Nevertheless, the largest part of the LNG growth is expected to come from China; the reason lays to the nation's environmental policy that leads the way to cleaner economic growth by switching energy consumption to natural gas and reducing greenhouse emissions. China aims to replace large amounts of coal and oil used for generation of electric power with natural gas. However, the country's efforts to boost domestic supply through shale gas drilling are not enough to meet future demand, therefore China is getting increasingly reliant on LNG imported volumes. The need of state oil companies to meet their energy needs has led them to initiate procedures in order to double their total LNG receiving capacity by 2015. Regarding Japan, an important reason is includes the negligible amount of domestic supply in these regions. Another reason is attributed due to the Fukushima nuclear accident in 2011, which has led to the shut-down of the main power generation i.e. nuclear power. Japanese LNG imports have risen since 2010 at a rate of 25% y-o-y and are expected to remain on the high side for the short and medium term (Wood, 2012). As for South Korea, LNG imports are also expected to rise, since the country has a large demand of natural gas due to its industrial sector. Countries like Singapore, Indonesia and Taiwan, also face implications on local production, therefore they are expected to contribute to the regional demand growth. Therefore we can infer that domestic production, governmental and environmental policies play an important role in the demand for LNG.

3.2 Factors Determining Maritime Transportation of Natural Gas

3.2.1 Market Powers

Supply and demand of natural gas constitute the main economic drivers that affect its transportation. Additionally, various exogenous factors such as the economic growth of countries, the economic welfare of the population, prices of competitive energy sources and sustainability advantages can totally affect its transportation. In this section, an analysis of the role of each driver is being conducted in the base of previous research.

According to Xun (2014), LNG trade is driven by LNG supply and demand; LNG demand is driven mainly by natural gas production and consumption, the regasification capacity of importers, the price of LNG compared to alternative fuels such as oil and coal, and energy policies such as carbon emissions. Supply on the other hand is driven by exporters' liquefaction capacity, natural gas production, and domestic consumption. Egging et al (2010) present a multi-period mixed complementarity model for the global natural gas market. The model is a mathematical formulation and it is calibrated to match production and consumption projections made in the past, based on behavioral assumptions of representative players that are active in the natural gas markets; market players include natural gas producers, trading companies, pipeline and storage operators, LNG liquefiers and re-gasifiers. (Egging et al 2010) The paper presents several development scenarios until 2030 exhibiting an increase in natural gas trade in the coming decades, a trend that will not be sustained at the same growth rates after 2020. The largest increase in consumption and imports and therefore at infrastructure capacity will take place in the Asian-Pacific basin. Egging et al (2008) also present a complementarity model for the European natural gas market. The paper presents a detailed model which accounts for the issues of market power of exporters and of globalizing natural gas markets with LNG trade. The players used include producers, traders and LNG liquefiers and on the consumption side LNG re-gasifiers, storage and pipeline operators, marketers and finally consumers for the industrial, residential/commercial and electric power sectors. Furthermore, the European gas supply model (GASMOD) presented by Holz et al (2008) illustrate a mathematical formulation for natural gas supply in Europe and explicitly focuses on infrastructure capacities. The results suggest that binding infrastructure capacity mainly influences intra-European trade.

Moreover, Jensen (2004) in his report refers to the forces that renew and stipulate the interest in LNG to be the combined power generation for electric power markets, technologic developments that have opened the way towards significant cost reduction, environmental concerns that have led traditional “gas poor” economies to embrace natural gas in their energy mix and the “stranded gas” phenomenon that describes the natural gas reserves uneven situation.

3.2.2 Natural Gas Consumption

Soldo (2012) in his work provides an analysis of published research on forecasting consumption for natural gas. The paper includes insights on applied area, used data, models and tools deployed in order to achieve useful results. The forecast of gas consumption has been investigated in different areas and on different forecasting horizons, using several different approaches; also because of the complexity the data applied as input is also divert. The most significant data input regardless the model and the time horizon used includes GDP, HDD (heating degree days), annual house income, natural gas price, oil price. Xu and Wang (2010) perform a forecast on the consumption of natural gas for China based on a combination model, whereas Li et al (2011) perform the same research using as data input natural gas production, natural gas prices and GDP. The relationship between natural gas consumption and the environment is also a vital topic.

Although natural gas is a fossil fuel, it is the less carbon intensive one compared to others (e.g. oil, coal). Therefore, despite the climate change measures that do not support the use of fossil fuels in general, natural gas’s position is being favored relatively to the rest. The main determinant of the demand growth for natural gas that is expected to take place in the coming decade, is the expected increased use of natural gas in the power sector; previous research has indicated that thermal power plants are in the process of switching their primary energy source (coal) to natural gas. The underlying reason is the strong carbon restriction (e.g. reflected through high CO_2 prices in the European Emission Trading Scheme) that leads the way towards gas fired plants. Therefore, we can infer that to some extend climate change policy can influence positively the demand for natural gas. Holtedahl and Joutz (2004) perform a research on the residential demand for electricity in Taiwan. The paper examines the demand for electricity as a function of household income, population growth, the price of electricity and the degree of urbanization. Similarly, Hondroyiannis (2004) performs the same research on the Greek region. The author focuses on price and income sensitivity as well as weather conditions (weighted average temperature) and size of population, employing a multivariate framework analysis. However, we must mention that despite that the power sector is a key determinant on behind demand growth, it also adds uncertainty to forecasting since it is highly sensitive to variations in prices.

Natural gas reserves are quickly declining in several parts of the world like Europe. On the other hand, demand for gas is increasing in today's major consuming regions. The emergence of new demand centers for natural gas and the globalization of the market caused by the rising importance of LNG trade have changed the supply patterns and structures. In Europe, thanks to the obligation to mitigate greenhouse gas effects and emissions under the framework of the Kyoto Protocol, the upward trend towards natural gas demand and consumption is expected to continue in the future. The increased consumption is also due to low indigenous resources, therefore the dependency of Europe to imports from abroad will also rise. (Lochner & Bothe, 2009) apply a global gas market model (MAGELAN) in order to produce a forecast for global gas supply to 2030, and analyze the particular long-term average costs of natural gas suppliers in three major consuming regions; US, EU and Japan. Major input for the model consist of assumptions for demand according to the IEA and transport capacities which include liquefaction, regasification and shipping capacities for transporting LNG. Concerning to future production, existing capacity as well as expected discoveries are also taken under consideration. Remme et al (2008) apply a TIMES model to discuss possible supply options as well as transport infrastructure to and within Europe taking into account the relative costs. Gas flows and infrastructure developments up to 2030 are being analyzed. Input consists of imports, exports, pipeline and LNG facilities capacity.

According to Krichene (2002), production and consumption of natural gas were relatively closely aligned, diminishing the need for long distance trading. However this situation faded quickly since natural gas has been "commoditized" and traded all over the globe. The global trade of LNG has as a main purpose to bring natural gas situated far from the focal market ("stranded" gas), to the people, factories and power plants that require the specific source of energy. The necessity of natural gas transportation in the form of LNG is significant, since the distribution of the world's supply is not consistent with patterns of demand; Russia, Iran and Qatar hold almost 60% of the global natural gas reserves, although they consume barely 20% of total volumes. (Clarkson, 2013) As Kumar et al (2011) indicate on their global perspective research on demand and supply of LNG, several undeveloped gas reserves are situated in large proximity from the OECD markets; therefore we can infer that LNG will play a significant role to bring gas to markets, when distance and natural obstacles make pipeline transportation infeasible. Moreover, Wood (2012) refers to LNG as a fungible commodity that can be reliably delivered to meet the global growth in demand for natural gas. Concerns regarding security of energy supplies and requirements for lower emissions have driven many countries to develop LNG supply chains. Therefore, can infer that the increasing volumes in supply of LNG, combined to the increased flexibility in LNG trade are contributing to the security of gas supply and to the diversification of energy sources especially to countries that are dependent on coal or oil; like all natural gases, LNG is "cleaner" than both.

3.2.3 Pricing Mechanisms

Prices and pricing mechanisms for natural gas are different around the world; currently there is no integrated market for natural gas although changes in the markets suggest the shift towards competition between regions. Nowadays, there are three general categories for pricing natural gas; pricing linked to oil, pricing regulated by governments and pricing determined by the market. (EIA, 2013) Oil linked pricing, reflects the gas being traded under long-term contracts with prices being linked by a formula to either crude oil or oil products, usually to some discount of the natural gas comparing to oil. Regulated pricing reflects prices being set by the government, whereas competitive market pricing means prices are determined by the competition between suppliers and consumers within established trading points or hubs. (IEA, 2013) Before deregulation took place in Europe in 2000, natural gas historically was traded under long-term contracts with prices linked to oil, only with a slight discount. Since deregulation began, several trading points have emerged; however hub pricing in Europe has not yet become fully implemented. Pricing in Europe currently consists of a mix spot-market prices linked to hubs, long-term contracts also linked to a trading-point and finally long-term agreements linked to oil prices (mostly pipeline gas). Nevertheless, regulated natural gas prices and prices linked to oil are giving the way to competitive gas pricing within the framework of deregulation in the natural gas industry. As globalization of the natural gas market tends to spread out and supply gets more diversified, a direct relation can be implied between the liberalization of gas markets and the detachment from oil indexation pricing.

Schlesinger (2010) asserts that prices often tend to act as a mechanism that balances supply and demand; they are mainly a function of market supply and demand. Due to the fact that there is a limited number of alternatives for fuel or heating in the short-run during peak periods, changes in demand or supply can result in great price volatility. Increases in supply push prices down, whereas decreases push prices up. Factors on the supply-side that impact prices include variations in the volumes of natural gas production, the volume of gas exported and imported (net imports) and the amount held in storage facilities. On the other hand, factors on the demand-side that influence prices are considered to be economic conditions (level of economic growth), seasonal weather and oil prices (depending on global region).

3.2.4 Economic Conditions

Gylfason and Zoega (2002), discover an inverse relationship between economic growth of a country and the dependence in its natural resources. Therefore, the highest are the levels of welfare for a country, the highest is the demand for alternative sources of energy. Moreover, they discover a direct positive relationship between energy consumption and employment; they focus on the correlation between per capita consumption of energy and the percentage of the population with jobs caused by the involvement of using machines that require fuel. Global gas demand is extremely linked to global economic growth; persistent downturns in the market can slow demand and reduce the usage of natural gas supply chain capacities. According to Annual energy outlook (2013), natural gas demand depends on a high extend to macroeconomic growth rates and expected rates of resource recovery from natural gas wells. Therefore, higher economic growth may lead to high consumption of natural gas. On the downside, an increase in levels of consumption may lead to both an increase in depletion of resources and cost of new production leading to prices moving upwards i.e. lower demand.

In the process of oil production, natural gas is being flared adding unwanted carbon dioxide to the atmosphere; conversion of natural gas to LNG, exempts oil producers from the aforementioned procedure; on the contrary they make a valuable use of product that otherwise would have been lost. LNG therefore, gives the opportunity to such producers to “monetize” their surplus by converting it into a salable product. Hence, the nature of the product provides both environmental and economic benefits having a positive impact on its demand. The desire of gas producers to monetize their remote gas reserves continues to diversify the sources of conventional and relative new gas supplies. So called “unconventional” supplies (including shale gas) could transform global energy markets. According to Silverstovs (2005), lower cost unconventional gas may impact on future demand, as it may capture part of the demand that would otherwise would have gone to LNG. While global gas reserves have been growing for decades, during the last recent years sources of “unconventional gas” (e.g. shale gas) have been tripled; (IEA, 2013) estimates reveal that unconventional gas supplies that currently account to 8% of total reserves will reach 25% of the world’s gas supply by 2035 (Silverstovs 2005). Therefore, “unconventional” gas supplies such as shale gas or tight gas will definitely play an important role in the future demand for LNG.

The abundance of natural gas resources and the robust production of the commodity, determine its competitive position compared to the rest energy sources. According to Xun (2014), development in import / re-gasification terminal infrastructure as well as export / liquefaction facilities, play a determinant role on the demand for maritime transportation of natural gas; therefore, in order to meet future demand and supply, developments must align with future expectations. Currently, the industry is centered on a total of 97 terminals, situated in 26 different countries, accounting capacity of 600 mtpa. Nevertheless existing development plans, point that by 2020 the number of countries that will serve as LNG importers will be double adding another 200 mtpa. (Clarkson, 2013) At the moment, the regasification plans that are under construction represent 15% of today’s total regasification capacity. On the export side, currently there are 92 liquefaction trains located in a number of 19 countries, offering a combined liquefaction capacity of 283.4 mpta. The region of Middle East (Qatar followed by Abu Dhabi and Yemen) constitutes the largest area for LNG exports, contributing 40% of global volumes (Clarkson, 2013). Middle East exporters maintain their large benefits from their position, as they are situated in the middle of two key regions of natural gas demand, i.e. Asia and Europe.

In conclusion, we are able to infer that demand for maritime transportation of natural gas, in other words demand for LNG, is being driven during these recent years by both economic and non-economic factors. The rising energy demand that prevails all over the world, the “cleaner” burning nature of natural gas as a fuel (comparing to its substitutes i.e. coal and oil), the relatively easy switching applicability in sectors such as power generation (as well as industrial and residential purposes), and the deregulation that the industry is facing in almost every single continental market, primarily in the US followed by Europe and Asia are some of the obvious reasons for which demand for LNG is rising. Nevertheless, LNG prices have also taken a downward path mainly due to technological improvements that have declined costs regarding liquefaction and regasification procedures, but also LNG carrier-construction has also dropped in monetary value resulting in lower costs of carriage. Last but not least, the diminishing global reserves and volumes of domestic production, as well as the “limiting” transit nature of pipelines, have resulted to the rising demand for energy sources in many regions in the world. Hence, the above reasons indicate that the specific commodity acquires all means to prevail in the global energy mix at least for the next two decades.

The table below illustrates the main results of the literature review performed:

Table 0-1 LNG Transportation Main Results

Authors	Dependent Variable	Independent Variables	Sample	Methodology
Egging et al (2008, 2010)	Production & Consumption Projections	Producers, traders, pipeline and storage operators, LNG liquefiers and re-gasifiers	80 countries, production consumption figures 2005	Multi-period mixed complementarity problem for natural gas
Holtz et al (2007)	Gas Supply	Liquefaction – Regasification Capacities	European Union	GASMOD
Jensen (2004)	Demand Factors for LNG	Environmental concerns, costs reduction, non-OECD demand growth	-	-
Soldo (2012)	Natural Gas Consumption	GDP, HDD (heating degree days), annual house income, natural gas prices, oil prices	Overview of Existing Literature	Various Methods
Xu and Wang (2010) / Li et al (2011)	Natural Gas Consumption	Natural gas production, natural gas prices, GDP	China	Combination Model

Holtedahl & Loutz (2004)/ Hondroyiannis (2004)	Demand For Electricity	Household income, population growth, price of electricity, degree of urbanization / price and income sensitivity, weather condition (weighted average temperature), size of population	China, Greece	Multivariate Regression Model
Lochner and Bothe (2008)	Global Supply Forecast	transport capacities: liquefaction, regasification shipping capacities for transporting LNG	EU, US, Japan	Global Gas market model (MAGELAN)
Remme et al (2008)	Supply Options	Imports, exports, pipeline and LNG facilities capacity.	European region	TIMES Model

4 The Case of the Port of Rotterdam

4.1 An Introduction to the Port

The Port of Rotterdam consists of one of the largest and most noteworthy industrial and logistics clusters in Europe. Having a throughput of 440 million tones and a turnover of 615 million euros for the year 2012, Rotterdam is considered to be the leader sea-port in the European region. It stretches over an area of 40 kilometers in length and covers approximately 12500 hectares of land and water including sites in Maasvlakte 2. (Port of Rotterdam, 2014) The port is visited by over 30000 ships every year, while another 130000 ships are being handled internally at the quays of the port annually. A main reason for this is the economic importance that Rotterdam has gained as a transshipment and transit hub, mostly thanks to the economic development of the Ruhr region in Germany. Nowadays, Rotterdam holds the dominant market position against his main competitors in the region, Hamburg and Antwerp that are far behind transshipment volumes, providing employment to more than 70000 people and serving a great part of the hinterland of 460 million consumers. (Port of Rotterdam, 2014)

The port has several important features that make it the most attractive location for ships to call in. First of all, the unrestricted depth and the location of the terminals that face directly the North Sea, give Rotterdam the advantage of accommodating even the biggest vessel types, staying in line with the quickly-changing and demanding trends of the maritime industry. Therefore, geographically the port is placed in an ideal way in order to take advantage of Europe's trade growth, as the port is serving millions of consumers within the EU region. The port has established connections with all major trades all around the world owing that to its central location and the fact that global shipping lines choose it as a first port of call. Nevertheless, being situated at the mouth of river Rhine has played a major role on the development of the port as it is today; despite being a sea-port, Rotterdam is also an important river port. The reason is that goods arriving by sea are being transferred via inland barges to major markets such as Germany, France and Switzerland. (Port of Rotterdam, 2014)

The Port Authority follows a landlord governance model; this means that the PA owns the land and infrastructure, and leases it to its clients such as terminal operators, logistics providers etc. Therefore, the basic flow of income for the port comes from contracts (lease of land) as well as from charges for incoming vessels (port dues). In order to be able to maintain its competitive position, the PA along with its partners invest in sites, infrastructure and handling equipment like quay wall, jetties, cranes and roads as well as commercial chains and networks in order to sustain its industrial complex.

The Port of Rotterdam has also played an integral role in the field of innovation; it is quite obvious that one of the largest ports in the world would be setting the standards regarding port operations as well as for the adaption of new ideas regarding port governance. Moreover, thanks to the Netherlands' long maritime history, the professional and legal systems are aligned and favored by most shipping companies and the rest stakeholders within the port complex. Therefore, the port consists of a friendly environment for potential investors and multiple leading companies which are willing to invest on infrastructure development. Consequently, the port is also an integral part of the Dutch economy; not only has it provided direct added value (employment) but it also possesses great strategic value by ensuring additional competitiveness to Dutch firms. Firms located within the port complex are part of an integrated supply chain which allows them to use state-of-the-art technologies in order to be efficient and sustainable. Hence, companies that rely on imports and exports are able to benefit from lower inventory and transport costs and can fulfill their clients' most demanding logistical wishes.

The aforementioned information provide a good reason for country, the city and of course the port itself, to maintain its position as the leader sea-port in the European region. Therefore, the Rotterdam Port Authority has issued a future port vision plan; the Port Vision 2030. In consultation with the major stakeholders of the port such as the Municipality of Rotterdam, the Ministry of Infrastructure & Environment etc., the Port Vision 2030 includes not only the organizational structures but also future prospects regarding the port's international strategy, showing the way towards long-term sustainability and prosperity. (Port of Rotterdam, 2014)

4.2 Analysis of the European Natural Gas and LNG Sector

Restrictions in CO_2 emissions mainly deriving from coal-based power generation, the nuclear phase out that was announced by some of the member countries after the Fukushima accident, and the slow-pace development creating obstacles in renewable power generation, are the main reasons that force the European Union (EU) into a high dependency on natural gas. In 2010, natural gas accounted about 26% (Ruud Egging, 2008) of the primary energy consumption in the 27 members of the European Union with observers believing that in the near future figures will rise even more, since the reliance on coal and nuclear power will be significantly less.

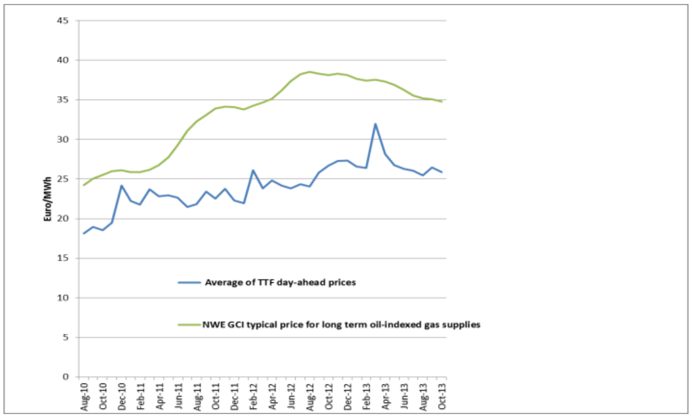
Specifically, regarding the residential and commercial sector, natural gas consumption has experienced an increase due to investments in the appropriate infrastructure that resulted in the rise of natural gas consumers. Currently, the use of natural gas in the sector of housing is the market-leader as it holds approximately a 35% market share, experiencing a 3% y-o-y growth since the beginning of the decade. (Ruud Egging, 2008) Concerning the industrial sector, natural gas holds a 30% of industrial final energy consumption (excluding industrial power generation), which makes it the primary source of energy in this market as well. Furthermore, the role of natural gas in the power generation has increased also significantly thanks to developments particularly in the UK, Italy and Spain, with gas-fired power stations producing more than 20% of the electricity within the European Union, compared to 7.5% in 1990 (Ruud Egging, 2008).

Europe's rising dependency on natural gas supply is determined largely on the geopolitical situation and relationships with Russia and the Middle-East; its principal natural gas suppliers. The Russian gas company Gazprom currently controls more than 85% of natural gas production in Russia and has a monopoly on Russian natural gas exports. (Remme, et al., 2008) However, the giant gas company is not planning to increase European deliveries in the near future to an extent that the European natural gas supply gap will be covered. Taking under consideration the growing natural gas demand but also the decreasing indigenous production in the continent, if additional supplies do not emerge, Europe will face an imbalance between natural gas supply and demand. More specifically, while gas demand is expected to rise by 40% by 2030, domestic production is expected to decrease significantly; nowadays European production accounts for 55% of total natural gas supply in the EU markets but is expected to drop to one third by 2020 and to one quarter by 2030 (Remme, et al., 2008).

As mentioned earlier, the necessity for security of supply has strengthen LNG's competitive position in comparison to pipelines over long distances. (Stern, 2013) This competition explains in some extent the reason for which prices in Europe are lower than the ones in Asia; the region lacks competition to LNG from pipelines because of long-distance transit that combined to tariffs, makes the gas more expensive than LNG. In Europe several large scale infrastructure projects have been developed in recent years including both modes of transportation. Projects such as the Nord Stream gas pipeline connecting Russia to Germany as well as the two import terminals in the UK and Netherlands, suggest that LNG and pipeline gas are to compete head to head for the largest share of European gas customers. (Egging, et al., 2010)

In fact, there are two gas prices in Europe; a long-term primary oil index and a short-term hub-gas indexed price in the UK (NBP) and the Netherlands (TTF). (Stern, 2013) Historically, most international and domestic prices did not follow the rule of demand and supply; pricing was linked to oil indices within long-term contracts. (Stern, 2013) However, after the appearance of the global economic recession in 2008, these –nonetheless successful- arrangements began to break down, initially in Europe and later on in Asia. As fundamentals changed contracts could not adapt; gas markets begun to globalize via LNG prices, therefore events in a certain market have impacts elsewhere. The growth of Chinese gas demand and LNG imports due to the Fukushima accident and the increase in oil prices due to the shale gas revolution in the US, resulted to a substantial growth of short-term LNG trade. Nevertheless, the liberalization of the natural gas industry increased the competitiveness of the market, turning oil-linked long-term prices to uncompetitive ones. In fact, several European natural gas utilities, exposed to competition, reported huge losses (e.g. E-ON Ruhr gas). Wood (2012), also refers to this transition mainly focusing on the increase of liquefaction capacity coming online in the Atlantic Basin (i.e. from Trinidad, Nigeria etc.) and the initiation of Qatari exports to Europe in 2008. He asserts that in times of high oil prices when deals of long-term gas pipeline contracts to Europe are oil indexed, gas-benchmarked LNG is very cost competitive, creating financial difficulties to European gas and power utilities who agreed on Russian contracts. The relation between the two pricing mechanisms is illustrated in the figure below:

Figure 0-1 The spot-traded gas price has been at a substantial discount to the long-term oil-indexed gas contract price



Source: Stern, 2013

The European wholesale gas pricing in 2012 consisted of 50% oil-index prices, 45% of gas-over-gas competition. (Stern, 2013) The region of North West Europe accounts for 50% of total European gas demand; from this percentage 28% is traded in oil prices whereas the rest in hub-prices. (Stern, 2013) However, Central and Mediterranean Europe are dominated by oil-index prices indicating that liberalization has not fully adapted to the European market yet. The transition from oil-linked to hub based pricing in Europe is on its way and most likely will not be reversed. However, in some regions such as the South East region the process make take several years to be completed. Nevertheless, this fact does not suggest that oil prices are no longer connected to the formation of gas prices. Consequently, this does not always implies that gas-over-gas prices will be automatically lower than oil-linked prices.

All in all, we can infer that the European market is a growing gas import market, in which LNG is meant to play a significant role in gas trading. However, stagnant economic growth as an ancillary of the global recession may slow-down LNG development in Europe. Nevertheless, with EU environmental policies favoring natural gas-fired plant developments among the rest fossil fuels, even if demand in the region does not increase, volumes of gas imports are destined to rise significantly. EU indigenous production has declined at an average rate of 7% over the last decade. (The Dutch Gas Hub, 2011) At the same time, gas supply to the EU-27 by pipeline has also suffered a decrease of 10%. (The Dutch Gas Hub, 2011) The prompted diversification to LNG suppliers facilitates the security of supply issues that were surrounded by the perception that it is risky to increase dependency on Russian gas. Pipeline still dominates gas supply over LNG, with Russia and Norway constituting the major share of supply. Contracts already been signed regarding future supplies, indicate a sustained growth of LNG capacity in the medium and long-term; this information also highlights the decline of domestic production and the ongoing diversification of gas imports. A new number of terminals are under construction and existing ones are being expanded. In the long-term LNG could represent 25% of total EU supplies. (The Dutch Gas Hub, 2011) In addition the Netherlands is the only net gas exporter in the EU. Since the operations began in its first regasification terminal in 2011, the country is about to become an important European trading hub, with LNG and pipeline gas competing for access to the large German and UK markets.

4.3 The Dutch Gas Sector

Although the Netherlands successfully diminished their greenhouse-gas emissions in times of economic growth (1990-2010), the country remains one of the most fossil-fuel and CO_2 intensive economies in the EU. The Netherlands has already reached its Kyoto Protocol target; however this has only happened form the reduction of other greenhouse gases rather than CO_2. The economic crisis kept CO_2 emissions decreasing for three years, interrupting the previous stable situation, but now the target has been set aiming at 2030. After the National Energy Agreement took place last year, the government focuses on a policy framework which is based on shifting into renewable energy sources. However, the transition has yet several obstacles to overcome, therefore this makes way alternative sources of "clean" energy.

The Netherlands is the largest natural gas exporter within the European Union. The Groningen field is one of the ten largest gas fields in the world, while hundreds of small underground fields in on land as well as under the Dutch offshore zone, consist Netherlands the largest producer in the continent. However, the country has passed its peak of gas production and reserves are declining; since 2000, production has halved with projections indicating that the current position will be maintained until 2025. Around that time Netherlands are expected to have changed into a net importer country, with security of supply being of significant importance. Consequently, LNG will play a key role under the framework of supply diversification. Nevertheless, this requires major infrastructure investments in LNG installations are necessary in order to secure supply flexibility.

The country's dependency on natural gas is obvious; it acts like a trading hub since it both imports and exports large volumes of natural gas, while at the same time, almost 40% of total volumes is used domestically. In 2010, exported volumes accounted for 57.8 bcm of natural gas, with the largest portion (some 21.6 bcm) went to Germany. (IEA, 2013) Other countries were supplied substantial volumes as well; UK and Belgium 10 bcm each, and Italy and France 7 bcm each. (IEA, 2013) Nevertheless, the Netherlands imported almost 25 bcm of gas mainly from Norway, the UK and Russia. (Clarkson, 2013)

The domestic consumption in the Netherlands accounts for about 55 bcm; over a third is consumed in the energy transformation sector, while the residential (96% of all households), industrial and commercial sectors share an even part of the consumption volumes. (Correljé, et al., 2012) Over 60% of total electricity derives from gas-fired generation. Daily gas consumption varied significantly between seasons with 88 million cubic meters being used in the summer and over the double during the winter (Correljé, et al., 2012). Seasonal variation plays an important role in the demand side of prices as well. Nevertheless, the demand for natural gas is expected to increase significantly over the next two decades, with contribution mainly from the power generation sector and less from the industry sector. The declining prices of coal in the European import markets, consist a main driver of this situation. Moreover, demand for the residential and commercial sectors is expected to decrease slightly mainly because of technological improvements in energy efficiency and insulation. The above information gives a good insight on the significant utility of natural gas as Netherlands main energy source. The gas is also a very important asset for the country's economy; as more than a half of the overall energy consumption is based on it, natural gas revenues account for around 10 billion euros per year. (Correljé, et al., 2012)

The country's gas market was liberalized in 2004. This resulted to the legal separation of the natural gas networks. The Netherlands acquires an exceptional network of gas transportation. The grid provides connections at several points on the networks of surrounding countries such as Germany and the UK. Nevertheless, a significant new connection, the Nord Stream, connecting Russia via the Baltic with Northern Germany, indicates that the country will operate as a gas interchange for North West Europe. Nowadays, the transportation network is being operated by a fully owned by the State infrastructure company called Gasunie and its affiliate GTS. The gas produced and sold domestically is being traded by a company called GasTerra, which is half-owned by the State and half by Shell and Exxon (25% each). GasTerra is the major player in the whole-sale market and has established strong European activity by acquiring import contracts with Russia, Norway and Germany. Furthermore, the Netherlands have a market based balancing model, with virtual trading being possible on its wholesale hub, called TTF. The market share of the incumbent shipper which is GasTerra has diminished over the last years as a sign of market liberalization. In contrast to most European countries, the Netherlands have regional distribution operators which act independently from producers and market suppliers.

4.4 The GATE Terminal

Predominantly Rotterdam is considered to be a major "energy port" in the European region. Handling oil and chemical throughput of approximately 200 million tons per year, (Rotterdam Port Info, 2014) the Dutch port consists of an essential node for the energy needs of the Netherlands and North West Europe. Specifically, commodities such as coal, biomass, and oil products as well as LNG since 2012, are driven to the hinterlands through the Rotterdam Energy Port. Nevertheless, power generation and capture/storage of carbon dioxide are also procedures initiated within the port complex. All in all, the port is destined to play a determinant role in the transition towards a cleaner and more sustainable energy future. In fact, according to Port Vision 2030, the Dutch energy mix is planned to contain 40% of natural gas, 30% renewables and only 30% of coal, therefore reaching its climate goals. (Rotterdam Port Info, 2014)

As demand for natural gas in northwest Europe (including the Netherlands) is rising, domestic production is yet declining. Therefore, gas must be imported from other regions, mainly via pipelines from Russia or in the form of liquefied natural gas (LNG). Since both options are considered necessary to meet the projected demand, an import terminal will be play an important role at increasing the security of supplies and also enable new players to enter the European gas market. Nevertheless, the terminal's direct connection to the natural gas transmission network establishes the Netherlands's position as a major European gas hub.

The GATE Terminal is a "Greenfield" project on a specified site at the entrance of the port of Rotterdam; on Maasvlakte, the Gate terminal consists of the first LNG import terminal in the Netherlands. The Gate Terminal B.V is an equally joint venture set up by the Dutch companies Vopak and Gasunie. The terminal aligns with all Dutch and European energy policies, which are based on strategic diversification of LNG supplies, sustainability, safety and environmental awareness.

The terminal consists of a LNG cryogenic storage facility which comprises of 3 tanks that reach capacity of 180000 m^3 each, keeping the liquefied natural gas in a stable form and temperature at -165^{o}C; it has initial throughput capacity of 12 billion m^3 per year with potential of future expansion to 16 billion m^3 if needed. (Gate Terminal, 2014) This corresponds to more or less 130 large LNG tankers that can dock every year in the terminal to provide North West Europe with gas. The facility includes all features related to modern LNG import terminals; two unloading jetties for receipt as well as regasification equipment and supply facilities. The jetties have the ability to accommodate the future generation of LNG carriers including Qatar maxes. Q-maxes are vessels with capacity of 250000 m^3, a length up to 350 meters and draught of about 12.5 meters. (Gate Terminal, 2014) The regasification takes place in 8 Open Rack Vaporizers which use warm sea water supplied through 2 ND pipelines and an underwater tunnel. The water pumping system is situated close proximity, about 5km away from the terminal. The system delivers the high pressure LNG to the ORVs before a pipeline and a metering station deliver natural gas to the European gas network. A system of compression that boils-off gas, a re-condenser and various utility systems complete the scope of work. (Gate Terminal, 2014)

Offtake agreements have already been made with five European energy suppliers such as Dong Energy, RWE Supply & Trading, Eneco, E.ON Ruhrgas and Econgas OMV International. E.ON currently uses 25% of the terminal's throughput and is a major supplier of electricity and heated water in the region. The company has made significant progress in supplying Germany and Europe with LNG. The GATE Terminal provides E.ON Ruhrgas with over three billion cubic meters of yearly LNG regasification capacity. E.ON also holds a 5% stake in the terminal operating company.

4.5 Results

From the literature review performed upon the demand determinants of port throughput, the key determinants of LNG transportation, as well as the above analysis of the European and Dutch natural gas sector, we are finally able to conclude on the factors that are most likely to have an effect on the LNG throughput in the Port of Rotterdam.

Due to environmental and security of supply concerns within the borders of the continent, Europe demands and will continue to demand in the future, significant portions of natural gas as the basic component of its energy mix. The Netherlands despite being the most fossil fuel intensive country of the European Union, consumes and trades significant volumes of natural gas and LNG. Natural gas is being consumed extensively to the power generation and domestic sectors. According to the literature review findings, natural gas consumption in our country is mainly determined by production, prices and GDP. Although the country is the largest natural gas producer in Europe, reserves are declining, hence additional supplies are necessary to be imported. Nevertheless, the exceptional pipeline infrastructure system creating interconnections between large natural gas markets as well as the newly-built regasification terminal in Rotterdam, allow the Netherlands to import and export large volumes of natural gas; the offtake agreement between the GATE terminal and five large power generation companies, as well as the energy policy in the Netherlands, indicate that natural gas consumption plays a significant role in our analysis.

Natural gas prices are clearly a key factor that determines the imported natural gas volumes through the port of Rotterdam. The imported flows through the GATE Terminal in Maasvlakte 2, accounted for 1.26 million cubic meters in 2012. (Clarkson, 2013) Of the total volume, only part of it (0.72 mm^3) is been contracted in oil-indexed long-term agreements. (The Dutch Gas Hub, 2011) Therefore, the remaining volume is being traded freely by entities upon the Dutch natural gas trade-hub, the TTF. As mentioned earlier, LNG hub-traded prices are competing against oil-indexed long-term pipeline gas prices. But what determines the fluctuations of prices is mainly deriving from market demand and supply forces. Factors from the demand side include economic conditions, coal prices and petroleum prices. The API 2 price index consists of the primary reference for physical and over-the-counter (OTC) coal contracts in North West Europe; approximately 90% of European coal derivatives are priced against the API 2 index. (Argus, 2014) Brent Crude is a major trading classification of light crude oil and serves as a major benchmark price for global oil trade. Brent Crude is sourced and extracted from the North Sea, therefore it serves as the main price index in the region.

Currently, the highest barrier regarding LNG imports at PoR, are expensive prices. (The Economist, 2014) Until the financial crisis elapsed in Europe, experts' anticipations were mostly concentrated on EU's cap-and-trade emission policies that would limit CO_2 pollution and turn industries towards gas-fired power plants. However, cheap coal prices and the emergence of solar and wind power sources as well as the long-term LNG contracts in Asia due to the recent Fukushima disaster, have harden LNG's position in the market. Nevertheless, the geopolitical situation in Russia could on the one hand rise prices even more (only for the short-run), but on the other hand could significantly increase LNG imports and solve the European energy supply issue. Experts state that if the Ukrainian dispute rmains unsolved, the energy supply situation in the entire continent could change rapidly; Europe has large regasification capacity not being used at the moment especially in the Netherlands and Spain. (The Economist, 2014) The terminal operator company Gasunie claims that if any changes take place, the grid is capable of providing major natural gas consumers such as Germany and Austria the full terminal capacity volumes. (The Economist, 2014)

There selected variables that are going to be used in our models and are considered to have a direct effect on the LNG throughput at the Port of Rotterdam are:

Table 0-1 Selected Variables

Dependent Variable	Independent Variables
LNG Throughput at PoR	NL – GDP
	TTF ICE Index
	Brent Crude Index
	API 2 Index
	NL – N.G Consumption
	NL – NG Pipeline Imports
	NL – NG Production
	NL- NG Exports

5 Variables & Hypotheses

5.1 The Variables

Demand for LNG has increased rigorously over the last decade. LNG throughput in the Port of Rotterdam is a relatively new-brought activity since the first import terminal began its operations less than three years ago. Since natural gas is becoming the most favorable source of energy for the upcoming decade, LNG volumes are going to play an important role in securing and diversifying North West Europe's energy supply. For this increasing trend it is necessary to identify the factors on which this growth can be attributed and therefore understand the true drivers of LNG throughput. It is the aim of the research to discover the variables that can determine the LNG throughput at the Port of Rotterdam and to test them statistically in order to measure how throughput volumes are affected by them.

Taking under consideration the literature review performed and studied, but also the assistance and consultancy of experts from the academic and business world, we have identified the variables that are going to be included to the model and formed the following hypotheses in order to answer the main research question and sub-questions of the study:

How will the expected growth in demand for natural gas in Northwest Europe, affect the throughput of LNG in the Port of Rotterdam?

Which are the economic factors related to the natural gas and LNG market?

Which are the trends affecting both markets?

Which are the variables going to be used, with the highest predicting value?

5.1.1 Dependent Variable

The LNG throughput for the Port of Rotterdam is going to be used as the dependent variable in our model. The data for LNG throughput at the PoR is being deployed for years 2012 to 2014, due to the short existence of the GATE Terminal, and is going to be used in monthly values. Besides imports, port throughput also includes re-exports of liquid product to international customers (e.g. Norway), all within the role of the Netherlands as a hub of natural gas trade.

The Netherlands imported 1.25 million cubic meters of LNG volumes in 2012, facing a significant decrease of 30% year over year (Clarkson, 2013); this situation is mainly attributed to the residues of the economic crisis on the maritime industry and the declining trend of coal prices, which led major players within the energy industry to switch from natural gas to coal usage. This whole situation has resulted to 29% decline in LNG imports to the EU. (Clarkson, 2013) The financial crisis that the world faced in 2008, decreased significantly the volumes of world trade. The Port of Rotterdam also saw a decline in LNG throughput of 30% in a year on year average from 2011 to 2012.

5.1.2 Independent Variables

1) The Netherlands's Gross Domestic Product: The GDP is the most broadly deployed indicator to monitor the overall performance of an economy. It provides to the reader an aggregate measurement of the total production output of a country's economy. The GDP is consisted of the total monetary value of domestically produced goods and services, including governmental expenditure, private investments and the foreign trade balance (net imports). The Port of Rotterdam is the major entrance through which natural gas in the form of LNG flows in North West Europe, and the single one in the Netherlands. The relationship between the Netherlands economy (depicted by the GDP indicator) and the LNG throughput at the port of Rotterdam is being analyzed in order to indicate how economic fluctuations have an effect on the total volumes imported.

2) TTF ICE-Index: The Title Transfer Facility (TTF) is a virtual market place where market parties are offered the opportunity to transfer "entry-paid gas" to another party. (The Dutch Gas Hub, 2011) Using the TTF, it is straightforward for gas that is brought into the national grid via an entry point (e.g. GATE Terminal) to change ownership before it leaves the system at an exit point. The TTF also ensures the availability of gas by securing that supply and sale are in balance. Gas traders and suppliers in North West Europe have started to increasingly turn on the TTF; TTF is becoming the benchmark for gas trade in continental Europe since market volumes and numbers of trades have increased significantly. Consequently, TTF has outpaced other trading facilities in Europe in terms of both physical volume supplied and volume traded. Natural gas at TTF is being traded in Euros per megawatt hour. (The Dutch Gas Hub, 2011) The relationship between the LNG throughput at the port of Rotterdam and the TTF ICE index is being analyzed in order to determine the price-fluctuation effects upon the former's performance.

3) ICE BRENT Crude Oil Index: During the last century, crude oil is considered to be the most widely used commodity in the world in terms of fueling purpose**.** The Brent Blend is used as a benchmark for more than half of the world's globally traded supply of crude oil; extracted form parts in the North Sea, it makes an obvious choice for the benchmark of crude oil in North West and continental Europe. (ONE Financial Markets, 2012) The most important drivers that determine Brent prices consist of the situation of the global economy, geopolitical tensions (e.g. in Middle East), emerging market demand from dominant countries such as China and the US and finally substitutes forms of energy under the global concept of "green energy". (Cummans, 2012) The relationship between LNG throughput and Brent crude-oil prices is going to be analyzed in order to determine in what degree the former is being affected by the specific index.

4) API 2 Index: The API 2 index is the benchmark price reference for imported volumes of coal in North West Europe. (Argus, 2014) The index is being calculated as an average of the Argus cif ARA assessment and the HIS McCloskey Europe Steam Coal indicator. Prices are being traded at USD per megawatt hour. (Argus, 2014) The correlation between the LNG throughput at the port of Rotterdam and the performance of the specific index is being analyzed in order to identify the impact of coal prices in the LNG volumes being imported at the GATE Terminal.

5) Natural Gas Consumption in the Netherlands: Consumption of natural gas in the Netherlands is going to play an important role in our analysis. As mentioned earlier, natural gas usage is being deployed in major energy sectors such as the power generation, industry as well as the residential. Nevertheless, the offtake agreement made between the GATE Terminal and five large power and electricity generator companies stipulates our interest to include the specific variable within the following analysis.

6) Netherlands Natural Gas Indigenous Production: The Netherlands during the last 50 years when the Groningen field was discovered, owns the largest natural gas field in the European Union. For decades, numerous wells in the north of the country have extracted natural gas from the same field at a high pressure. Annual natural gas production reaches currently 80 billion cubic meters but production reserves are declining; estimations indicate that production at the current rate can be maintained for approximately 15 years more. (The Dutch Gas Hub, 2011) Nevertheless, the Dutch energy policy aims to maintain the current status of the country as a natural gas producer for the next two decades but not in the expense of supply security. Therefore, fluctuations in supply volumes from indigenous sources have a major impact upon the volumes of LNG that will enter the country as supplementary. The aforementioned relationship therefore, is to be tested in our analysis.

7) Netherlands Natural Gas Imports-Exports via Pipelines: As discussed in previous chapters and the literature review, the Netherlands, besides from importing LNG or producing natural gas domestically, as a major consumer also has the option to import the specific energy fuel through the use of pipelines. Therefore, we can infer that demand for LNG and generally LNG trade, are subject to natural gas volumes transported by pipelines. This relationship is going to be examined in order to identify potential impacts on LNG throughput at PoR.

5.1.3 Hypotheses

H1: There is a positive relationship between the Netherlands GDP and the LNG throughput at the Port of Rotterdam.

H2: There is a negative relationship between the TTF ICE Index and the LNG throughput at Port of Rotterdam.

H3: There is a positive relationship between ICE Brent Crude-Oil Index and the LNG throughput at Port of Rotterdam.

H4: There is a positive relationship between the API 2 Index and the LNG throughput at the Port of Rotterdam.

H5: There is a positive relationship between natural gas consumption in the Netherlands and the LNG throughput at the Port of Rotterdam.

H6: There is a negative relation between natural gas imports via pipeline in the Netherlands and the LNG throughput at the Port of Rotterdam.

H7: There is a positive relationship between natural gas exports via pipeline in the Netherlands and the LNG throughput at the Port of Rotterdam.

H8: There is a negative relationship between natural gas indigenous production in the Netherlands and the LNG throughput at the Port of Rotterdam.

The above hypotheses are going to be examined by the use of a regression analysis, in order to determine which of the variables and to which extend, have an effect on the LNG throughput at Rotterdam.

6 Data & Methodology

The aim of this study is to produce a comprehensive analysis report on the factors that have a major influence upon the volumes that contribute to the LNG throughput at the Port of Rotterdam. The report initially aims at providing a qualitative understanding regarding the role of ports and the evolution of this role with respect to the techniques deployed in order to attract as more throughput as they can. Furthermore, the analysis is based upon the determinants and key drivers of the maritime transportation for natural gas, as well as an overview of the European and Dutch natural gas sectors. The aforementioned analysis consists of the foundation for the quantitative part of the study; the part in which the macroeconomic variables correlated with the volumes of LNG that handled at the Port of Rotterdam are being identified. A multiple regression model is being deployed using the variables selected in the previous chapter while taking under consideration the monthly LNG throughput of Rotterdam as the dependent variable for the regression model.

6.1 Data Sources

The following table illustrates the data used as well as the source/sources by which the data has been retrieved from:

Table 6-1 Data Sources

Type	Variable	Source
Dependent Variable	LNG Throughput at PoR	Data Stream / Statistics Netherlands
Independent Variables	NL – GDP	Data Stream / Eurostat
	NL – Natural Gas Consumption	Data Stream / Eurostat
	TTF ICE Index	Data Stream / Eurostat
	Brent Crude Oil ICE Index	Data Stream / Eurostat
	API 2 Index	Data Stream / Eurostat
	NL – Natural Gas Indigenous Production	Data Stream / Statistics Netherlands
	NL-NG Exports	Data Stream / Statistics Netherlands
	NL – Natural Gas Imports via Pipeline	Data Stream / Statistics Netherlands

6.2 Multiple Regression Analysis

Multiple regression analysis consists of a statistical analysis instrument deployed in order to analyze the effect of various independent variables upon the focal dependent variable. This technique is broadly used for the purpose of estimating one variable (dependent) on the basis of a numerous other variables (independent). Despite that in some occasions it is preferred to deploy a regression analysis using only one independent variable, in our case a multiple regression must be used in our model. Generally, it is preferred to include as many independent variables as possible, in the basis that you believe they will have an effect on the dependent variable. By limiting the number of variables, the model's usefulness and validity is also decreasing.

The following equation is considered to represent a typical multiple regression equation:

$y = \beta 0 + \beta 1 \cdot \chi 1 + \beta 2 \cdot \chi 2 + ... + \beta \kappa \cdot \chi \kappa + \varepsilon$ where y represents the dependent variable, $\chi 1$, $\chi 2$ ... $\chi \kappa$ are the independent variables, $\beta 1$, ... $\beta \kappa$ are the coefficients and ε is the error variable. (Keller, 2012)

In our case, the multiple regression equation that is going to be used in our model is the following:

LNG Throughput = B_0+ B_1*Netherlands GDP + B_2*Netherlands NG Consumption + B_3* TTF ICE Index + B_4 * Brent Crude Index + B_5 * API 2 Index + B_6 * Netherlands NG Production + B_7 * Netherlands NG Imports via Pipeline + ε

The IBM SPSS statistical software is going to be used and the aforementioned data is going to be the input of the model. A linear regression shall be run several times in order to result to the most probable outcome.

6.3 Time Series

For the purpose of our forecasting model we are going to use TIME SERIES by including the so called "lagged" variables into the regression equation. The usefulness of the lagged variables in the regression model is necessary for our study, since "lagging" the existing variables allows the regression model to provide us a forecast of the future; to forecast what will happen in period "t" is based on the knowledge of what took place in period "t-3". Therefore, the typical multiple regression equation provided earlier is being transformed to:

$Y(t) = \beta 0 + \beta 1 \cdot \chi 1 (t-3) + \beta 2 \cdot \chi 2 (t-3) + ... + \beta \kappa \cdot \chi \kappa (t-3) + \varepsilon$ (Keller, 2012)

Again, we are going to use the IBM SPSS software in order to run the multiple regression, only this time the regression of our dependent variable (LNG throughput) is going to run on "lagged" variables. Results of both cases are going to be presented on the next chapter.

7 Results of the Analysis

7.1 Results of Multiple Regression

In the effort to explain the variations in the LNG throughput at PoR, after the required data was collected a linear multiple regression was performed via the IBM SPSS software. After multiple run-tests, results showed that the model interprets only two of our selected independent variables. Specifically, the statistical significant values consist of the NL_GDP and the API 2 Index. The statistical significance is being identified below:

Table 0-1 Multiple Regression Coefficient Analysis

Model	Standardized Coefficient	t	Sig.
Constant		-2.764	.012
NL_NG Consumption	-.352	-.634	.533
NL_GDP	.915	2.692	.014
NL_NG Prod	-1.522	-.714	.484
NL_NG Imports	.037	.108	.915
Brent Crude Index	.189	.856	.402
TTF Index	.374	1.797	.088
API2 Index	.933	2.350	.029
NL_NG Exports	1.424	.641	.529

We now must check the table of "Coefficients" by specifically focusing on the t-test. By theory, we know that the null hypothesis of the t-test states that the coefficient of the independent variable is 0. This would mean that the independent variable would not have any effect on the dependent variable. In our results, we first observe that the absolute value of the t-test is larger than two for both independent variables; the t-test for NL_GDP is 2.692 whereas the value of the API2 Index is 2.350.

Furthermore we see that the p-value of the test is 0.014 for the NL_GDP and 0.029 for the API2 Index. This fact gives strong evidence to reject the null hypothesis as both values are smaller than 0.005. Moreover, our initial hypotheses are being confirmed; as we can see at the block of the "Unstandardized Coefficients", the relationship between LNG throughput and NL_GDP is positive, and also the relationship between throughput and coal prices (API 2) is also positive.

Moreover, the ANOVA table is being used in order to check the significance of our model. We focus on the value of the F-test. The null hypothesis of the F-test states that the model has no explanatory power, meaning that none of the independent variables help to predict the dependent variable. In order to decide if we are going to reject or not the null hypothesis, we must take a look at the p-values which stand at the next column marked as "Sig". The value of the p-value indicates that there is not that strong evidence to reject the null hypothesis, and therefore our model has some degree of explanation for the reason that only two out of the eight variables were accepted from the model.

When conducting multiple regression analysis, the first value note is the “Adjusted R Square”. The term is used to quantify the proportion of total variability in the dependent variable that is explained by the causation of the independent variables. In our case therefore, the value explains the measure of variation in LNG throughput that was explained by the selected independent variables. The value we get is rather small, 0.164, meaning that 16.4% of variation in the LNG throughput can be attributed to only 2 independent variables, GDP and coal prices.

We can also observe that the “Standard error of Estimate” is quite high; this value measures the dispersion of the dependent variable around its mean. Taking a close look at the exact figures of the monthly throughput volumes at PoR, one could realize that almost half of the observations have no value; that simply is caused because during these specific months there were no volumes at all handled at the GATE Terminal.

7.2 Results of Time Series

In order to make a probable estimate we have turned the independent variables into lag variables. The reason of doing this is that the lag variables will help us forecast the future LNG throughput for the remaining months of 2014, since monthly data was used. However, not all variables used in the regression analysis will be used for the forecasting; only the two variables that were statistically significant will be deployed, which are the NL_GDP and the API2 Index.

For the formulation of the model, the forecast begins after the last non-missing range of the requested estimation period, and finishes at the last period for which all the predictors are available.

Figure 0-1 LNG Throughput Forecast

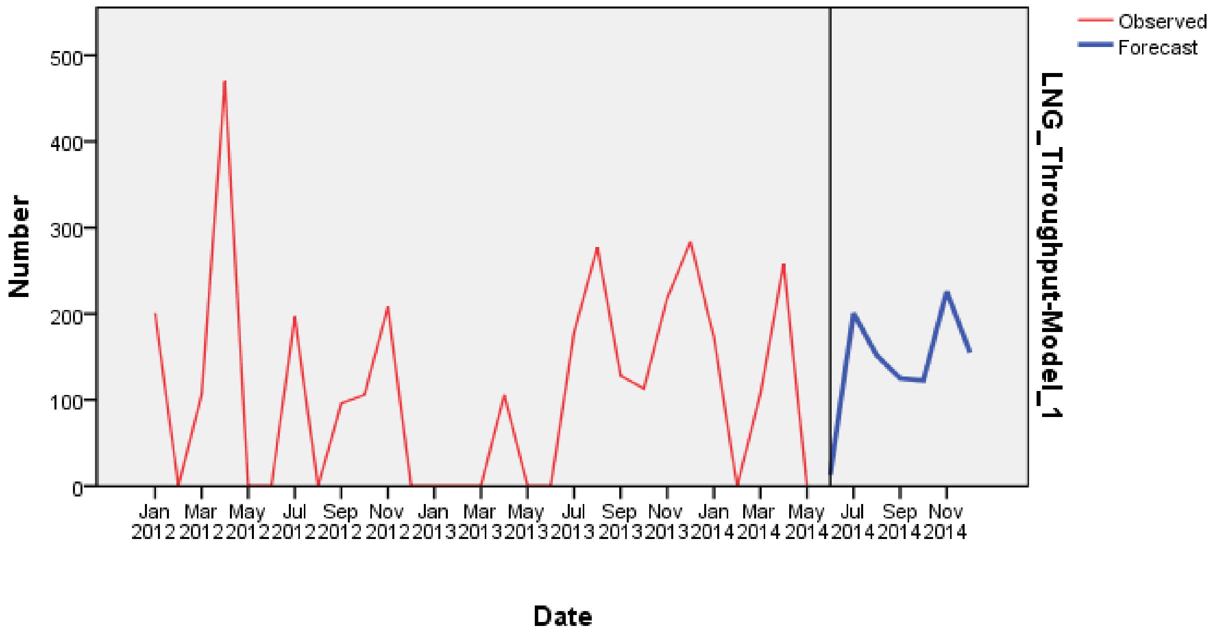


Table 0-2 LNG Throughput Forecast

Forecast							
Date	Jun 2014	Jul 2014	Aug 2014	Sep 2014	Oct 2014	Nov 2014	Dec 2014
LNG Throughput	13	200	151	125	122	226	155

The results of the forecast indicate that the volumes of LNG throughput at PoR do not fluctuate significantly in comparison to the actual data. The throughput volumes still remain low comparing to the total natural gas usage and the capacity that the terminal can handle. This can also be visualized from the figure above. However, we must acknowledge that because of the relatively small life-span of the GATE Terminal, the data that was deployed led to the conclusion that the model may suffer from heteroscedasticity. This phenomenon occurs in cases where there is a large differences among the sizes of the observations. Hence, the forecast may not be accurate in a large degree. Further information on this extent will be provided at the limitations section of the research.

8 Conclusions and Limitations

8.1 Conclusions

During the last decade, demand for natural gas is constantly rising mostly because of environmental concerns, competitive pricing and substantial reserves. Gas consumption therefore has increased its significance in many different regions and sectors. A main reason for this is attributed to the rise of global maritime transportation of natural gas in a liquid form, known as LNG. LNG gives the opportunity to “stranded” natural gas to reach in regions that the main transit mode (pipelines) cannot reach; therefore it provides a certain degree of supply security and diversification to its users, especially in regions that are fully dependent on the product and at the same time have limited suppliers, like Europe.

The Thesis has as an objective to determine the main factors that have an effect on the throughput at the only import terminal in the country of Netherlands. The introduction of the research gives the reader a holistic understanding of the topic, while it provides the research questions that are going to be examined on the paper.

Moreover, a literature review on ports and forecasting methods is performed in order to describe the role of seaports throughout the years; specifically the requirement of port existence and its functions through different segments is being analyzed, in order for us to determine the factors that determine the throughput of a specific port. Several macroeconomic variables were identified as main factors, including GDP and trade flows (imports / exports), an indication that asserts that port throughput is mainly driven by the economic prosperity that characterizes the region(s) it covers. Furthermore, an analysis of the key factors that determine the maritime transportation of natural gas was made, with the main results indicating that import-export capacities, production, consumption, pricing and environmental concerns play a determinant role on the significant growth of LNG trade. The literature review assisted in the formulation of a list of variables that were used as guidelines in order to define the forecasting variables that were used on the specific Rotterdam case. After a thorough analysis of the European and Dutch natural gas and LNG sectors was made, a list of selected variables was produced. The regression analysis performed, indicated that GDP and coal prices are the most significant factors that affect the volumes of LNG throughput at the Port of Rotterdam. As discussed in the literature review, despite the significant decrease of the LNG supply chain costs, pipeline transportation still remains the main mode of natural gas transport. Nevertheless, the geopolitical tensions that take place within the European continent, combining with the residuals of the economic recession, have impacted on the volumes that insert the port of Rotterdam. Moreover, the decrease in coal prices have stimulated power generation companies to switch their usage fuel from natural gas to coal. This has created a significant down turn on LNG volumes at the Port of Rotterdam, since a large part of them is being claimed by power generation companies that operate in the Netherlands.

Finally, the research provides a forecast of the LNG throughput for a time-horizon of seven months. The estimation indicates that volumes will not fluctuate significantly combined to the actual throughput, since the development of the LNG terminal in Rotterdam is in a primitive stage in the market. Nevertheless, LNG volumes imported and exported form the port can also be attributed to seasonal patterns, as well as negotiations on climate change affairs as well as potential regasification and liquefaction investments.

8.2 Limitations

During the Thesis procedure there were a number of implications that we ought to be dealt with. First of all, the GDP in most of the European countries is measured in quarterly data. The purpose of the research demanded that all data had to be converted in monthly time horizons. Therefore, a problem occurred when quarterly data had to be measured in months. This fact opens the way for further research to be made with GDP data to be found in actual monthly values.

Furthermore, the short life-span of the GATE Terminal at the Port of Rotterdam also created implications to our research. Taking a close look at the throughput volumes, one can realize that almost half of the observations result to zero figures. This creates a problem to our model as it suffers from heteroscedasticity. Despite the visual inspection that was made through the scatter plot and histogram, the phenomenon was also statistically tested through the Breusch-Pagan and Cook-Weisberg tests. The above fact combined to the relatively small sample of observations (29), created partial distortion of the model. It must be noted that when the sample is too small it is difficult for the model to identify significant relationships from the data; this is because statistical tests normally require large sample sizes in order to illustrate a representative distribution of the population. Therefore, in order for the model to be able to identify the effects of the independent variables upon the dependent one, the confidence intervals were lowered from 95% to 90%. Further research could be conducted in the future either by using smaller time-horizons such as weekly data, or by anticipating for the LNG throughput to grow so the data sample can be more representative.

Finally, other factors that can have significant impact on the LNG throughput at the Port of Rotterdam can be analyzed but on the basis of a deeper time-horizon than the two years that were analyzed. Regasification and liquefaction capacity as well as LNG carrier capacity, can play a determinant role on describing the fluctuations of the dependent variable (LNG throughput). The reasons for which these variables were not chosen is because within two years no significant variations occurred, therefore the specific data could cause phenomena of distortion and multi-collinearity of the data. Finally, variables that could not be quantified, but according to the literature review (e.g. geopolitical situation and climate change debates), do play a significant role in LNG throughput at PoR, can also consist of topics for further research.

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Appendices

Descriptive Statistics

	Mean	Std. Deviation	N
LNG_Throughput	111.24	119.690	29
NG_Cons	1733.10	207.340	29
GDP	53553.85	232.816	29
NG_Prod	6526.31	2540.478	29
NG_Imp	2030.07	298.036	29
Brent	82.2861	4.39768	29
TTF	25.7734	1.98223	29
API2	64.8362	6.74887	29
NG_exp	5014.00	1517.641	29

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.634[a]	.403	.164	109.468	2.623

a. Predictors: (Constant), NG_exp, GDP, TTF, Brent, NG_Imp, API2, NG_Cons, NG_Prod

b. Dependent Variable: LNG_Throughput

Correlations

		LNG_Throughput	NG_Cons	GDP	NG_Prod	NG_Imp	Brent	TTF	API2	NG_exp
Pearson Correlation	LNG_Throughput	1.000	-.121	.244	-.099	-.051	.270	.069	.028	-.081
	NG_Cons	-.121	1.000	-.201	.926	.495	.413	.059	.444	.908
	GDP	.244	-.201	1.000	-.026	.007	-.119	-.232	-.758	.024
	NG_Prod	-.099	.926	-.026	1.000	.520	.399	.052	.267	.990
	NG_Imp	-.051	.495	.007	.520	1.000	.069	-.115	.046	.604
	Brent	.270	.413	-.119	.399	.069	1.000	-.008	.441	.374
	TTF	.069	.059	-.232	.052	-.115	-.008	1.000	-.059	.047
	API2	.028	.444	-.758	.267	.046	.441	-.059	1.000	.202
	NG_exp	-.081	.908	.024	.990	.604	.374	.047	.202	1.000
Sig. (1-tailed)	LNG_Throughput		.266	.101	.304	.397	.078	.361	.443	.338
	NG_Cons	.266		.148	.000	.003	.013	.381	.008	.000
	GDP	.101	.148		.446	.486	.269	.113	.000	.451
	NG_Prod	.304	.000	.446		.002	.016	.394	.081	.000
	NG_Imp	.397	.003	.486	.002		.361	.277	.407	.000
	Brent	.078	.013	.269	.016	.361		.484	.008	.023
	TTF	.361	.381	.113	.394	.277	.484		.381	.404
	API2	.443	.008	.000	.081	.407	.008	.381		.146
	NG_exp	.338	.000	.451	.000	.000	.023	.404	.146	
N	LNG_Throughput	29	29	29	29	29	29	29	29	29
	NG_Cons	29	29	29	29	29	29	29	29	29
	GDP	29	29	29	29	29	29	29	29	29
	NG_Prod	29	29	29	29	29	29	29	29	29
	NG_Imp	29	29	29	29	29	29	29	29	29
	Brent	29	29	29	29	29	29	29	29	29
	TTF	29	29	29	29	29	29	29	29	29
	API2	29	29	29	29	29	29	29	29	29
	NG_exp	29	29	29	29	29	29	29	29	29

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	161454.794	8	20181.849	1.684	.164[b]
	Residual	239666.516	20	11983.326		
	Total	401121.310	28			

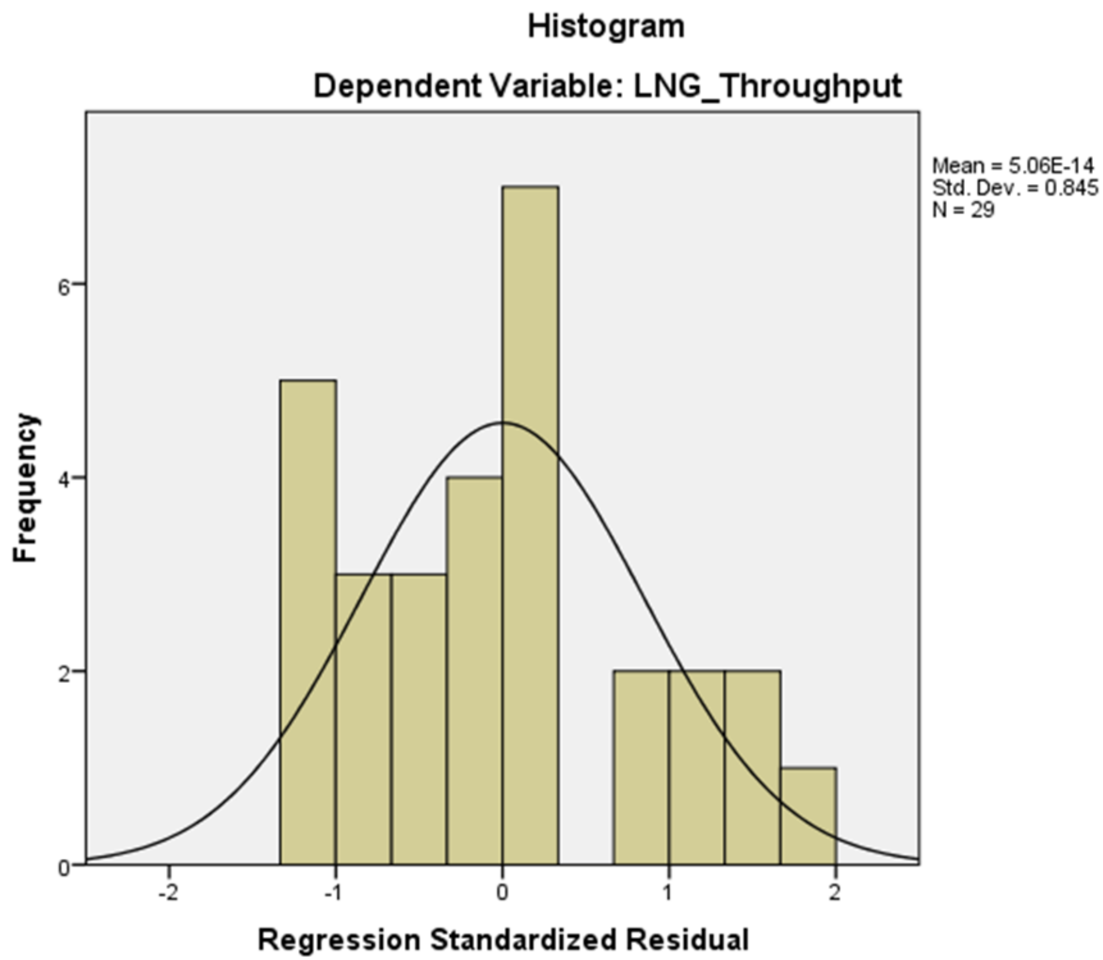
a. Dependent Variable: LNG_Throughput

b. Predictors: (Constant), NG_exp, GDP, TTF, Brent, NG_Imp, API2, NG_Cons, NG_Prod

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	90.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-26919.129	9739.465		-2.764	.012	-43716.962	-10121.296					
	NG_Cons	-.203	.321	-.352	-.634	.533	-.757	.350	-.121	-.140	-.110	.097	10.335
	GDP	.470	.175	.915	2.692	.014	.169	.771	.244	.516	.465	.259	3.864
	NG_Prod	-.072	.100	-1.522	-.714	.484	-.245	.102	-.099	-.158	-.123	.007	152.154
	NG_Imp	.015	.138	.037	.108	.915	-.223	.253	-.051	.024	.019	.253	3.958
	Brent	5.136	5.998	.189	.856	.402	-5.209	15.481	.270	.188	.148	.615	1.626
	TTF	22.579	12.567	.374	1.797	.088	.905	44.254	.069	.373	.311	.690	1.450
	API2	16.541	7.040	.933	2.350	.029	4.399	28.684	.028	.465	.406	.190	5.275
	NG_exp	.112	.175	1.424	.641	.529	-.190	.415	-.081	.142	.111	.006	165.270

a. Dependent Variable: LNG_Throughput



Histogram
Dependent Variable: LNG_Throughput
Mean = 5.06E-14
Std. Dev. = 0.845
N = 29
Frequency
0
2
4
6
-2
-1
0
1
2
Regression Standardized Residual

Model Statistics

Model	Number of Predictors	Model Fit statistics		Ljung-Box Q(18)			Number of Outliers
		Stationary R-squared	R-squared	Statistics	DF	Sig.	
LNG_Throughput-Model_1	0	.844	.559	23.419	16	.103	0