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Impact of The U.S. Shale gas export on East Asia LNG Trading and Pricing - by 2020

by

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Acknowledgments

This thesis marks the culmination of a truly transformational year at the Maritime Economics & Logistics Master Program. As I prepare to graduate, I recollect the journey and express my acknowledgments to those who made this journey easier for me.

First and foremost, I express deep gratitude to my parents. I thank them for countless reasons. Second to none, I thank my wife for being supportive through this year.

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Lastly, I end this by saying - I love you Jaanvi, my little daughter. I missed you badly and cannot wait to get back to you.

Abstract

In the context of present economic environment of low oil price, this paper analyses the impact of U.S. Shale gas export on the Asian LNG market and explores potential implication in terms of LNG trading and pricing - up to 2020. Substantial U.S. LNG supplies will reach the global market by 2020 and the supply would exceed Asia's appetite for LNG. However, the issue now is not just the one of supply and demand, but also of whether or not Henry-Hub pricing of U.S. LNG supplies could fundamentally reconfigure the pricing framework in Asian LNG market? If so, then will the expansion of Panama Canal and over tonnage in LNG fleet be enough to maintain netback for traders in the narrowing US - East Asia LNG price arbitrage window, an opportunity which once enticed traders into LNG business?

This research employs integrated methodological approach of scenario planning and content analysis to navigate through above uncertainties of Asian LNG pricing and LNG transportation cost. This methodology develops a set of credible scenarios about what could happen to the U.S - East Asia LNG market in different contexts and finally proposes strategic insight for LNG trading house.

From the research analysis, Author draws practical implication that low arbitrage margin (less than $1/MMBtu) will be the new normal post 2016. In context of above low arbitrage margin the paper puts forward a strategic insight for the LNG trading houses to long term charter the LNG fleet before 2018. The research develops respective strategy and quantifies possible trajectory in which LNG market will evolve by 2020. The research finds that in the most probable scenario LNG shipping charter rate of around $40,000 /day will erase the positive arbitrage between the U.S.- East Asia LNG trade by 2018.

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List of Abbreviations

U.S.	United States of America
$	U.S $
$/MMBtu	Value of LNG expressed as US$ per million Btu
EIA	US Energy Information Administration
Henry-Hub	The pricing point for natural gas futures contracts traded on NYMEX.
IEA	International Energy Agency
JCC	Japan Customs-Cleared Crude Oil price. It is used for price formation mechanism in long-term LNG contracts in Japan, Korea, and Taiwan
Liquefaction Plant	A large scale processing plant in which natural gas is liquefied by cooling up to minus 161° Celsius.
MMBtu	Million British thermal units
Mt	Million tonne
Mtpa	Million tonnes per annum
Oil-Indexed Gas Prices	Gas prices within long-term contracts, which are determined by pricing formulae having crude oil or defined oil product price.
Regasification	The process of reconverting LNG to gaseous state so that it can be fed to gas distribution system.
F.O.B	Incoterm Free on board
C.I.F	Incoterm Cost, Insurance & Freight

1. Introduction

Author opens this research by putting forward a snapshot of certain events in a chronological order.

- The U.S shale gas revolution led to a tremendous increase in U.S. gas production from 2005 onwards.
- LNG portfolio players, who buy LNG from multiple sources and divert cargo on price signals, started to become more active in global LNG market from 2007onwards.
- Japan LNG price, world biggest LNG import market, reached $16 /MMBtu in second half of 2011. LNG spot and short term market continued to grow in this decade.
- LNG vessel charter rates began to collapse in early 2014. The dramatic oil-price crash in August 2014 gave birth to a new era of low oil price and corresponding gas price. Asia appetite for LNG flattened as China slowed down.
- The 160000 m^3 LNG tanker Asia Vision loaded LNG from U.S. Cheniere's Sabine Pass terminal on 24th February 2016.
- A 161,870 m^3 LNG Vessel transited the expanded Panama Canal on 25th July 2016.

A glance through above discrete events may lead to inconclusive thoughts. However, in fact, above discrete events do have a common thread – a focal issue – and this research aims to put forward the factors, the scenarios and the implications that emerges thereof in view of above events. The research meticulously connects the above dots of events amidst uncertainty of LNG pricing evolution in the Asian markets and LNG shipping charter rate and eventually develops a strategic insight for LNG trading houses, a key player in LNG market.

1.1. Situation

Since the advent of this millennium, the Global LNG sector has been on a roller-coaster ride. What is more remarkable about this rollar-coaster ride is that it has been caused, in part, by a country which was expected to play just a cameo character on the global LNG stage.

The U.S. is poised to become the third largest LNG exporter by the end of this decade (CNBC, 2016). It is a remarkable turnaround because U.S. was expected to be a net importer of natural gas by 2005. However, technological innovation led to low-cost extraction of huge shale gas reserves in the U.S. and unlocked potential export opportunities. The U.S. shale gas boom raised the prospect that significant volumes of natural gas would be available to export markets, and this encouraged companies to set up LNG export facilities. The US LNG export frenzy caught the imagination of traders, businesses and policy makers alike and had worldwide implications. Participation by international traders in the LNG market picked up after 2010, when regional gas prices started to widen, especially caused by the surge of Asian gas prices and the fall of Henry-Hub price. This situation created a tempting arbitrage opportunity in LNG markets, leading international traders to venture into the business. As the price spread between Asia and the United States widened (2011-2013), international traders could purchase LNG from producers or resellers in Europe or the United States and sell it to the Asian buyers at premium.

It is however, important to underline that it is not just the abundance of natural gas reserve and low Henry-hub natural gas prices, in the U.S., that is leading the structural and fundamental changes in the global LNG market. It is happening because the U.S. export contracts are structured very differently to standard LNG supply contracts. They allow contract buyers to source gas on a Henry-Hub pricing formula rather than an oil-indexed price basis. They also allow buyers complete destination flexibility to respond to prevailing global spot price signals. It is no coincidence that a substantial majority of US export volumes have been contracted by LNG portfolio aggregators. LNG portfolio aggregators buy destination free LNG from a wide number of suppliers and then sell it to the highest bidder. This inherent flexibility in U.S. export contracts is set to be a catalyst for the evolution of LNG trading and pricing. The buyers will utilise contract flexibility and then it will drive an increase in LNG market liquidity and also strengthen the dominance of Henry-Hub on Asian LNG pricing. The impact of U.S. shale gas on global stage has started to take effect sooner than expected. To cite few instances - most of the Asian buyers and portfolio players have signed destination flexible contract with U.S. LNG exporters on pricing terms indexed to Henry-Hub. The ripple effect of newly adopted pricing terms became visible on global stage when in late 2013 Qatar Gas, one of two state-owned LNG companies in Qatar, signed a sale-and-purchase agreement with E. ON Global Commodities (Germany) and Petronas (Malaysia) to supply LNG for five years on flexible terms, thereby abandoning its preferred long-term agreements (The Economist, 2015).

1.2. Complication

By Q3 in 2014, the US LNG export frenzy centred around arbitrage potential between the U.S. and Asia-Pacific region started to fizz out as the oil-prices crash started. The tumbling oil-prices brought down also the oil-indexed LNG prices in East Asia markets and thereby severed the arbitrage opportunity. Earlier to the oil-price crash, the East Asian LNG market was seen as a lucrative destination for U.S. LNG, not only because of expected strong growth in demand, but also because the Asian market offered the best arbitrage opportunities. In March 2014, the contract price of LNG in Japan reached over $18 /MMBtu while the U.S. Henry-Hub prices were trading at just over $4 /MMBtu (BP Energy, 2016). However, due to the oil price crash the LNG market dynamics changed drastically in next two years after 2014.

LNG market, characterized by regional pricing, offered price spread regions and allowed arbitrage. However, today, the LNG market is adjusting to the new reality of regional price convergence. This regional price convergence is a result of the perfect storm created by weak Asian demand, supply glut and low oil price. In February 2016, Henry-Hub prices fell to $2.01/MMBtu and the landed price in Asia decreased to a range of between $5.6/MMBtu and $5.75/MMBtu. The U.S. LNG exporters and other players in the LNG market, prior to 2014, would not have originally foreseen such a narrow difference between oil-indexed prices in Asia-pacific and Henry-Hub prices in the U.S. As a result of price convergence between US Henry-Hub and the Asia-Pacific LNG price, after taking into account liquefaction and shipping cost, the profit margin of exporting the U.S. LNG to the Asia-pacific has become even narrower. In these conditions, LNG shipping costs are set to play an increasingly important role in determining LNG flows and arbitrage margins.

The LNG shipping charter rate is expected to stay depressed in short-term, much to the relief of LNG traders, since cheap ship finance resulted in excessive tonnage being introduced in the LNG shipping market. It is especially beneficial for traders who sign short-term contracts and take part in the spot market, as they allow more flexibility and opportunities to hire vessel in last hours and to deliver cargoes.

Also, the opening of new Panama Canal is set to have significant implications for the LNG trade. It has significantly reduced the travel time and transportation costs for LNG shipments from the US Gulf Coast to key Asian markets of Japan, South Korea, China, and Taiwan. These four East Asian countries collectively account for almost two-thirds of global LNG imports. According to (EIA(a), 2016) the expanded canal will now be able to accommodate 90% of the global LNG fleet and would reduce sailing time to North Asia by approximately 14 days.

Under the uncertainty created by regional price convergence, changes in Asian LNG pricing mechanism and the opportunity created by Panama Canal expansion and low LNG charter rates, the LNG trading houses need much better insight into the short term developments to survive the tough days coming ahead. This research aims to provide this insight to the LNG trading houses in this complex and dynamic LNG market.

1.3. Research Question

In the light of above developments, a conservative outlook now characterises the U.S. – Asia Pacific LNG market. The supply-demand would not balance in short-term and the supply overhang would continue in current low oil price environment. However, the liquidity due to oversupply and destination free U.S. contracted LNG volume could accelerate the evolution of LNG pricing mechanism in Asia-Pacific.This volatility of US-Asia pacific LNG trading and pricing, as studied in this paper, is a reflection of LNG market moving to adolescence from infancy. The developments in this adolescent LNG market over the next five years will lay the foundation for future trajectory of change in LNG markets and will have global impacts and implications. So the developments in the Asian LNG trading and pricing for the next five years is important to understand and analyse in academic context.

The aim of this research is to evaluate the impact of U.S Shale gas export on East Asia LNG market. The research evaluates above impact in order to provide strategic insight to LNG trading houses. The research question framed for the purpose is -

What will be the impact of US "Shale gas" export on East Asia LNG pricing and trading by 2020?

In order to aptly answer the above research question, the following sub-research questions have been investigated and answered sequentially in this research, except sub research question 5.

Sub Research Questions.

1. What is the current configuration of Global LNG market?

The purpose of this sub-research question is to present an overview of Global LNG market and thereby set the tone for subsequent research. Respecting the scope of this research, the focus will be on the U.S. as emerging player. Furthermore, the current LNG market is characterized by the rise of LNG trading houses and has been purposefully discussed here. The LNG trading house finds mention also because the implication of this research will reflect on the trading houses.

However, defining the configuration of global LNG market is neither appropriate nor complete if it is done in isolation. It is because no development occurs in a vacuum and there exists interconnected relationships with other factors. One of the significant factor is the influence of oil price on the LNG market and hence the next sub-research question is

2. What is the impact of low oil price on the LNG market?

Answer to this sub-research will lead to the context of regional price convergence and narrowing arbitrage margin between the U.S and the East Asia LNG market. In this new normal of regional price convergence, the cost of transporting LNG from U.S to East Asia market and the evolving LNG pricing mechanism in the East Asia will play a critical role in determining the net arbitrage margin. So moving forward, the next two sub research questions are on evolution of LNG transportation cost and of East Asia LNG Pricing.

3. How will the cost of transporting LNG from the U.S to East Asia evolve in the short term?

Charter rate per day and the fuel cost forms the major cost component for transporting a commodity by sea. Currently LNG charter rates are depressed and the expansion of Panama Canal has drastically reduced the sailing days from U.S Gulf Coast to the East Asia. As the cost of transporting LNG depends on both of above two factors hence, the following sub-sub research question has been framed which when answered in combination will shed light on evolution of LNG transportation cost in short-term

3(a) *How will LNG shipping charter rates evolve in the short-term?*

3(b) *What will be impact of expanded Panama Canal on the cost of transporting LNG from the U.S. to the East Asia?*

4. How will East Asian LNG pricing evolve in short-term?

4(a) *How will East Asian LNG price evolve under continuation of oil-indexed pricing?*

4(b) *How will East Asian LNG price evolve under Henry-Hub indexed pricing?*

4(c) *How will the Henry-Hub price evolve in the short-term?*

Because of the complexity due to above uncertainties of LNG shipping charter and East Asia LNG pricing, the choice of methodology for the research was a significant challenge. So one of the sub research question is -

5. Which methodology should be used in order to quantify and sketch the possible trajectories in which East Asian LNG market would evolve under the impact of U.S Shale gas?

In order to maintain thesis structure and clarity, this sub question is answered early in the research – Section 1.4. The choice of methodology leads to scenario planning. This leads to the next sub research question -

6.What could be possible scenarios for evolution of East Asian LNG Pricing and Trading by 2020?

Based on quantitative and qualitative analysis in combination with scenario planning, the research then attempts to draw practical implication for above scenarios on LNG trading and pricing by 2020. This steers to the final sub research question

7. What will be the implication of resulting scenarios on Asian LNG Pricing and Trading?

This final sub research question will answer the implication of the research findings on the real world of LNG trading houses. The implication will depend upon the scenario which evolves in the short term. The early indicators, discussed in section 1.4, will guide the conclusion towards the most likely scenario.

1.4. Methodology – The Art of Scenario Building

"But, of course, you can never identify all the forces at play. If you could, and see their interactions, then real prediction of the future would be simple."
- Jimmy Davidson, head of Shell group planning 1967–1976 (Kupers & Wilkinson, 2015)

The overarching purpose of this research is to look into short- term future of LNG market. The future of LNG market – like everything else involving future – is full of complexity, uncertainty, and unpredictability. At the start of the research, the Authors confronted a methodological dilemma of choosing between two established methods of futures research methodologies, namely Forecasting, and Scenarios building (Anheier & Katz, 2009). A glimpse of past academic work (Jensen 2004), reveals that the predictions and forecasts, in particular for LNG industry, has been rather difficult exercise for academicians and businesses. In the paper for Oxford Institute of Energy, (Jensen 2004) concluded that North America will emerge as major LNG importer and that LNG spot traded volume will continue to be on lower side. The conclusion was based on extrapolation of knowledge about the past and present into the future. In the present context, or in reality as we can see, the conclusions of above paper and other similar paper no longer hold true. A technological innovation of horizontal drilling and hydraulic fracturing led to low-cost extraction of shale gas reserves in North America and the resulting shale gas boom contradicted then existing academic work. Had been a Scenario methodology adopted, then the external factor of "horizontal drilling and hydraulic fracturing" would also have had been included for development of possible future scenarios.

According to (Kosow & Gaßner, 2008) in a forecasting method, the selection of a single future direction and the emergence of a single future scenario automatically excludes certain alternatives, the alternatives that could emerge due to the interaction of "External factors" and "uncertainties". The choice of single future methodology (forecasting) proved itself not so reliable methodology for the academician (Egging et al. 2010);(Lochner & Bothe 2009);(Weijermars 2012) and industry experts (EY, 2011) ; (Archives-EIA, 2011);(Voser 2012) again at start of this decade. The surging Asian LNG gas demand and high oil price led many to estimate a future with LNG demand exceeding supply and the continuation of high arbitrage margins between Asian and Atlantic markets. However, the dramatic oil price crash in 2014 and unexpected flattening of Asian gas demand brought LNG market at the threshold of an unexpected scenario - something which was not thought off at the start of this decade. 2015-2016 sees the LNG industry at a crossroad. It is an open question whether it would embrace new possibilities of pricing and trading in an orderly way or would be lost in the chaos created by low oil price and only lead to ad hoc adjustments in the market. Either way the implications are wide and deep for the LNG market players.

For above reasons of uncertainty and unpredictability which lies ahead, it makes more logic to discuss in the plural of the "possible scenarios" for LNG market rather than of "single future scenario". The research methodology technique which allows developing "possible future(s)" is that of scenario-building and so was preferred as a methodology in this research.

Scenario building, simple it may sound, but is much more strategically sound technique. The technique is not new and finds its root in the military - where many uncertainties exists and incorrect choices often lead to grave and regrettable consequences. The scenario building technique was developed and seasoned - with corporate texture, by Shell in early 1970's. Not coincidentally, the scenarios were developed for the volatile energy market - then oil - as the traditional forecasting proved very limiting as a tool. Head of Shell's Group Planning Division, Pierre Wack challenged then existing usual business forecasting techniques and laid the foundations for scenario planning. Shell strategically developed a set of credible scenarios about what could happen to the energy market in different contexts. The scenarios that were developed allowed Shell to respond effectively and to even profit from the 1973 oil crisis (Wilkinson & Kupers, 2013).

A proper scenario building technique can provide organizations(market-players) with the foresight of probable scenario and can help them balance structure and agility at same time. This improves the chances of survival in a foreseen crisis. The LNG market is a sub-set of natural gas market, which in turn, is a sub-set of overall energy market. The energy sources – LNG, coal, oil, renewable energy source and nuclear energy – interact in a complex environment which is directly influenced by supply-demand fundamentals, geo-political strategies, commercial motives and environmental regulations. (McDermotta, et al., 2015) successfully conducted a complex system analysis of the natural gas market and highlighted the need to analyze such complex system in view of complexity theory. LNG market being a part of global natural gas market is also a complex system. Even in this complex system, the market-players (traders, buyers and sellers) need to maintain a balance between being organized and structured on one hand and being adaptive and agile on other hand. Such balance is hard to achieve in a dynamic, unpredictable and multi-dimensional system (Marjorie, 2012).

In view of above, this research employs an 8 step scenario planning technique to develop scenarios for the complex and evolving U.S - Asia LNG market and to provide strategic insight for LNG trading houses. A conventional scenario planning technique does not suffice the requirement of a complex system. But fortunately the scenario planning techniques has evolved over time and this research applies the most recent and innovative 8 step Scenario Planning methodology. This concept has been developed by Stratfor - a reputed geopolitical intelligence firm that provides strategic analysis and forecasting.

This methodology has following 8 steps - Source: (Ogilvy, 2015)

Step 1: Focal Issue
The process commences with identification of focal issue. The research question itself identifies the focal issue.

Step 2: Key Factors
Based on the scope of this research the key factors are introduced and discussed. The key factors are the prime cause factor – the U.S Shale gas export in this research, and the end affected factor – the LNG trading house. The content of subsequent steps 3,4 and 5 evolve separately but would converge at scenarios development in step 6. The ultimate objective is to develop scenarios from the strategic view point of LNG trading house.

Step 3: External Forces
After discussing the key factors, the most relevant external forces are introduced and analysed. Sound strategic planning and scenario planning includes the influence of external forces because no event or development happens in vacuum but instead happens in a complex environment. The oil price crash and developments in LNG shipping industry are the two relevant external forces discussed in this research. The external force pertaining to geo-politics and environmental regulatory measures have not been included and has been mentioned as a limitation of this research.

Step 4: Critical Uncertainties
Identification of the critical uncertainties is an exhaustive exercise which involves interviews and feedbacks from industry participants. This research, constrained by limited resource, employs content analysis for determination of the key uncertainties. For content analysis, Author diligently referred to most of the trusted source for information on LNG market. The sources include but not limited to news from Reuters, Bloomberg, Financial Times, Wall Street Journal, reports from International Gas Union (IGU), reports and information from U.S. Energy Information Administration (EIA), publications by Oxford Institute for Energy Studies, Commodity Market reports from World bank, publications from Rice Baker Institute for Energy Policy, papers from Institute of Energy Economics-Japan, papers and bulletins from International Association for Energy Economics, publications from Ministry of various other peer-reviewed journals and lastly reliable industry sources such as Trade winds, IHS Fairplay, LNG-World, Poten & Partners, Wood Mackenzie, Timera-Energy, Drewry, EY, BP energy outlook to name few.
The key uncertainties that surfaces above are namely; How Japan LNG pricing mechanism could evolve in the short term and the how the cost of transporting LNG from the U.S to the Asia-Pacific LNG market could evolve in the short term?

Step 5: Scenario Logics
After identifying the critical uncertainties, the next challenge is to narrow down to possible futures that can lead to strategic insight. To elaborate – LNG charter rates reached more than 100,000 $/day after the Fukushima incident in 2011. However, based on content analysis it becomes evident in paper that the LNG charter rates will not reach the such high value in the short-term. So, in essence, the scenario logic filters out such high values of charter rate in this step. On basis of content analysis, the research narrows down to realistic estimate of Henry-Hub price band and LNG charter rate range for the short term.

Step 6: Scenarios
Based on Steps 3,4 and 5, this step sketches the 2x2 scenario matrix.

Step 7: Implications
This step carves out the implications of each scenario. The implication of a scenario is discussed within the scope of focal issue 1 and the key factors 2.

Step 8: Early Indicators
The scenario planning steps results in a 2x2 scenario matrix which comprises of four scenarios. The purpose of scenario matrix is to make an organization aware of possible futures that may emerge. Realistically all the four scenarios are possible. However, for an organization to simultaneously adopt four different strategies for four different scenarios is neither feasible nor advisable. Early indicators are harbingers of subtle changes and serves the important function of indicating the scenario which is most probable to happen among the identified four scenarios. It filters the most probable scenario so that the most suitable strategy can be adopted. Early indicators appear in form of reporting, publications, news and announcements.

1.5. Thesis Structure

This research develops around the 8 step scenario planning methodology as shown below.

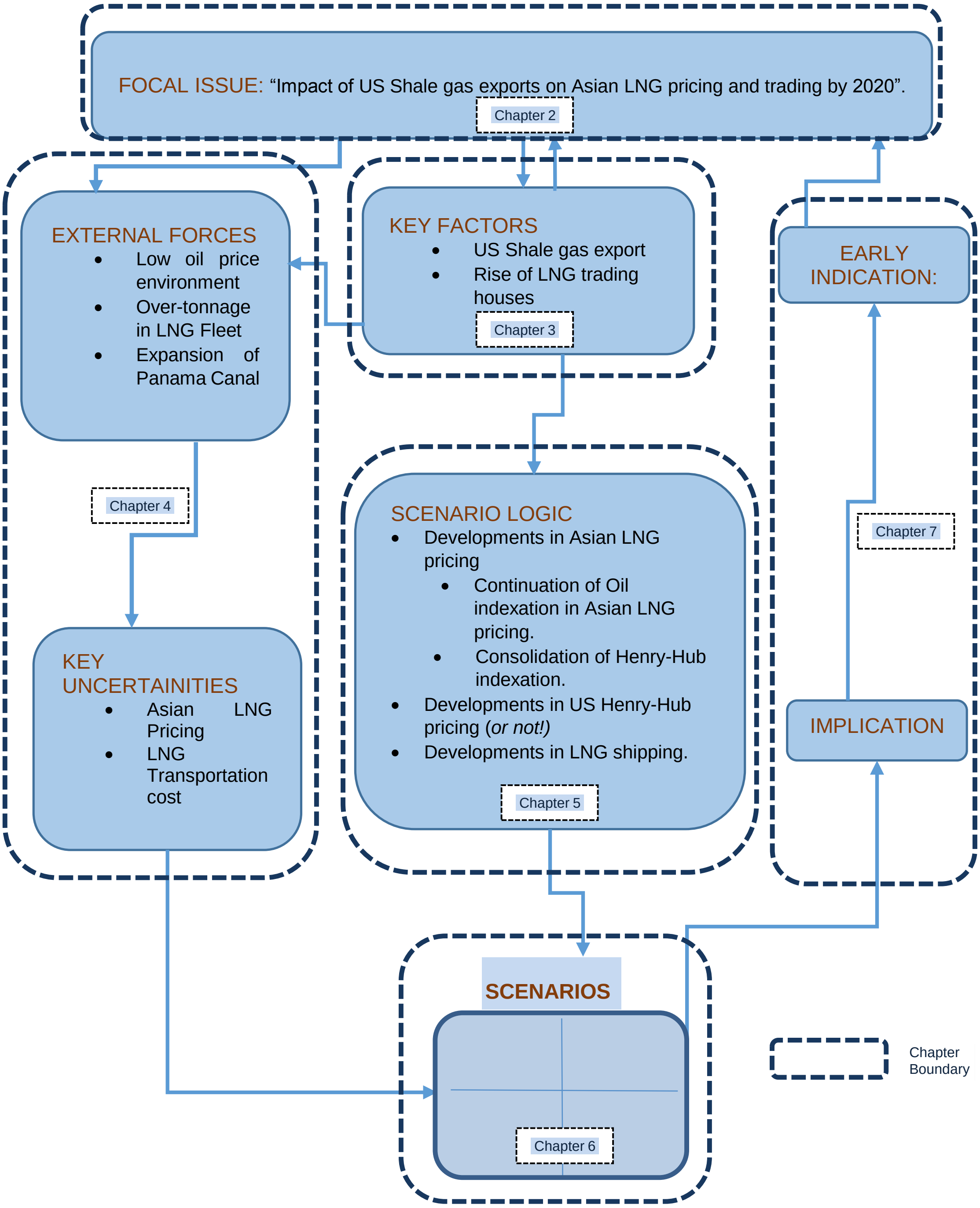


Figure 1: Scenario Methodology

Concept Source: (Stratfor, 2015)

The research begins with an introduction of the focal issue "Impact of US Shale gas exports on Asian LNG market and its implication on LNG pricing and trading by 2020". The research commences with Chapter 2 - which gives a brief analysis of LNG market in the conceptual context of overall natural gas market. It then narrows down to - the overview of LNG market with focus on key LNG importer market of Asia. This is followed by a discourse on business structure and pricing structure of Asian LNG market. Next, in Chapter 3 the paper introduces key factors of the U.S. shale gas export and the rise of LNG trading houses. The aim is to qualitatively motivate as to how the U.S. shale gas export could trigger transformation of East Asian LNG market and introduces the focal issue of this research. In the next Chapter 4, the external driving forces of oil price crash and LNG shipping are introduced and discussed in context of potential threat arising out of persisting low oil prices and hidden opportunities spurting from the expansion of Panama Canal and over-tonnage in LNG fleet. The purpose, here, is to anticipate possible scenarios that could develop due to the complex and unpredictable interplay of the key factors identified in Chapter 3 and the external driving forces discussed in Chapter 4. Chapter 4 also serves the purpose of answering the sub research question numbered 2 and 3. Later in Chapter 5, scenario logic is developed by aligning the key factor of U.S. LNG export and the external factors of oil price and LNG shipping rate. This chapter answers the sub research question number 4. Next in Chapter 6, a scenarios development is discussed and explained. This chapter elaborates on the sub research question number 6. Finally, the last Chapter 7 outlines the conclusions, implications and presents some early indications, outlines the research limitations and suggests some topics for further research. This chapter answers the final sub-research question number 7.

2. Liquefied Natural Gas (LNG) Market - An Overview

This chapter is divided into three sections and aims to provide an overview of Global LNG market. Section 2.1 discusses LNG in the bigger context of natural gas market. Section 2.2 focuses on key LNG demand market of Asia-Pacific and Section 2.3 discusses the contractual and pricing structure in the LNG market. *The completion of Chapter 2 marks the introduction of focal issue and closure of 1st sub-research question "What is the current configuration of Global LNG Market?"*

2.1. LNG in context of Natural gas market

"*There is no demand for LNG per se; only demand for natural gas*" (Moore, et al., 2014). The LNG market is a derived market of natural gas. It is, therefore, important to see LNG supply-demand in the context of the overall natural gas market. The focus of this paper is on LNG trade, however, a brief introduction to the natural gas market would make the picture complete.

The natural gas trade flows from the natural gas supply markets to the demand markets where natural gas consumption exceeds the supply of natural gas from local sources. According to (IGU, 2016), roughly 70% of global gas production is consumed in the country where it is produced, and about 30% of global gas production is exported across international borders. Out of above 30% of the global natural gas flow that crosses international borders nearly 67.5% flows through pipelines, and 32.5% is moved to market destinations as liquefied natural gas (LNG). LNG is a liquefied form of natural gas, produced by cooling down natural gas to -162 Degree Celsius. By doing so the gaseous volume shrinks 600 times and hence allows for efficient transportation by LNG vessels over long distances.

Prior to the development of liquefied natural gas (LNG) technology, the transportation of natural gas was limited to distances that could have been served by pipeline and it consequently, led to regionally segmented gas markets. However, with the advent of cost effective technology for liquefaction of natural gas, the option for trading gas by LNG tankers became more significant for long distances.(Jensen 2004) clarifies that pipeline is more cost effective for short distance but longer distances favour LNG . It is because LNG transportation involves additional cost of liquefaction and regasification irrespective of the distance travelled. (Neumann 2009) shows that that the inflexibility of delivery points in the pipeline trade and restrictive cost of pipeline transportation over 3800 miles led to regionally isolated gas markets whereas, the flexibility provided by LNG transportation and lower cost over longer distance has led LNG to play a key role in global gas market integration. Other research (Barnes & Bosworth 2015), further substantiates analytically that LNG trading has helped to integrate global natural gas markets over years.

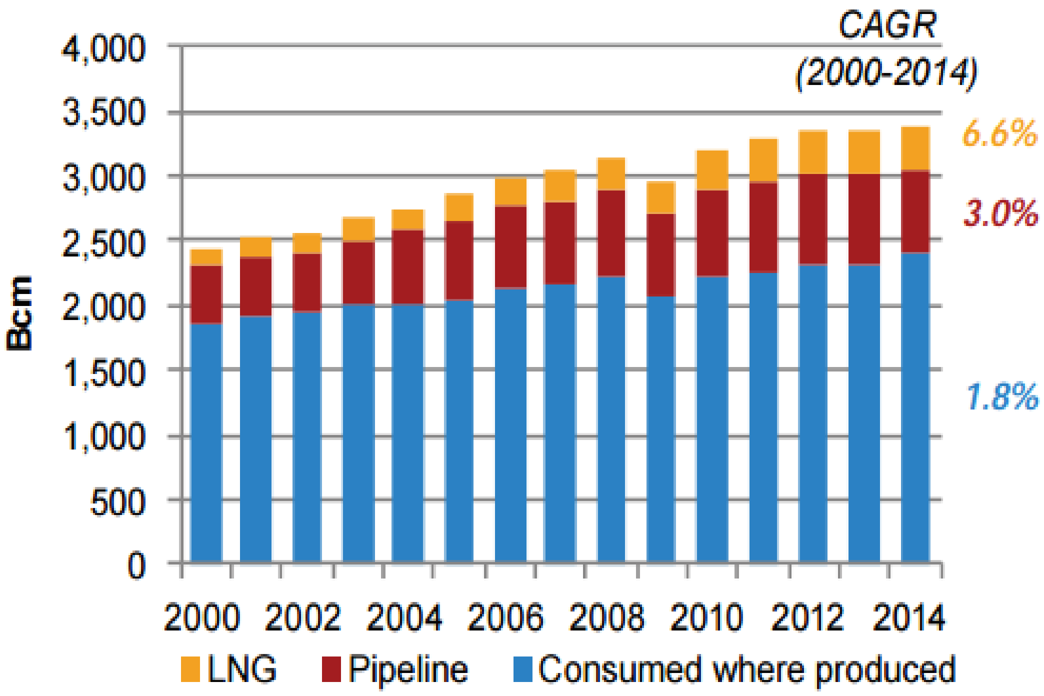


Figure 2: US Natural gas trade flow

Source: (IGU, 2016)

The LNG trade has increased at compounded annual growth rate of 6.6% from 2000 to 2014 (Melorose et al. 2016). According to (BP Energy Outlook, 2016), LNG trade would continue to increase at above rate and overtake pipeline trade as a major form of gas trading by 2035- see figure 3.

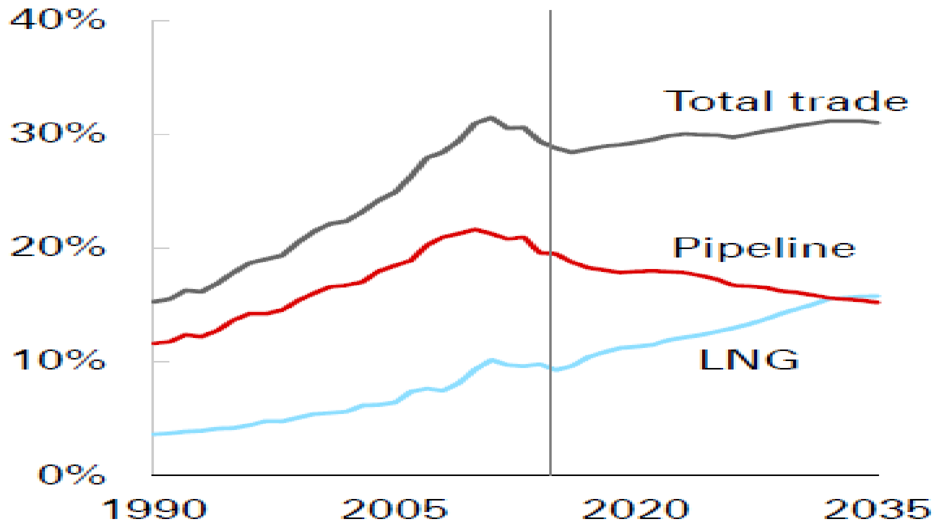


Figure 3: Global Natural gas trade

Source: (BP Energy Outlook, 2016)

LNG, as a means of transportation and trading natural gas, has been in existence for five decades. It started in 1959 when first LNG tanker “Methane Pioneer” with cargo capacity of 5000 m^3 carried the first LNG shipment from Louisiana, U.S to U.K. The largest LNG tanker today “Mozah” has cargo capacity of 266,000 m^3. This increase in size of LNG tankers is just one of the indicators of the volume growth in global LNG trade. The global LNG trade grew from 50 Million Tonnes in 1990 to more than 250 Million tonnes in 2015 (Figure 4). The success of LNG tanker “Methane Pioneer” prompted Shell to order two purpose built LNG tankers for Algeria-UK gas trade in 1964 and triggered the growth of global LNG trade. Today, Shell manages and operates more than 40 LNG carriers in an industry-wide fleet comprising around 400 carriers (Shell, 2016).

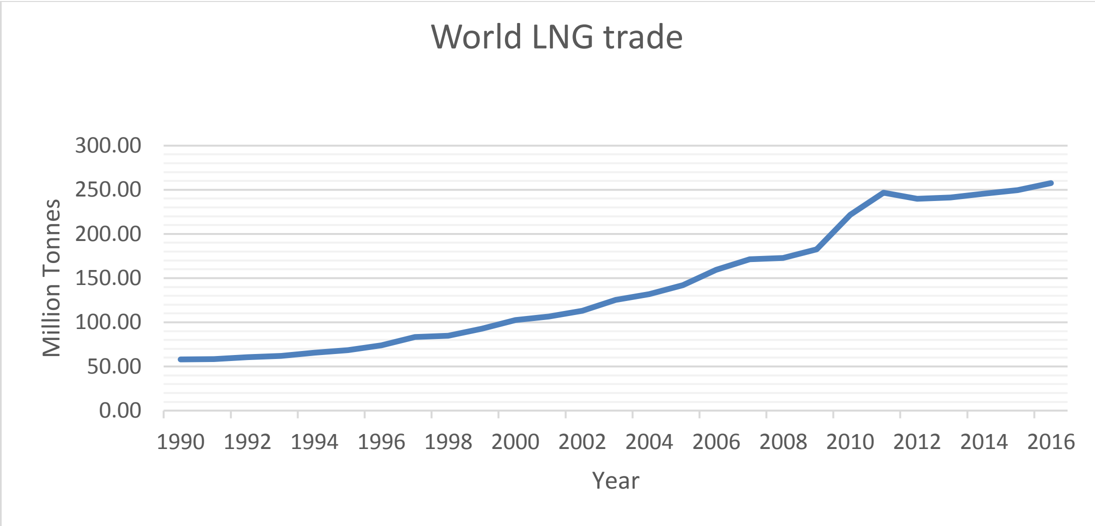


Figure 4: World LNG trade

Source: Clarkson Research data

2.2. East Asia LNG market

Most LNG demand growth as reflected by figure 4 comes from the East Asia region. The four countries- Japan, South Korea, Taiwan and China account for almost two-third of global LNG import. The Asian markets of Japan, South Korea, Taiwan and now China and India is regarded as demand center for LNG. Figure 5 shows how significant is the East Asian countries for the global LNG trade.

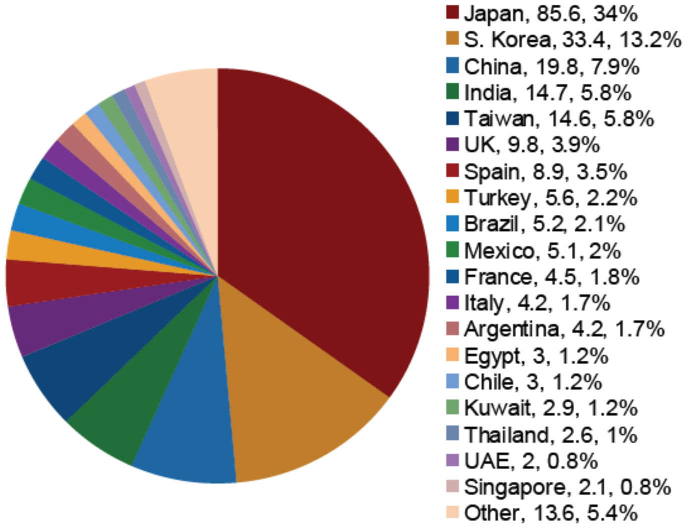


Figure 5: Global LNG demand in MTPA

Source: (IGU, 2016)

For the prominent LNG markets in Asia Pacific LNG the only feasible source of gas supply. It is due to the geographic and geologic restrictions of those countries. Japan, South Korea and Taiwan – the three most important LNG markets in Asia – rely almost entirely on LNG import to meet the gas demand. They have zero to negligible domestic production and no pipeline import infrastructure (IGU, 2016).

Having underlined the importance of Asian market as the key import market for LNG, now figure 6 illustrates the LNG trade in 2015 between the importing and exporting regions. It is remarkable to observe that the North America and Asia & Asia-Pacific LNG trade stood at 0.3 MT in 2015. The 0.3 Million tonnes LNG if converted into shipment, will be equivalent to approximately three vessels of 160,000 m^3 annually leaving U.S. for the import markets. As per EIA estimates, LNG traffic through the expanded Panama Canal could reach more than 550 vessels annually, or 1-2 vessels per day, by 2021 Most of the vessel would originate from U.S and proceed for the Asian market. Such would the magnitude of the impact of the U.S Shale gas export on the Asian markets and hence is the focal issue of this research. The impact of U.S shale gas would not be just volumetric as discussed above but also structural. The structural change such as Henry-Hub pricing due to the U.S LNG export will be detailed in Chapter 5.

Exporting Region / Importing Region	Africa	Asia-Pacific	Europe	Former Soviet Union	Latin America	Middle East	North America	Reexports Received	Reexports Loaded	Total
Africa	0.5	0.1	0.1		0.1	1.7		0.6		**3.0**
Asia	4.4	14.6	0.1	0.2	0.4	15.5		0.7	0.3	**35.6**
Asia-Pacific	9.7	68.5	0.3	10.7	0.4	49.4	0.3	1.1	0.5	**139.8**
Europe	15.8		2.3		2.1	20.8		0.2	3.6	**37.5**
Latin America	3.2		1.3		7.5	1.6		0.9		**14.6**
Middle East	1.2	0.8			0.9	3.0		1.0		**6.9**
North America	1.5	0.2	0.3		4.8	0.6		0.1	0.2	**7.4**
Total	**36.3**	**84.1**	**4.2**	**10.9**	**16.2**	**92.7**	**0.3**	**4.6**	**-4.6**	**244.8**

Figure 6: LNG Trade in 2015 (in MT)

Source: (IGU, 2016)

The buyers in the major Asian import countries – Japan, Taiwan, China and South Korea are characterized by affirmation to sign long term contracts with LNG prices linked to crude oil prices. For buyers such terms ensure supply security and an easy non-contradictory reference pricing to crude. The LNG suppliers prefer such contractual structure in order to mitigate risks associated with high capital cost involved liquefaction facility.

2.3. Contractual and Pricing structure

Contractual Structure

LNG has been traded mainly under long-term, fixed destination contracts. However, in recent years, the supply glut and weakened demand in conjunction with emergence of portfolio players and traders has aided in increase of LNG volume being traded under "non-long term" contract. IGU defines non-long term contract as the contracts signed for less than 5 years. The development of "non-long term" contract or in other words the "spot & short term" contract was further aided by Fukushima crisis and the shale gas production in the U.S. The two factors led to huge increase in the arbitrage margin between the U.S and East Asian markets.

According to (IGU, 2016) in 2015, 28 percent of global trade was done under spot & short term contract- see figure 7. Spot & Short term trade has following two key feature which distinguishes it from long-term contracts.

- It refers to cargoes that are less than 5 years of Sales and Purchase Agreements.
- Cargoes are free from destination clause and can be diverted from their original/contractually binding destination.

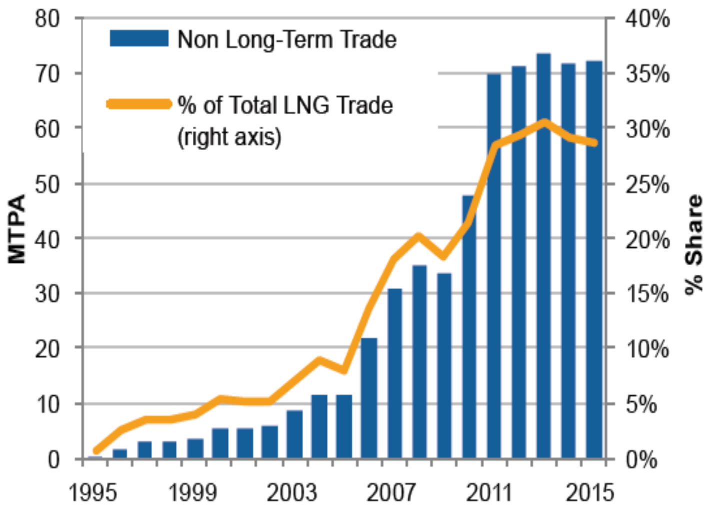


Figure 7: LNG contract structure

Source: (IGU, 2016)

<u>*Pricing Structure*</u>

(IGU, 2016) in Global Review of Pricing Mechanism Report identifies 8 types of pricing mechanism for international trade in natural gas. However, broadly there is two kinds pricing system that is used for LNG trade. One is oil-indexed pricing and the other is gas-on-gas based pricing. In Gas-on-gas pricing the spot price determined by market fundamentals of supply and demand. The Henry-Hub natural gas price is the perfect example of gas-on-gas pricing. Under oil-indexation, the price of natural gas linked to oil market spot prices. The oil indexation gives rise to a fundamental pricing problem because in oil-indexation the price of gas changes in response to supply-demand balance of oil. Figure 8 shows the global LNG pricing formation.

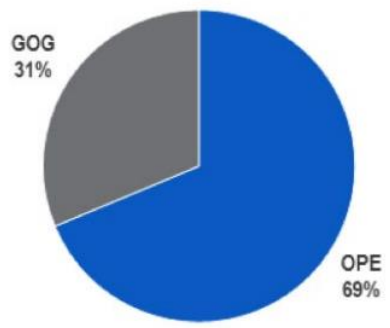


Figure 8: Global LNG Pricing mechanism.

Source: (IGU, 2016)
Note: GOG stands for Gas-on-gas pricing mechanism and OPE stands for oil-indexation

Clearly oil-indexation still dominates the LNG pricing mechanism. The prime reason for this is Asian import markets which account for almost two-third of LNG import and use oil-indexed pricing. Figure 9 illustrates that international trade in North America entirely uses the gas-on-gas pricing system and is Asia-Pacific, oil indexation is dominant.

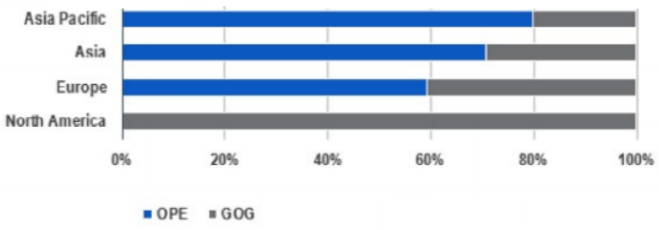


Figure 9: LNG pricing mechanism in regions

Source: (IGU, 2016)

The above discussion on pricing mechanism highlights the contrasting difference between the pricing mechanism used in North America and in the Asia-Pacific region. As the west meets east due to shale gas export from U.S. to the Asia-Pacific, it is expected that a stage will be set for major adjustments in the pricing mechanism of Asia-Pacific. The excitement of the pricing confluence and its implication are hence also the focal issue of this research.

3. Key factors

Based on the scope of this research the key factors are introduced and discussed. The key factors are the prime cause factor – the U.S Shale gas export in this research, and the end affected factor – the LNG trading house. In reference to the thesis structure outlined in section 1.5, figure 1 – the below block acts as readers guide to the flow of this research

KEY FACTORS
- US Shale gas export
- Rise of LNG trading houses

3.1. *Game Changer "US Shale gas"*

U.S. Energy Information Administration report (EIA, 2003) and prominent research (Jensen 2004), prior to 2005, reported as U.S. to emerge as biggest LNG importer. However, today the U.S. is poised to become top three LNG exporters by 2020 (CNBC, 2016). The United States transition from being a net importer of 1.0 Trillion cubic feet of natural gas in 2015, or 3% of U.S. total natural gas supply, to a net exporter by 2018 is truly remarkable and has been made possible by technological innovation of low-cost extraction of huge shale gas reserves in the U.S. According to the U.S Energy Information Administration (EIA), the US will become a net exporter of natural gas in the 2nd half of 2017 (EIA(b), 2016). Another remarkable side of this story is that the lion's share of U.S. gas export will be through LNG transportation- see figure 10. According to projections in the Annual Energy Outlook 2016 (EIA(a), 2015), almost 50% (3.6 Trillion cubic feet) of the growth in net exports that occurs by 2021 would be liquefied natural gas exports.

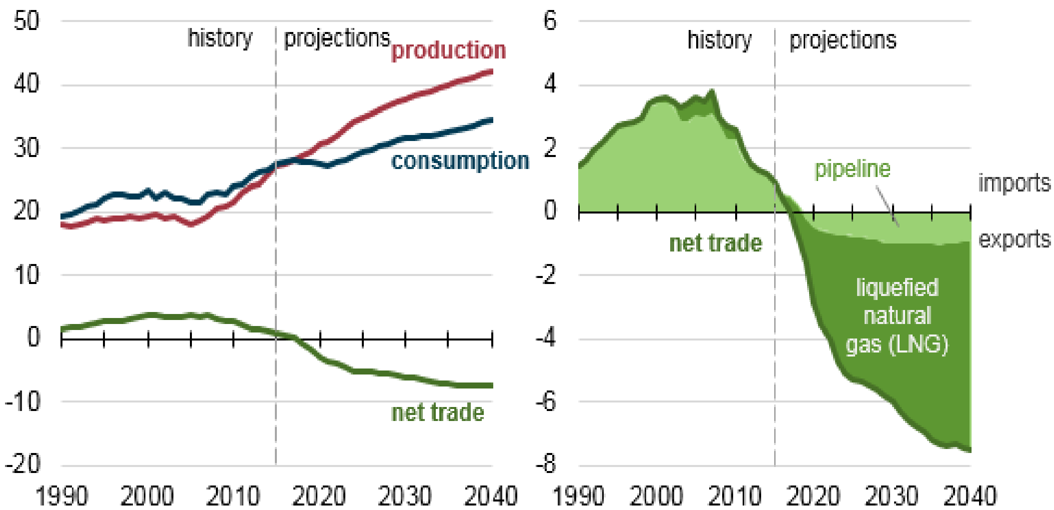


Figure 10: US Natural gas production & consumption

Source: (EIA(a), 2015)
Note: Unit in trillion cubic feet

As it is evident from Figure 11, that the U.S. LNG will increase from virtually zero in 2015 to almost third largest LNG exporter by 2020. The phenomenal rise in the U.S. Shale gas production and the corresponding increase in LNG export capacity is the prime reason as to why the impact of Shale gas export will be much more radical than the conventional exporter Qatar. There will be no increment in Qatar LNG production in up to 2020. Australia will also add significant liquefaction capacity between 2015-2020.

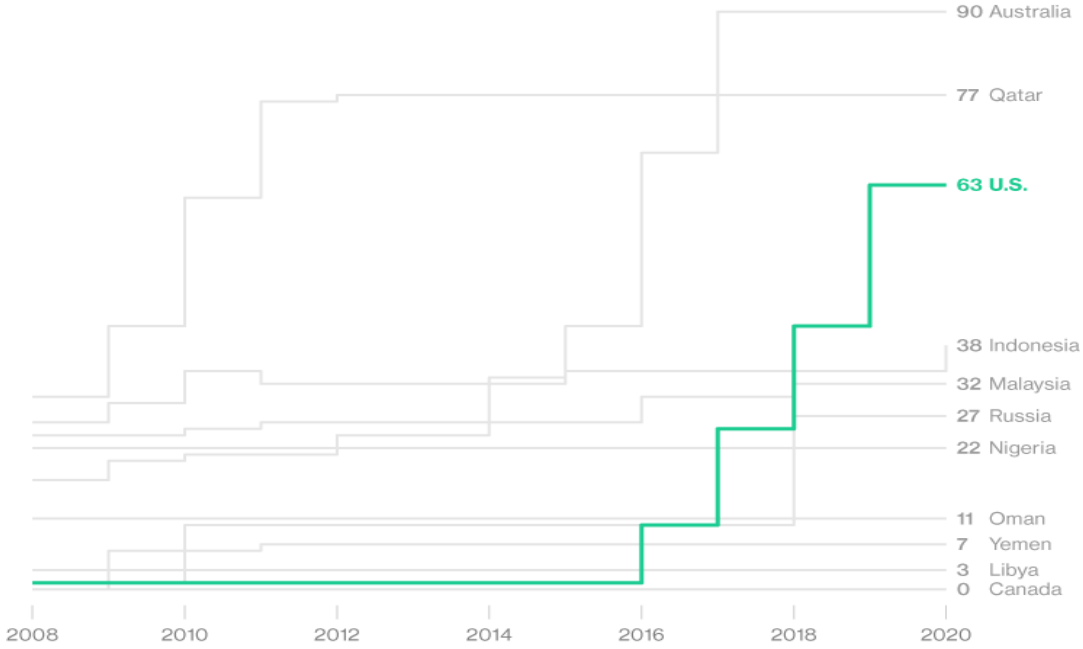


Figure 11: Global Natural gas exporters

Source: Energy Aspects via (Bloomberg(a), 2016).
Note: Liquefaction capacity in MTPA

The impact of Australian export will not be as significant as the U.S LNG export because the Australian LNG contracts have oil-indexed pricing clauses. In a contractual clause with oil-indexed pricing, the price of LNG is calculated in relation to oil. This pricing mechanism will be discussed in detail in section 2.3. The U.S shale gas is cheaper to produce and has pricing mechanism linked to Henry-Hub. The Henry-Hub pricing and the destination free contract gives puts U.S shale gas export at an advantage to the Australia export. The Australian LNG suppliers need to reduce prices in order to compete with U.S. LNG . However, the Australian projects are facing steep price increase, mainly because production costs are higher than anticipated, and labor costs rose sharply. Because of that, combined with the fact that Australian LNG prices have been linked to oil, the Autralian LNG export will loose to U.S LNG export, inspite of being closer to the Asian market (Boersma, et al., 2015). The Australian and Qatari LNG export would continue to add volume to an already over supplied market but the U.S. LNG export is a game changer because firstly; U.S. LNG export, unlike LNG export from other countries, has unorthodox pricing mechanism-linked to Henry-Hub and secondly; the contracts signed by U.S LNG exporters does not have any destination clause. It is a clause which restricts the LNG buyer to only move the LNG cargo from the loading terminal to a specific unloading terminal, as mentioned and signed in the contract.

In essence, the U.S. will not only emerge as a large exporter and add LNG volumes to supply side but will also disrupt global LNG commercial and pricing practices. By initiating transformation in LNG trading & pricing dynamics, the US shale gas is set to tear apart the conventional fabric that prevails in global LNG trade. Export terminal developers and sponsors are “breaking the rules” of global LNG trade by bringing new low-cost LNG volumes, without the inherent destination clause, at transparent Henry hub-based pricing. The evolving results of this unorthodox structuring of price and contractual terms will fundamentally alter global LNG commercial and pricing practices (Goncalves, 2014).

The remarkable and unorthodox nature of U.S LNG contracts and its’ phenomenal rise as third largest LNG exporter by in 4 years (2016-2020) – see Figure 11, is the prime reason as to why this research focuses on the impact of U.S LNG export on LNG market.

3.2. Rise of New Players: LNG Trading Houses

In a landmark sale and purchase contract, signed in 2004 and effective from 2007, the Equatorial Guinea LNG project sold its entire LNG output to British Gas - BG (now Shell) for 17 years on a Free-On-Board basis. The F.O.B term with destination flexibility in the sale and purchase agreement (S.P.A.) allowed BG to divert cargoes on price signals and thus enabled BG to optimize and monetize the delivery and act as an aggregator (Reuters, 2013). BG signed the contract at a fixed discount to the U.S. benchmark futures price at Henry-Hub in Louisiana. It made sense for BG to sign the contract at fixed discount to U.S. Henry-Hub since BG intended to send the cargo to U.S. markets. It is remarkable to again underpin the fact again that in 2004, the U.S. was poised to become a major LNG importer and Shale gas revolution had not yet happened. However, by the time the contract came to effect in 2007 the U.S. shale gas revolution had slashed domestic U.S. Henry-Hub price to $4 /MMBtu. Though BG was buying LNG from Equatorial Guinea LNG project at about 90% of Henry hub price, profit remained feasible but profit volume reduced dramatically. Riding on to the destination flexibility clause in S.P.A., BG then diverted Equatorial Guinea LNG to Asian markets and gained remarkable Asian premium. This deal and the subsequent chain of events marked the entry of Portfolio players also named aggregators (arbitrageur). An aggregator buys LNG cargoes from multiple supplier, as indicated by multiple blue lines – see figure 12. The grey circle represents commodity transformation in space. The portfolio player does so to improve optionality. They prefer to be asset-light and rent underutilized assets (excess shipping tonnage or LNG storage capacity) to serve the purpose. The LNG cargo is then diverted to the buyer has need of commodity and is eager enough to pay the price of optimality. Figure 12 is representation of a Portfolio player, as visualized by BG Group.

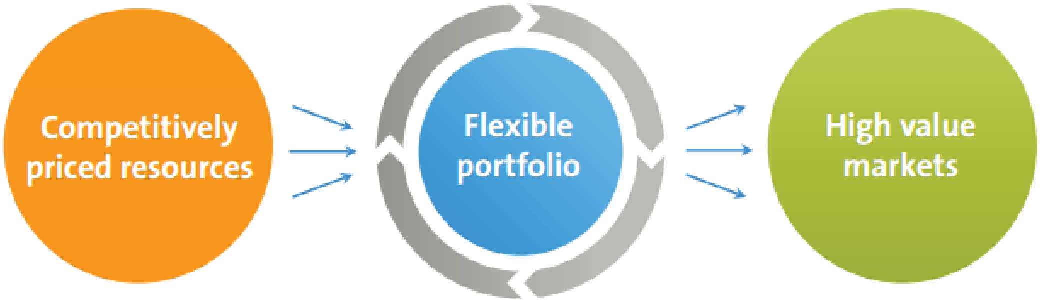


Figure 12: Portfolio

Source: (BG, 2011)
Note: Above source is no longer available as Shell updated the content.

(Zhuravleva 2009) in her paper "The Nature of LNG Arbitrage: an analysis of the main barriers to the growth of the global LNG arbitrage market" for Oxford Institute for Energy Studies, identified three basic models of physical LNG arbitrage.

- LNG seller acting as Arbitrageur
- LNG buyer acting as Arbitrageur
- Independent trader acting as Arbitrageur

She further categorized portfolio optimization and LNG spot trading as activities different to arbitrage transactions stated above. However, much in line with recent developments, (Ledesma & Corbeau 2016) mentions that rise of aggregators (arbitrageur) and increase in portfolio LNG, in conjunction with other market developments, led to the entry of new players -The LNG traders. LNG traders such as Trafigura, Vitol, Gunvor, and Glencore progressively are getting more and more involved in LNG trading. The paper (Ledesma & Corbeau 2016), in hindsight, suggests intertwining of the broader activities summed up by (Zhuravleva 2009). Also, (Hartley et al. 2013) argues that LNG market liquidity encourages greater volume and destination flexibility in contracts and increases reliance on short-term and spot market trades. These changes, in turn, reinforces the initial increase in market liquidity. Even though there is no known academic work that investigates the relation between how increased liquidity effects the growth of LNG portfolio players and LNG traders or vice-versa, a simple timeline reveals that growth of spot markets from 2000, see figure 13, facilitated the growth of Portfolio players as reflected by BG deal in 2004 and this, in turn, created room for entry of organized LNG traders as indicated by Vitol entry in 2007-2008 (Poten & Partners, 2015). The cause & effect relation among above developments is not of prime interest to this research, however, assuming the above causation flow, as evidenced by timeline, leads to a more structured flow of current research. The net result is significant because the entry of liquefied natural gas (LNG) trading marks a turning point for a market that has been for long constrained by the grip of major oil companies on long-term supplies.

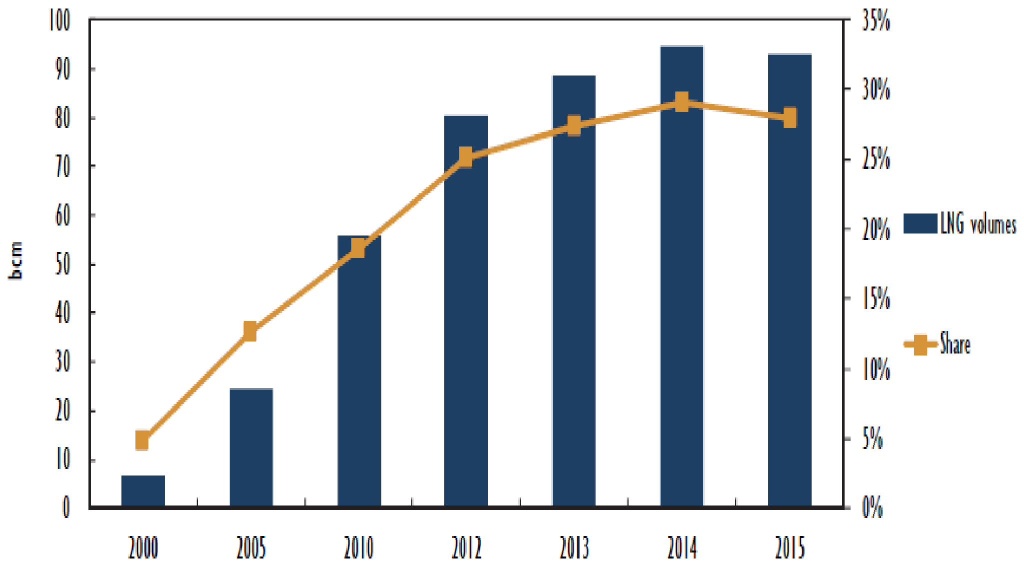


Figure 13: Spot and Short-term LNG contracts: 2000-2015

Source: (International Gas Union, 2016)

The trend of international LNG traders increasing their share in the LNG market is hard to ignore as it points towards a major restructuring of existing LNG market. In June 2015 (Poten & Partners, 2015) reported that independent commodity traders delivered volumes around 3% LNG of market share. (Reuters(a), 2015) approximated the trading companies to account for 10 percent of overall LNG trade. The reported further highlighted that as the exchanges from Singapore/Tokyo spot indices and futures contracts matures, the increase in volume traded by LNG trading houses will trigger a more liquid Asian LNG market. True to above anticipation Trafigura -a leading trading house, made the first trade of newly-launched derivatives contract for liquefied natural gas (LNG) in January 2016 (Reuters(b), 2016). The transaction was done based to Singapore SLInG, Singapore's weekly spot price index for Asian LNG. In addition to increased liquidity, five other structural factors that can be linked to growth and increasing clout of LNG traders. They are

- significant divergence of regional gas prices at start of decade.
- risk profile of emerging buyers (Pakistan, Jordan etc.)
- un-tight LNG market from excess supply (U.S. Shale gas export & Australian projects) and weak demand (in Asia).
- contractual flexibility of U.S. shale gas exporters.
- availability of free (uncontracted) LNG tonnage

The significant divergence of regional gas prices, caused by a surge of Asian gas price in 2010, caught the attention of trading houses and their participation grew rapidly since then. A four-year supply deal with Kuwait Petroleum Corporation (KPC) in 2010 allowed Vitol to enter into a mid-term supply deal without having its own supply source. This was followed by Trafigura 18 months of supply deal to Mexico in 2013. (Bloomberg, 2013). Gunvor Group in 2015, won a tender to supply 120 cargoes to Pakistan over 2016-20 (Reuters(c), 2015). Most, but not all, of the supply contracts secured by the independent trading houses are short to mid-term. In a deal announced in April 2012 and effective from 2015, Vitol secured 10 years of supply contract to Korea Midland Power (Komipo). Such medium and long-term positions are valued high in LNG market and so Vitol 10 years' supply could act as crystal glass of future opportunities for other traders. Table 1 below summarizes the recent LNG trading activities.

Major LNG Traders and recent contracts		
Trader	Buyer	Recent Contract
Vitol	Egypt	9 LNG cargoes during 2015-17
Trafigura	Egypt	33 LNG cargoes during 2015-16
Koch	Nigeria	6 LNG cargoes
Gunvor	Pakistan	3 LNG cargoes from Aug to Oct 2015
Noble Group	Egypt	7 LNG cargoes during 2015-17

Table 1: Major LNG traders and contracts

Source: (International Energy Agency 2016)

As the price spread between Asia and the United States widened (2010-2013) traders purchased LNG from producers or resellers in Europe or the United States and sold it to Asian buyers at a premium. However, it is important to mention that LNG traders' participation grew not only with an eye on Asian premium over other markets but also with an eye on increasingly scattered pockets of demand which fuelled the spot markets. The emergence of importing destinations such as that in the Middle East, Latin America and non-OECD Asia created opportunities for traders because the demand in these new regions was volatile and buyers in these regions were unwilling and unable to commit to long-term contracts. The traders successfully exploited this opportunity in the LNG market that has been for long constrained by the grip of major oil companies on long-term supplies (International Energy Agency 2016). Forward thinking and greater risk appetite allowed the traders to venture into volatile markets (Argentina, Egypt, Pakistan & Jordan) where the credit risk is perceived high by the conventional risk-averse suppliers like international oil companies. Traders have been also pro-active in connecting the dots of LNG supply chain. The LNG supply chain can be broadly divided into four steps of upstream gas production, liquefaction and storage, shipping and lastly regasification (Figure 14).

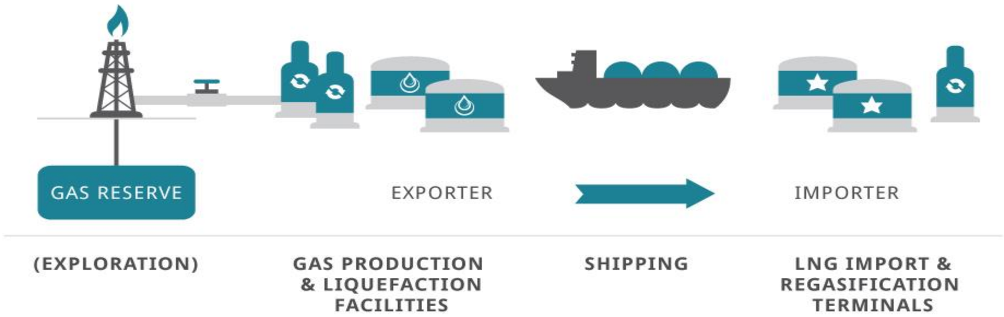


Figure 14: Natural gas process cycle

Source: (GOLDBOROLNG, 2016)

Initial two steps, namely exploration and liquefaction are most capital intensive and are wisely away from the trading radar perspective. The LNG trading house are characteristically asset-light. The traders, however, have been particularly active in securing access to key infrastructure downstream (LNG storage, vessels) and it has given them operational flexibility closer to the buyers. Trafigura signed a 15-month storage deal with Petronet's underutilized import terminal at Kochi, India and a similar deal with Singapore's Jurong Island import terminal (Reuters(d), 2015). The deals allowed Trafigura to guarantee supply security to buyers. It is because the LNG trader would not go short due to stored LNG. Again even the downstream infrastructure is rented, which maintains them asset-light and enable the trading houses to offer optionality to the buyers.

In order to optimize operation and maximize profit, the LNG trading houses have also been very watchful for the developments in LNG fleet. As an instance, Trafigura chartered LNG Vessels at very competitive rates in and took advantage of over-tonnage on LNG fleet (Reuters(e), 2015). Historically, because of high cost of LNG vessels, the LNG shipping has been characterized as "Industry Shipping"; where ships were usually custom built or chartered for long term to load/unload cargoes between specific pair of port. This high cost of shipping constrained LNG trading for long. But 150 ships are expected to hit oceans before the end of the decade and the global LNG fleet would reach 600 vessels. This excessive growth in LNG shipping capacity will further depress the existing charter rates and will drive down the cost of transporting LNG from one place to another, enabling the LNG trading house to deliver LNG to new markets at competitive prices (Trafigura, 2016).

The oversupplied LNG tanker market provides LNG traders the additional flexibility to bid on short-term F.O.B. supply tenders. It is because the traders are more certain that they could charter a vessel at short notice. Previously, in contrast, the prospective buyer was required to nominate a LNG carrier in order to be eligible for bidding on a F.O.B. cargo. The management of vessel chartering will transform from "*profit optimizing tool*" to more of a "*survival tool"* for the traders in the LNG market braving the triple impact of supply glut, converging regional prices and lower oil price. This will be covered in detail in Chapter 4.

Entry of LNG traders at the start of this decade was further incentivized by the expectation of shale gas boom to increase U.S. LNG exports from 2015 onwards. The rise of trading houses, not coincidentally, also parallels with the growth of LNG supply amid weak demand. Supply glut relieves the market from being tight and buyers then can increase their reliance on spot and short term contracts. In a tight market, buyers first priority is to secure volume from a reliable source for a foreseeable duration. In such scenario, it could be difficult for traders to make big breakthrough unless they have access to significant supply.

From supply side, the U.S. Shale gas boom is one of the key drivers of the existing and the forecasted supply glut. The U.S. began shale gas LNG export in February 2016 and is projected by the International Energy Agency to become the world's third-largest liquefied natural gas supplier before the end of this decade. The U.S. shale gas export is adding to the global supply glut triggered by new Australian supply and flattening Asian consumption.

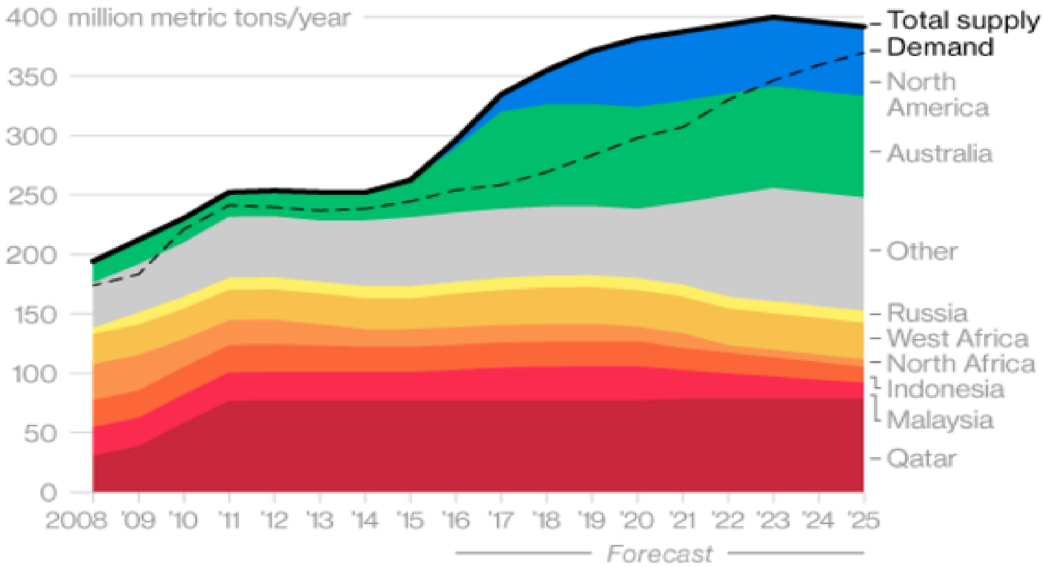


Figure 15: Expected LNG supply and demand: 2008-2025

Source: (Bloomberg(b), 2016)

Figure 15, the dotted black line represents the LNG demand and solid black line shows forecasted supply. As per (Bloomberg(b), 2016), the supply glut is here to stay, at least up to mid of next decade.

With the LNG vessel market saturated from speculatively ordered tonnage and excessive supply of LNG the buyers are eying for shorter and flexible contract durations. This has prepared the stage for LNG traders to root themselves deeper into the LNG market, mutually aiding to and benefitting from the development of spot and short term LNG trading (IGU 2016).

4. External forces and key uncertainty

After discussing the key factors in Chapter 3, the most relevant external forces are introduced and analysed in this Chapter. Sound strategic planning and scenario planning includes the influence of external forces because no event or development happens in vacuum but instead happens in a complex environment. The oil price crash and developments in LNG shipping industry are the two relevant external forces discussed in this research. The external force pertaining to geo-politics and environmental regulatory measures have not been included and has been mentioned as a limitation of this research. The below two blocks related to the thesis structure outlined in section 1.5

EXTERNAL FORCES

- Low oil price environment
- Charter rate in LNG Fleet
- Expansion of Panama Canal

KEY UNCERTAINITIES

- Asian LNG Pricing
- LNG Transportation cost

Section 4.1 outlines the answer to the sub-research question 2; "What is the impact of low oil price on the LNG market?". Section 4.2 answers the sub research questions 3; "How will the cost of transporting LNG from the U.S to the East Asia evolve in the short term?" The respective sub-sub sections of 4.2.1 and 4.2.1 elaborates respectively the sub-sub research questions 3(a) and 3(b).

4.1. Dramatic fall of Oil price

In this section, the research assesses the impact of low oil price on the LNG price in the Asian market.

The majority of long term Asian LNG contracts still are indexed to crude oil, and crude prices therefore continue to greatly influence the LNG market. Traditional market structure having long-term contract and oil indexation has been the key characteristic of the Asia Pacific region. This led to the Asian buyers buying, consistently, at the highest price among all regional markets. The price paid was exorbitant, in particular, after the Fukushima disaster in 2011. As a result, new potential price setting mechanisms discussion in the region became stronger after 2012. New price setting mechanisms such as Henry hub indexation, spot market indicators, and even continuation of oil indexation gained heavy momentum in recent time. The high price differential that resulted due to Fukushima disaster can be traced back as an important reason behind the origin of concern related to new price setting mechanism. For instance, Ministry of Economy, Trade and Industry M.E.T.I, Japan decided to clarify a trend of spot LNGs market in response to the recommendation of the LNG futures market council after the Fukushima incident. M.E.T.I started to publish monthly spot price statistics, since March 2014, and is intended to be the guiding reference for government policy such as establishment of an LNG futures market. (M.E.T.I., 2014).

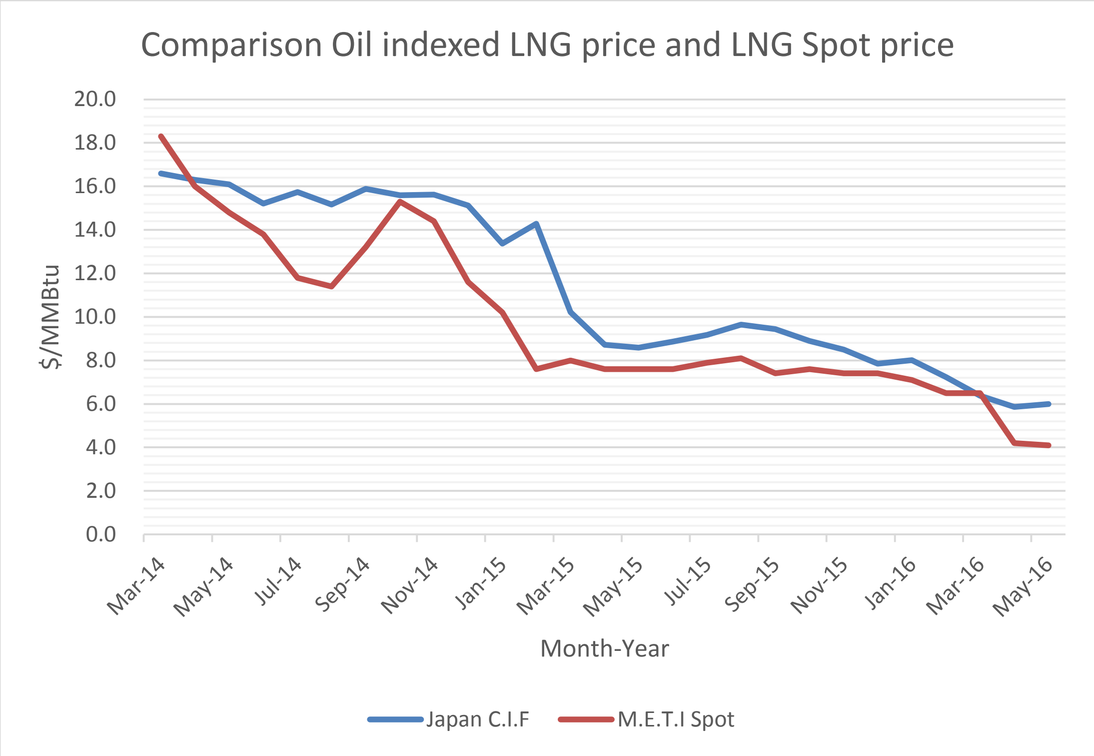


Figure 16: Oil indexed and Spot price comparison

Source: Data from M.E.T.I, Japan and World Bank via Y-charts

Figure 16 illustrates a comparison between the M.E.T.I spot LNG price in Japan and the Japan LNG C.I.F price. The Japan C.I.F price reflects the price dictated by the oil-indexed pricing and the M.E.T.I spot price reflects the actual demand-supply fundamentals of Japan LNG spot market. The comparison is from March 2014 as M.E.T.I started reporting spot LNG price from March 2014 onwards. It can be observed that in the current market environment of low oil-price and weak Asian demand there is negligible spread between the two prices.

The ultimate objective of the Asian buyers has been to reach “fair” gas price and to increase the supply flexibility. The desire of supply flexibility is a lot different from the desire of supply security. Supply security is a reflection of a tight market however; supply flexibility is a manifestation of supply glut. The evolution of a “buyers dictated” terms clearly shows the transition of LNG market from sellers’ market of 2010-2014 to the buyers’ market of 2015 and ahead.

Furthermore, after the second half of 2014, the oil prices crashed from historic height of more than $100/barrel to less than $30/barrel by January 2016 (Figure 17). Oil prices plunged more than 70 percent since mid-2014 as Saudi-led OPEC, threatened by shale oil, pumped above its quota in an attempt to recover market share from North America and other producers. The price recovered to around $45-48 per barrel by the end of second quarter this year.

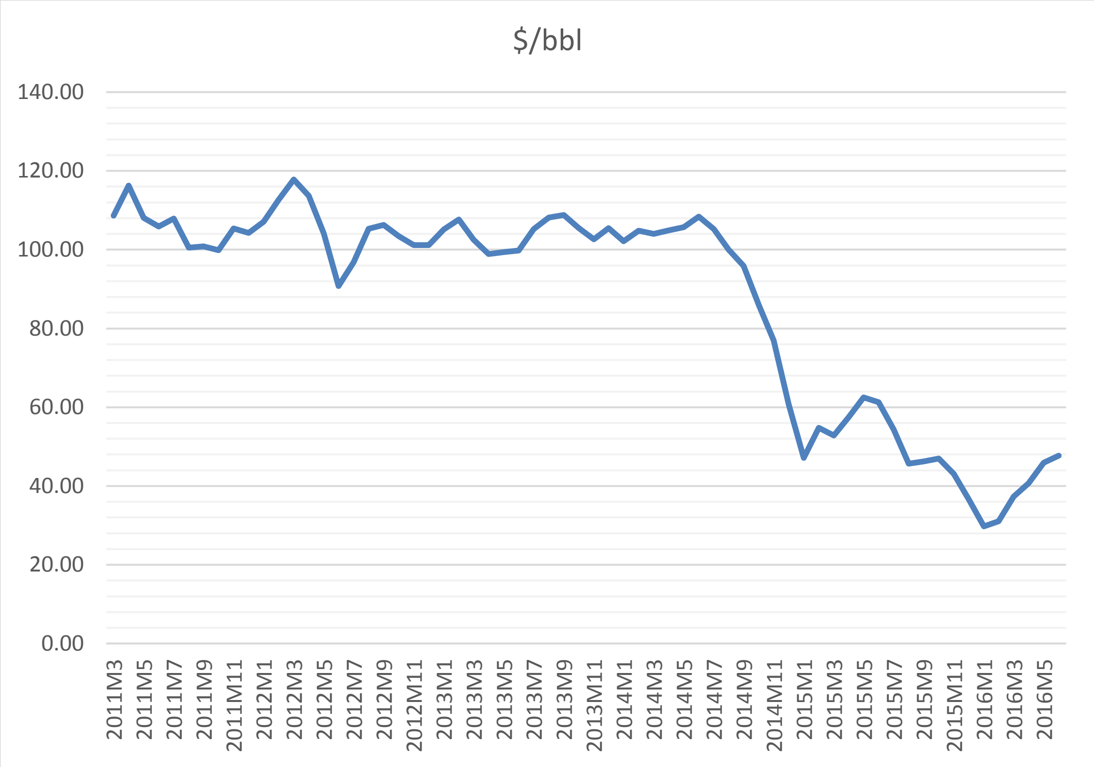


Figure 17: Average crude oil price (Brent, WTI and Dubai Benchmark)

Source: World Bank Commodity Via (Knoema, 2016)

The recovery in price since start of this year, from January 2016 till June 2016, has been commendable with 71 percent rise from $28 per barrel to $48 per barrel. Oil prices jumped up due to disruptions in supply sources, particularly due to wildfires in Canada and sabotage of oil infrastructure in Nigeria. The World Bank raised its 2016 forecast for crude oil prices to $43 per barrel from $41 per barrel due to supply outages and robust demand in the second quarter. However, the rise of the phoenix back to the sky high levels over or even close to 100 $ per barrel seems improbable, at least in short to medium term.

This oil price crash has taken away the heat, for now at least, from the discussion of delinking the LNG prices in Asia-region from the traditional oil indexation. There does exists a possibility that Asian LNG price continues to be dictated by oil indexation clauses because the dramatic fall in oil price plummeted the Asian LNG price from the highs of $15-18 per MMBtu to around $5 per MMBtu and had pacified the Asian buyers who had been consistently paid highest price levels among all regional markets.

4.2. Developments in LNG shipping

The objective of this section is to examine the two major developments in the LNG shipping; firstly, the over-tonnage in LNG fleet and secondly, the Panama Canal expansion and then to quantify its effect on the U.S-East Asia LNG arbitrage margins.

(FT, 2013) reported on 23rd November 2013 that the "LNG market has rebounded with rates reaching about $90,000 per day with the prospect that they will maintain around the $80,000 to $85,000 rate per day over the next five years - i.e. up to 2018." Ironically, the charter rate started to decline after the report and today stands at around $20,000 /day. Clearly, the LNG charter rate is also one of the key uncertainty going forward, even in the short term.

Weak Asian demand, new liquefaction capacity and low oil-indexed LNG prices; they all have contributed to convergence of regional price differentials. It is no longer a far flung statement to say that the LNG market is adjusting to the new reality of regional price convergence. Under this tight price band (US- East Asia LNG trade -Figure 18) where arbitrage margin has virtually vanished, the LNG shipping costs and the expansion of Panama Canal are destined to play an increasingly important role in determining LNG arbitrage.

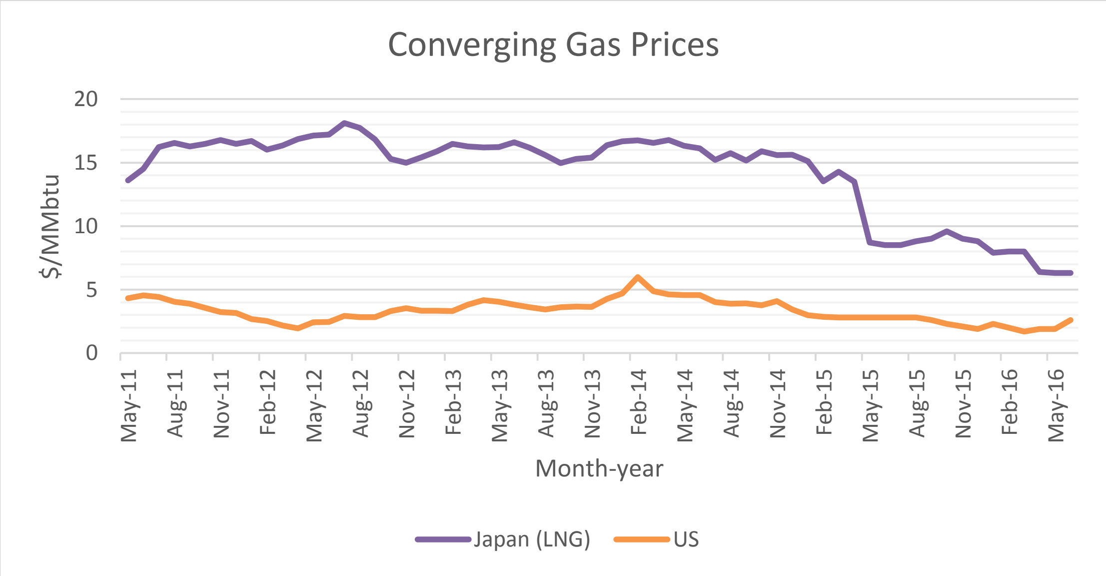


Figure 18: U.S. Henry-Hub and Japan LNG price

Source: World bank data

Much to the relief of LNG traders, the over-tonnage in LNG fleet has provided them with cheaper uncommitted tonnage; and the expanded Panama Canal, which can accommodate 90 percent of current fleet, has reduced the round trip sailing days to almost two-third of initial. Reduced sailing days means much lower transportation cost. The above developments in LNG shipping are developments parallel to the converging LNG regional prices and has happened just at the right time for the LNG trading houses. It is so, because even with moderate Charter rates (60000 $/day) the U.S LNG would not had been competitive in the Asian market with the Suez or Cape of Good Hope route. This statement will be validated in section 4.2. The significant sailing day saved from transiting the new Panama Canal can probably make the U.S. LNG exports competitive in the East Asia LNG market and LNG trading houses could still pocket marginal profit.

4.2.1. Charter rates in LNG fleet

Fundamentally, the demand for LNG carriers is driven by the demand for LNG in the importing countries. The higher the LNG volumes demanded and the more the importing countries are, the better the utilization of existing fleet will be and more will be the demand for new fleet. However, speculative ordering of tonnage aided by cheap finance (made worse by weak Asian LNG demand) resulted in the LNG shipping tonnage to exceed the demand. This resulted into plunge of LNG shipping charter rates.

The cost of transporting LNG from loading terminal to destination i.e. LNG transportation cost has become much more important for LNG trading activities in the current low and converging price environment cost. LNG transportation cost is the total cost a buyer has to incur in a F.O.B contract or the seller has to incur in a C.I.F contract, in order to ship LNG cargo from the loading terminal to the unloading terminal.

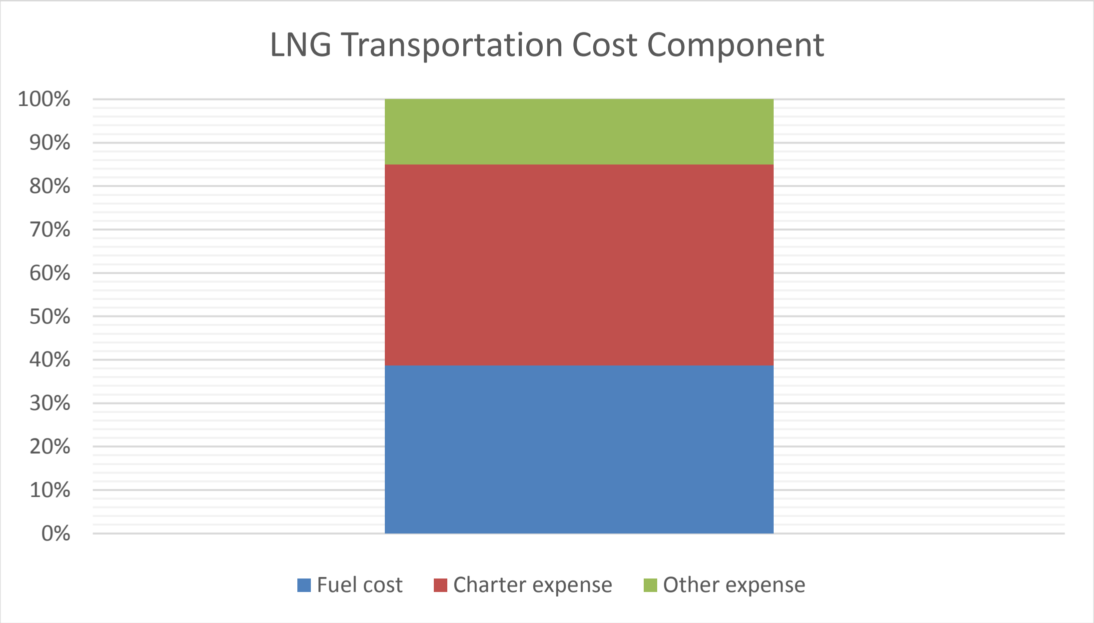


Figure 19: LNG transport cost share

Source: Author

Note: Data from sea-distances.org; IFO 380 CST bunker cost from www.bunkerindex.com
Above calculated for Sabina, U.S to Tokyo, Japan
One day each for loading-discharging
One day for canal transit
Vessel speed 19 knots and consumption 180 MT/day
Charter rate $ 40000 /day.

The share of LNG transportation cost in the total cost of liquefied natural gas ranges between 10-35% of the final price paid for natural gas (Zhu & Maxwell 2008); (White, 2012). The chartering cost and the fuel cost, in turn, account for lion's share in the LNG transportation cost. The Cost associated with the LNG transportation includes charter cost, fuel costs and other cost (port fees, canal charges and insurance)

(Stokes & Spinks, 2015). Fuel and charter costs constitutes almost 80 to 85 percent of total transportation cost – see figure 19.

The LNG charter rates skyrocketed after the Fukushima incident and the average fleet utilization from end-2011 till mid-2012 crossed 90 percent (Reuters, 2012). The consequence was speculative ordering by ship-owners, resulting in an investment boom that ended up putting far too tonnage at sea. After spot rates for a 160,000 m^3 LNG carrier reached over $140,000/day in end-2011, the short-term LNG charter market has been under significant pressure, reflecting the impact of investment boom, slower growth in short-term trade and weaker Asian demand. By July 2016, spot rates stood at around $20,000/day- see figure 20.

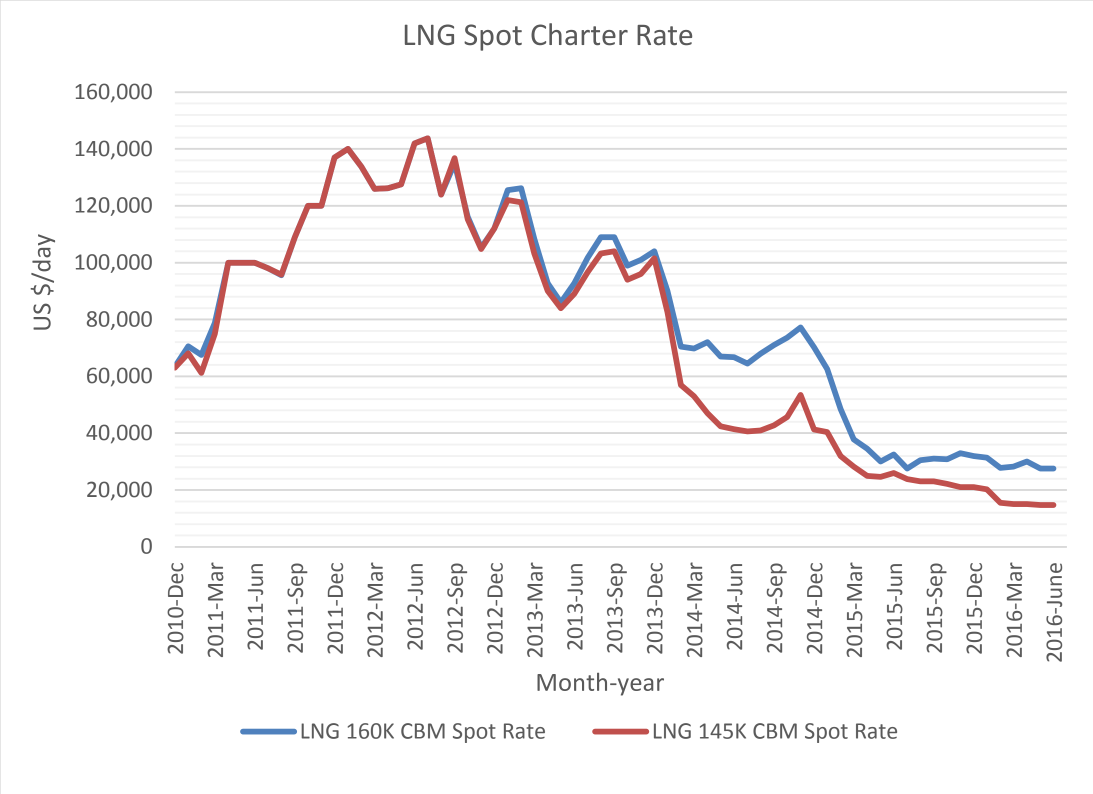


Figure 20: LNG Spot charter rates

Source: Author via Clarkson Research data.

As per (Clarkson, 2015) LNG Trade and Transport Report of 2015, the negative fundamentals will not pacify in the short-term, since global LNG demand is not projected to be strong, and the availability of tonnage in the short-term market is expected to increase further. Weak LNG demand in Asia and the increase in the tonnage capacity of the global fleet has resulted in a constant decline of LNG charter rates since mid-2013 (Figure 20).

As of April 2016 the fleet consists of approximately 450 vessels, while at the end of 2010 there were 360 and in 2005 the number was 160. The order portfolio, deliverable up to year the 2020 includes as many as 150 vessels. The order-book represented 33% of the fleet at the start of July 2016, a substantially higher level than observed in the major volume shipping sectors.

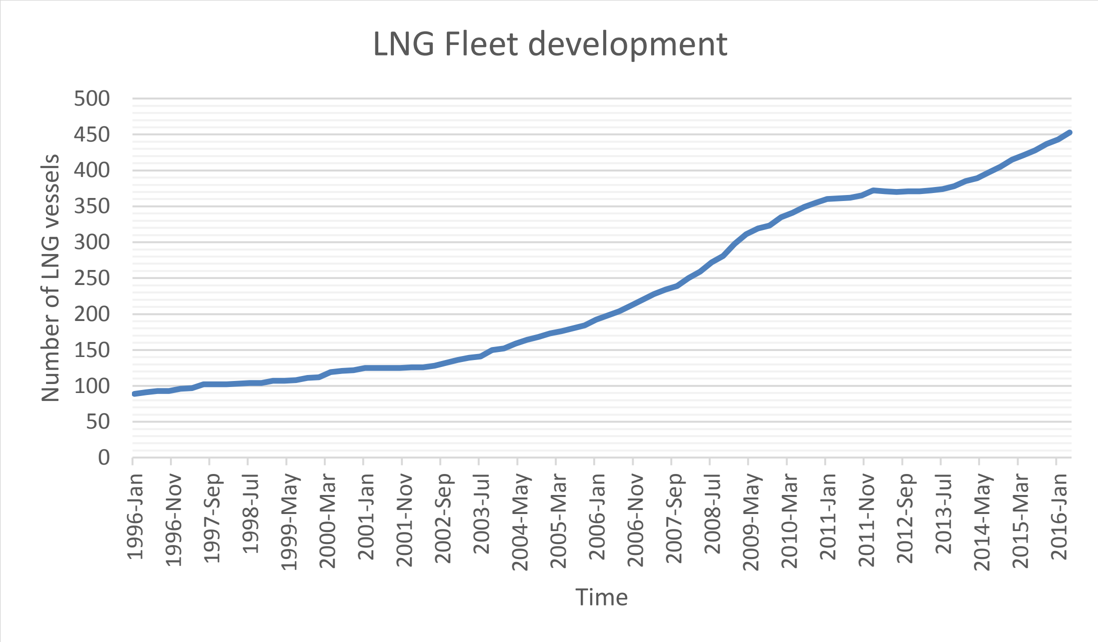


Figure 21: LNG vessel fleet development

Source: Author via Clarkson Research data.

This section now draws upon two likely scenarios for the LNG Charter-rate development in the short term, based on content analysis source of industry announcements and reports.

“Hope for the best and prepare for the worst” seems to be the mantra for all the players in the LNG market. The industry executives had maintained that a rebound in LNG rates is possible pre 2020. Reported by *IHS Fairplay*, GasLog Ltd CEO Paul Wogan said that the start or restart of delayed liquefaction projects should absorb tonnage from the spot trade and strengthen utilization and rates (IHS Fairplay, 2016). Above optimism was further substantiated by a recent report from Drewry. As per Drewry LNG Forecaster report, despite the current weakness in LNG shipping rates, Drewry believes that the market will require more vessels than listed on the current order-book-see figure 15.

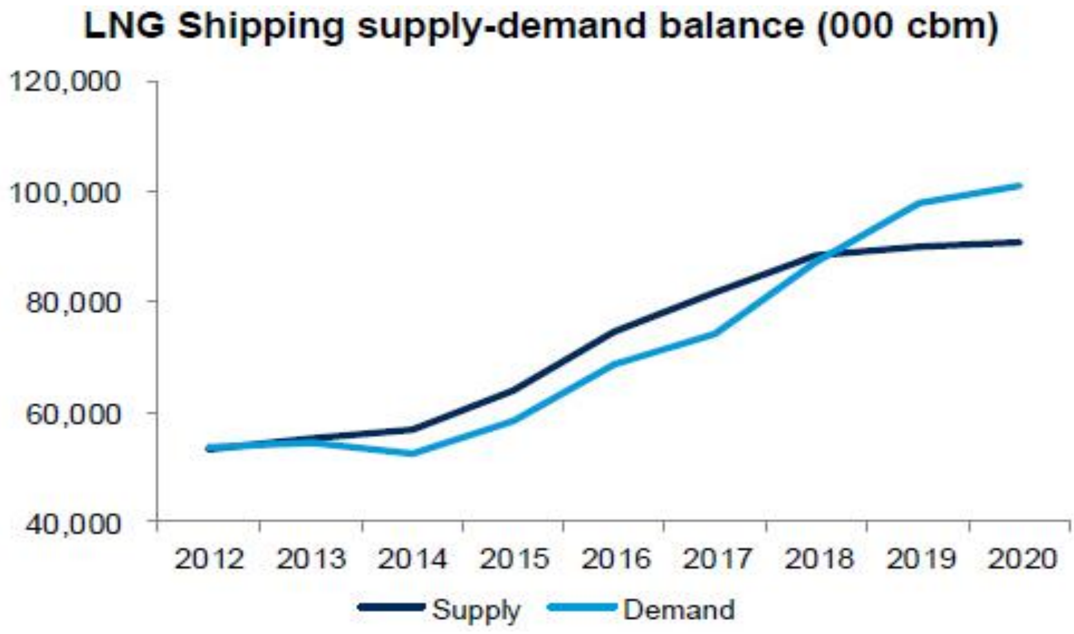


Figure 22: LNG Shipping supply-demand balance

Source: (Drewry, 2016)

*"*The reason for Drewry's optimism is that almost 125 million tons of capacity is currently being built and more are expected to come online. Also, because a majority of supply has been contracted on long term agreements, it is expected that LNG will be traded and so would require more vessels*"* (Drewry, 2016).

However, another report - by IHS Energy - warns that rates could remain depressed through 2020. As written in (IHS Fairplay, 2016) the excess tonnage has pushed charter rate to below 20,000 $/day and there is "no sign of recovery in the near term", It adds that "the shipping capacity surplus will exceed beyond the requirement generated by Australian and US volumes over the next three years. Delay or shut in of liquefaction train - is probable in low gas price market and the current order-book (Table 2) already exceeds the shipping requirement for LNG liquefaction outlook in 2020. Any shut-in will add more unutilized tonnage to the fleet".

LNG carriers (> 40000 cubic meters)					
No. Vessels(end)	2014	2015	2016	Order-book	
Fleet Total	391	415	425	2016	32
Deliveries	33	28	11	2017	42
Scrapping	3	3	1	2018+	57
Contracting	63	31	0	Total	131
Order-book	142	142	131	%Fleet	30.80%

Table 2: LNG vessel

Source: Clarkson Research

Oversupply is likely to be even worse as IHS Energy asserts there will be shut-ins. It is the period when certain LNG terminals with higher operational cost reduces export volumes. Reduced export volume will further free up shipping capacity and more LNG will be available for charter on the spot market. The increase in spot shipping capacity, due to existing over-tonnage and the anticipated freed up tonnage due to shut in, would ensure that spot charter rates will not recover even by 2020 (IHS Fairplay, 2016).

The contradiction between Drewry forecast and IHS Energy report arises due to the underlying assumption of effective and operational liquefaction capacity. The Drewry forecast assumes that all the under-construction liquefaction capacity or at-least most of the planned liquefaction capacity will come online by 2020 and the existing ones would continue to operate at acceptable utilization. However, the IHS report assumes or rather asserts that some of the existing liquefaction capacity would be temporarily shut-down in the low gas price environment. In view of above two possibilities, this research outlines these two probable charter rate development in the short term.

- Medium Charter rate:
  As per figure 22, the Drewry Forecast suggest the demand to exceed LNG fleet supply by 2018. The tightening of charter rate post 2018 would start pulling up the rates and would achieve medium charter rate around $60,000 /day in the short-term. The $60,000 /day charter rate is based on break-even operational cost of a new LNG vessel (Financial Times, 2013); (Wall Street Journal, 2015).

- Weak Charter rate:
  Based on IHS Report, the weak charter rate is expected to continue in the short-term. The (IHS Fairplay, 2016) quotes "hopefully charter rates will recover from current levels, which barely cover operating costs". The hopeful scenario is the above medium charter rate scenario. This scenario of weak charter rate is the more pessimistic one considering there could be shut-ins and overcapacity would further aggravate thereby keeping the charter rates depressed in the range of existing $20,000 /day.

In view of above content analysis and the identified key uncertainty of LNG charter rate, the two probable development in charter rate is shown in figure 23.

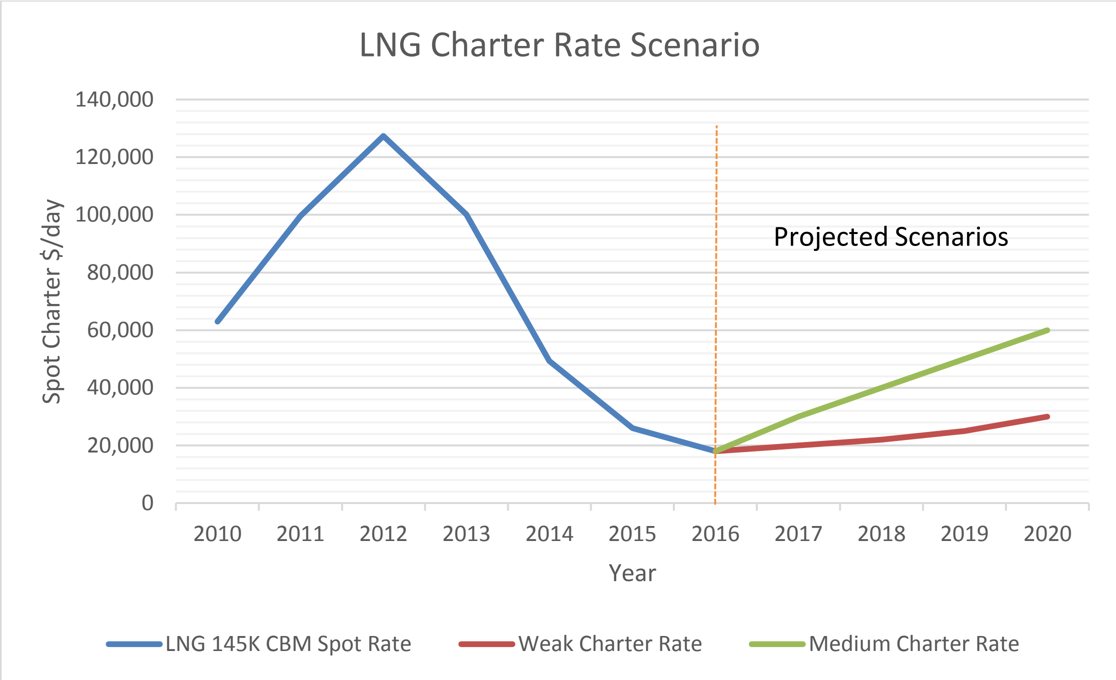


Figure 23: LNG vessel charter rate scenarios

Source: Author
Note: 2010-2016 spot annual charter rate data from Clarkson Research for 145,000 m^3 vessel.

Having outlined the two realistic scenarios for LNG charter rate development, the next sub-section will analyze the impact of another significant development- the Panama Canal Expansion- on the LNG transportation cost.

4.2.2. Expansion of Panama Canal

The Panama Canal, a remarkable feat of engineering, was opened in 1916. It is a 50-mile waterway slicing through Panama and allowing ocean going vessels to travel from Atlantic side of U.S to the Pacific Side (or vice-versa). The canal transit made it possible to avoid 8000 nautical miles of going around South America. The opening of the Panama Canal in 1916 redrew the global shipping trade routes (Maersk, 2016). The 5.4 billion US$ expansion of Panama Canal, which started in 2007 and completed in 2016 now allows much larger ships to transit the canal. A century after redrawing global trade and markets, the Panama Canal is again set to revamp global shipping trade routes. The new locks allow passage for neo-Panamax ships with a capacity nearly three times (14,000 containers instead of just 5,000) that of Panamax ships. (Wall Steet Journal, 2016). The popular yardstick for comparing the size of old and new Panama Canal size has been the TEU units of a container vessels and why not, as much of impact of Panama Canal expansion has been discussed in context of the container trade flow. Amidst all the fanfare of the first transit through the expanded Panama Canal on June 11,2016 – of a COSCO owned Container ship named Panama; the implication of the Panama Canal expansion on the global LNG trade flow missed the focus.

This section will discuss and signify the colossal importance of the Panama Canal expansion on the evolving U.S. – East Asia LNG trade flow in the current low and converging gas price environment. When the expansion project was approved by national referendum in 2007, not many could have predicted the magnitude of the impact of shale gas revolution in the United States and certainly not the potential of Panama Canal to play a decisive role in the global LNG market. Expanded Canal now can accommodate over 90 percent of the world's LNG fleet, up from just 8.6 percent pre expansion - see figure 24.

LNG Vessels with cargo capacity of more than 180,000 m^3 cannot transit the expanded Panama Canal. However, there are not much vessels which are larger than 180,000 m^3- just 10 percent of existing fleet - and not many of that size are on order. Prior to the expansion, only 30 of the smallest LNG tankers with capacities up to 32000 m^3 could transit the canal. The expansion will have a significant implication for LNG trade, as it would now allow majority of LNG vessels to transit the canal and also reduce travel time and shipping costs for LNG cargoes originating from the U.S. Gulf Coast to key markets in Asia. Only the 45 largest LNG vessels, with capacity in excess of 200,000 m^3 , Q-Flex and Q-Max tankers designed for exports from Qatar, will not be fit in the expanded canal (EIA(a), 2016).

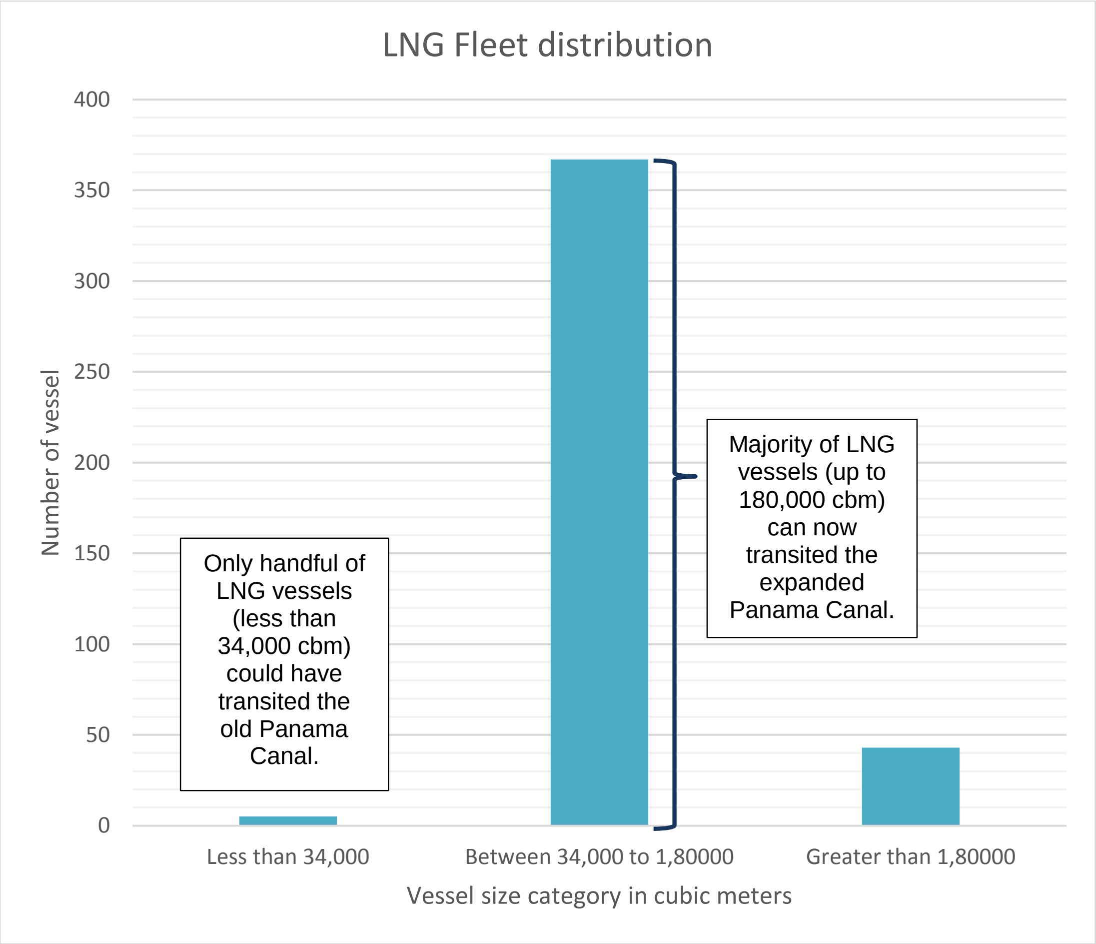


Figure 24: LNG vessel fleet distribution

Source: Authors own analysis based on data from LNG Journal
Note: On basis of 415 vessels out of 453 as on April 2016.

As it can be observed from figure 24 that the majority of LNG vessels (approximately 85-90 percent of existing fleet) can now cross the Panama Canal. Even the LNG fleet on order, which is on average bigger than the existing average fleet size, can still cross the expanded Panama Canal. The average size of LNG ships in the order book is between 160,000 m^3 to 180,000 m^3 – see figure 25. This implies that expanded Panama Canal will not be a bottle even for LNG fleet on order.

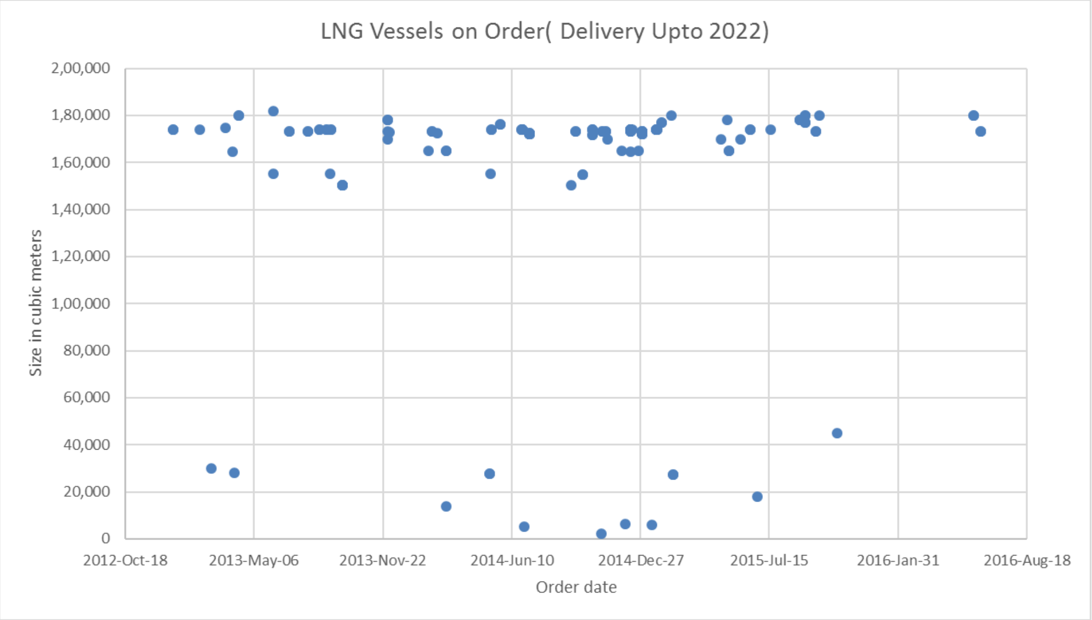


Figure 25: LNG vessel newbuilding order book

Source: Authors own analysis based on data from Clarkson Research
Note: 140 Vessels on order as on July 2016

The expanded Panama Canal is positioned to play a decisive role by shipping the U.S. shale gas at much more competitive price to major demand centers in East Asian markets. It is bound to become a big story for U.S. LNG as the canal expansion will allow most of the LNG vessels to transit and drastically reduce travel time from the U.S. Gulf Coast, where most of the LNG export projects are located, to Japan to 20 days, compared with 34 sailing days voyage around Cape of Good Hope or 32 days for ships using the Suez Canal -see figure 26 and 27.

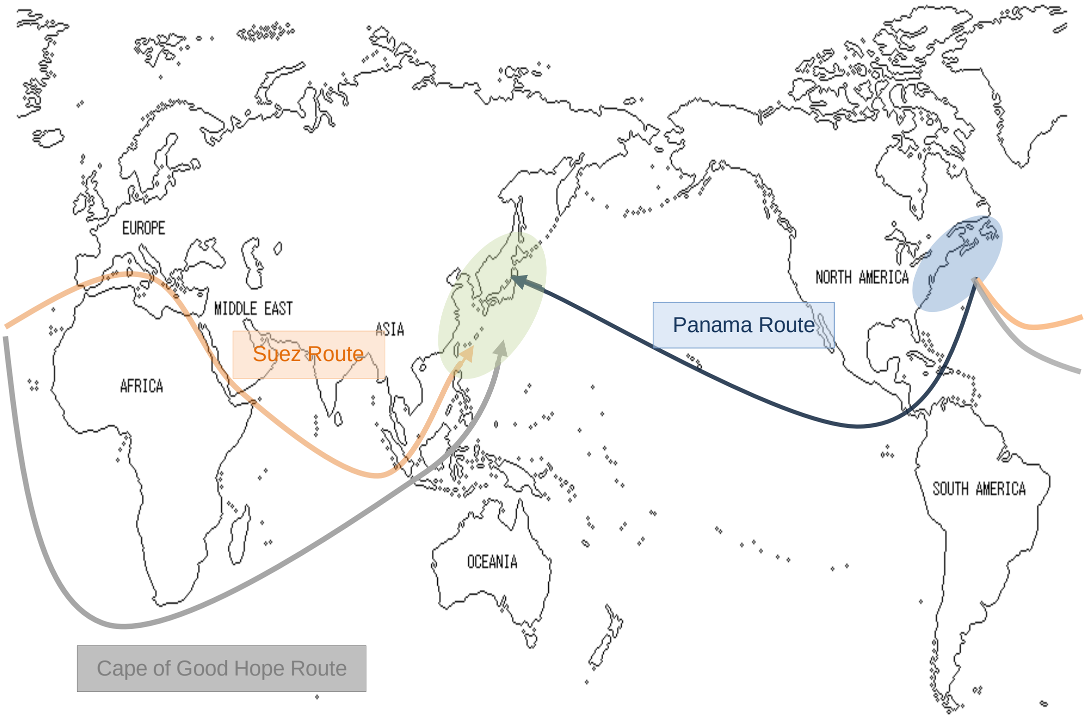


Figure 26: Major Sea trade route from US to East Asia

Source: Author's own representation

Significant time savings will result in ships using the expanded Panama Canal to reach North China, South Korea, Japan and Taiwan. These four countries, together, account for nearly 70 percent of the global LNG import market. The extended Panama Canal will also shorten U.S. Gulf to South America bound LNG exports. Voyage to Chile, for instance, will take 10 days less. For the emerging markets south-west such as India and Pakistan, the Panama Canal route will take longer than crossing the Suez Canal or sailing around the Cape of Good Hope, Africa (EIA(a), 2016).

As per EIA estimates the LNG traffic through the Canal could reach more than 550 vessels annually, or 1-2 vessels per day, by 2021. By 22nd August 2016, three LNG vessels had already made a transit through the expanded Panama Canal. Two of those vessels carried U.S. LNG exported from Cheniere's Sabine pass liquefaction plant. The 161,870 m^3 LNG Vessel - *Maran Gas Apollonia*, chartered by Shell, was the first LNG tanker to transit the newly expanded Panama Canal on July 25th 2016 (Trade Winds, 2016).

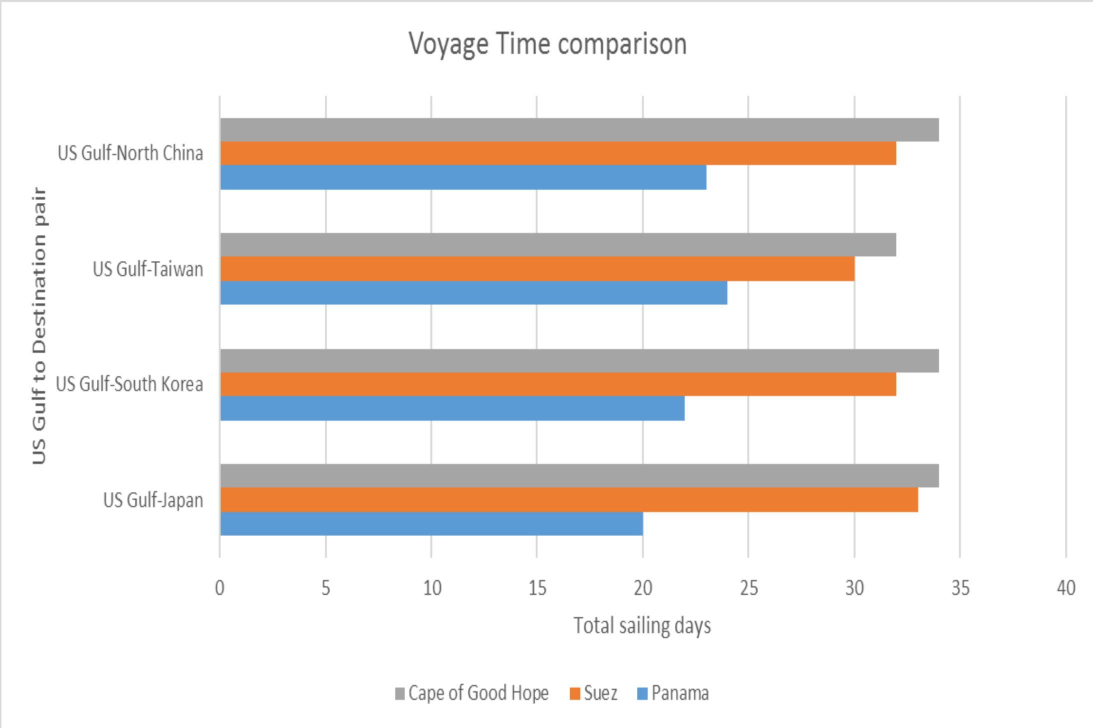


Figure 27: Voyage Time comparison

Source: Authors calculations based on distance data from sea-distances.org
Note: Calculations assume export from the Sabine Pass liquefaction terminal at an average LNG Carrier speed of 19 knots and one-day transit time through the Panama [Source: (Rodrigue, 2013)] and Suez Canals.

As a further incentive, the Panama Canal Authority has introduced encouraging toll structure for LNG vessels aimed to foster additional LNG traffic through the Canal, especially for the round trips- see table 3.

Toll structure for LNG Vessels			
Bands in cubic meters	Laden	Ballast	Ballast (Round-Trip)
First 60000	$2.5	$2.23	$2
Next 30000	$2.15	$1.88	$1.75
Next 30000	$2.07	$1.8	$1.6
Rest	$1.96	$1.71	$1.5

Table 3: Panama Canal transit charge

Source: (Panama Canal Authority, 2016)

For the purpose of this research it is required to delve deeper into how the shortened sailing duration and the Panama toll structure would translate into critical cost savings as compared to other routes. Both the above factors - lower charter rates and expansion of Panama Canal will ultimately trickle down to saving in LNG transportation cost. The objective is to convert the total cost savings (Panama Canal route + Lower Charter rates) into the Unit most commonly used as cost values for the LNG trade. LNG value is commonly expressed in US $/MMBtu. MMbtu stands for

Million British Thermal Unit. “One Btu is the heat required to raise the temperature of one pound of water by one degree Fahrenheit” (EIA(a), 2016).

Authors calculation on basis of Panama Toll – table 3, the Panama Canal dues for LNG vessel, in a round trip, will be as below. (Table 4)

Size of Vessel (in m^3)	Total toll in a round trip (US $)	Equivalent MMbtu	Canal Cost in US $/MMbtu
145000	1359000	3480000	0.20
160000	1404000	3840000	0.18
170000	1434000	4080000	0.18

Table 4: Panama Canal transit toll for LNG vessel

Source: Author
Note: 1 m^3 LNG equals 24 MMbtu Source: (IGU, 2012)

It means that for 145,000 m^3 LNG vessel booked on a round trip through Panama Canal, the seller (in C.I.F contract) or the buyer (in F.O.B) contract will pay $0.18 – 0.20 /MMBtu as canal dues.

The expanded Panama Canal would also mean shorter sailing time and so lesser payable charter amount. Below is the comparison in LNG transportation cost between the existing option (Expanded Panama + Low Charter rate) and the earlier feasible route (Cape of Good Hope + High Charter rate).

US Gulf-Japan LNG Cost Transportation Cost Comparison								
	Distance (Nm)	Sailing days	Canal Transit day	Port Stay	Fuel cost	Charter Cost in (000’ $)	Total Cost	Cost $/MMBtu
Panama in 2016	9209	20.2	1	2	1318656	928	2246656	0.91
Cape of Good Hope in 2013	15762	34.5	0	2	2252160	7300	9552160	2.88
Suez Canal 2013	14521	31.9	1	2	2082432	6980	9062432	3.04

Table 5: LNG transportation cost: US Gulf - Japan

Source: Authors’ calculation
Note: Charter rate for 2013 considered $100,000 /Day – Figure 20
Vessel speed 19 Knots
Bunker cost 204$/MT in all three cases
Charter rate for 2016 considered 20,000 $/day
Vessel Fuel consumption 160 MT/day for a 145,000 m^3 vessel
Panama Toll $0.2 MMbtu added to final cost – Table FF
Suez Toll $0.3 /MMbtu added to final cost- Approximate
Loading percentage 99%
1% Heel Volume
10% Boil-off

From above Table 5, it can be observed that the combined effect of the slump in charter rate and the expansion of Panama Canal has resulted the LNG transportation cost to decrease from $2.88 /MMbtu to $0.9 /MMbtu, a remarkable reduction of sixtynine percent. Squeezing out an extra $2 /MMBtu from shipping cost is much more important today and in the short-term future which is a world of much smaller margin- see figure 18.

In the current situation where the difference between U.S. Henry-Hub price and Japan LNG price is around $3 to 3.5 /MMBtu, the LNG transportation cost of $2.8 /MMBtu, of 2013, when added to average liquefaction cost of $2.5-3 /MMBtu, there would have been negligible arbitrage activity between the U.S and Asian market as the total cost (Liquefaction + transportation) would exceed the price difference between the markets.

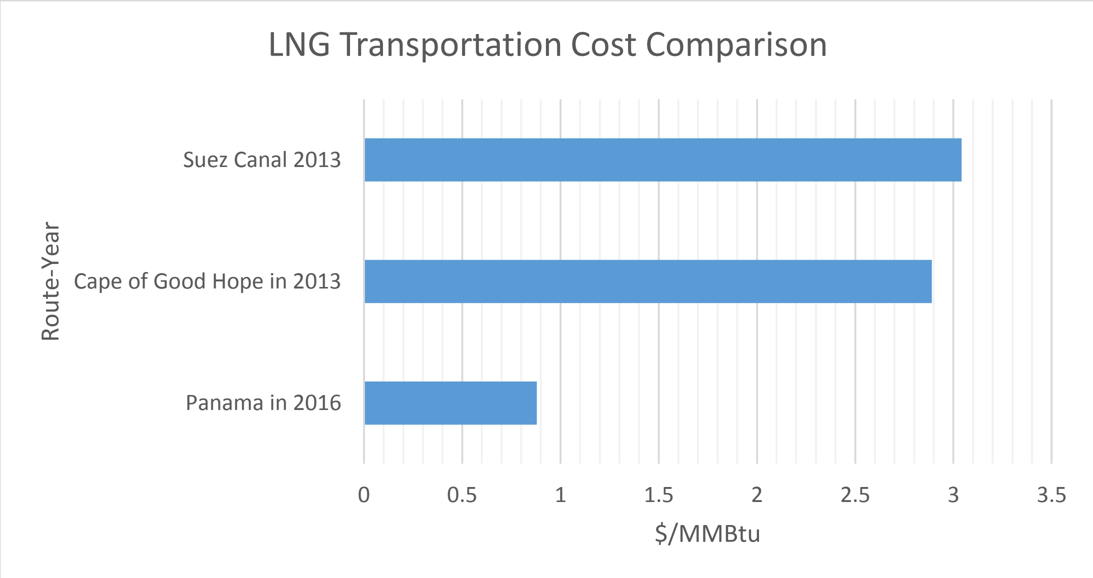


Figure 28: LNG transportation cost saving comparison

Source: Authors' calculation

In medium charter rate of around $60,000 /day, the estimated transit costs through the Panama Canal for a 145,000 m^3LNG carrier is calculated to be $1.4 /MMBtu for a round-trip voyage. Table 22 gives a comparison between existing routes at medium charter rate of $60,000 /day.

US Gulf-Japan LNG Cost Transportation Comparison in Medium Charter Rate environment								
	Distance	Sailing days	Canal Transit day	Port Stay	Fuel cost	Charter Cost	Total Cost	Cost $/MMBtu
Panama Route	9209	20.2	1	2	1318656	2784000	4102656	1.51
Cape of Good Hope Route	15762	34.5	0	2	2252160	4380000	6632160	2.11
Suez Canal Route	14521	31.9	1	2	2082432	4188000	6270432	2.33

Table 6: LNG transportation cost comparison: US Gulf – Japan

Source: Authors' calculation

From above Table 6, it can be seen that even at charter rate of $60,000 /day, the Cape of Good Hope Route incurs a cost of $2 /MMBtu. Adding to it the liquefaction cost of $2.5-3 /MMBtu, the total cost would again exceed the existing price difference between the U.S. Henry-Hub and Japan LNG price (Figure 18).

Above calculation quantifies the cost for the two scenarios and shows that how significant is the expansion of Panama Canal and simultaneous drop in charter rates. Conclusively, the two scenarios are as below (Table 7).

	Assumed Charter Rate ($/day)	Panama Transit Transportation cost ($/MMBtu)
Low Charter Rate Scenario	20,000	0.91
Medium Charter Rate Scenario	60,000	1.51

Table 7: Cost of transporting LNG through Panama Canal.

Source: Authors' calculation

The above two scenarios will form the basis of 2x2 scenario matrix in Chapter 6.

Based on Authors calculation, the round trip voyage cost for ships traveling from the U.S. Gulf Coast to North Asia through the Panama Canal is $0.45/MMBtu to $0.75/MMBtu lower than transit through the Suez Canal and $0.35/MMBtu to $0.55/MMBtu lower than sailing around the Cape of Good Hope. Transiting the Panama Canal offers significant reduction in shipping costs to the East Asian countries - Japan, South Korea, Taiwan, and North China.

This section and precisely Table 7, marks the closure of the sub research question 3 "How will the cost of transporting LNG from the U.S to East Asia evolve in the short term?"

5. Scenario Logic and development

The objective of this Chapter is to develop scenario logics built by choosing two critical uncertainties and then to plot them in a 2 X 2 matrix. The two critical uncertainties, in turn, are built from scenario logic as below:

Scenario logic

- Developments in LNG shipping rates
  - Charter rates in LNG fleet
  - Panama Canal Expansion

- Developments in Asian LNG pricing
  - Continuation of Oil indexation in Asian LNG pricing.
  - Increased usage of Henry-Hub indexing.

- Developments in US Henry-Hub pricing (*or not!)*

SCENARIO LOGIC

- Developments in Asian LNG pricing
- Continuation of Oil indexation in Asian LNG pricing.
- Consolidation of Henry-Hub indexation.
- Developments in US Henry-Hub pricing (*or not!)*
- Developments in LNG shipping.
- Expansion of Panama Canal

As discussed in Section 4.2 – the external development in LNG shipping leads to an uncertainty between two scenarios in the short-term. First scenario is of low charter rate that has LNG transportation cost - Via Panama - of $0.91 /MMBtu and the second one is medium charter rate scenario that has LNG transportation cost - via Panama - of $1.51 /MMBtu. The second uncertainty, as will be discussed in this section 5.1, is how the Asian LNG pricing would evolve in the short term. The two scenarios which emerge out of this uncertainty are; continuation of oil-indexed pricing or consolidation of transparent trading pricing. By combining above two critical uncertainties, the themes of the four scenarios will then become apparent.

This section 5.1 outlines the answer for the sub research question 4 "How will East Asia LNG pricing evolve in the short term?" and the section 5.2 sketches the answer to sub-sub research question 4(c) "How will the Henry-Hub price evolve in the short term?"

5.1. Which way forward for Asian LNG pricing?

This section sets out to evaluate the extent and direction of potential changes in the Asian LNG market in terms of pricing.
During 2011-2013, there was a huge discontent about the high price of LNG in the Asia-Pacific market. It was clear that the discontent was due to high LNG price paid by Asian buyers but the underlying argument was not clear. The low oil prices in 2014–2015 brought natural gas prices in the Asia Pacific closer to the spot LNG prices in

Asia. As a result the appetite for new pricing away from oil indexation diminished but certainly not vanished (Mironova 2015). The oil price crash and the lowering of oil-indexed LNG price cleared the fog over two school of thoughts. One who argued that prices need to be reduced while retaining the oil-indexation mechanism, and the other who argued that the for replacement of oil-indexation mechanism. This research considers continuation of oil-indexed pricing (sub-section 5.1.1) as one of the scenarios going forward. As the second scenario, as the replacement of oil-indexed pricing, the research builds upon Henry-Hub indexing (sub-section 5.1.2) for the LNG reaching Asian market. In subsequent sub-sections 5.1.1 and 5.1.2 the relevance of the scenario being considered is highlighted.

The sub-section 5.1.1 answers the sub-sub research question 4(a) "How will East Asian LNG price evolve under continuation of oil-indexed pricing?". The sub section 5.1.2 answers the sub-sub research question 4(b) "How will East Asian LNG price evolve under Henry-Hub indexed pricing?"

5.1.1. Will there be continuation of Oil Indexed Pricing in Asian Market?

The discussion in section 4.1 on the "Dramatic fall of oil prices" revealed that the oil price crash of 2014 has resulted in corresponding low prices for oil-indexed LNG. The majority of Asian LNG contracts still continue to be dominate by oil-indexation. So, the Asian LNG buyers, as of today, are not complaining about the oil-indexed pricing mechanism and there exists a scenario that the oil-indexed pricing mechanism would continue at least in the short term – as in the short-term the oil price is expected to be below $60 /barrel-see figure 29.

To develop a sound scenario which involves continued oil-indexation of Asian LNG price, it is required to understand two aspects: Firstly, the likely development in crude oil price in short-term and secondly, how the developments in crude oil prices would impact Asian LNG prices. An obvious and explicit problem in forecasting the oil price and predicting the effects of oil-price movements is that any change, either an increase in global supply or a decrease in global demand can result in price fluctuation. Slowing demand in Asia is one part of the story, but the increased supply is equally significant. To elaborate on this, for strategic and geo-political reasons the Organization of the Petroleum Exporting Countries (OPEC) continued to increase oil production recently even when prices have fallen, unlike in some previous cycles. New exports from Iran, as well as from some non-OPEC countries and the U.S. resilient supply of shale oil in the face of lower prices would also played significant part in oil price fluctuations. The cushioning provided by storage can also lead to distortion in price estimations. As it could be seen that forecasting of crude oil prices in itself is an exhaustive exercise and is certainly not the focus of this research. So this section draws heavily on the World Bank Report on commodity market (World Bank, 2016) to look into the short term future of oil price and also the impact of forecasted oil price movement on the Asian LNG prices.

The combination of continued demand growth and falling U.S. production eventually touched floor at start of 2016 and since the oil prices have been on way up and expected to touch $50 /barrel range by year-end. The report also forecasts that it would continue to rise steadily in the short-term-see figure 29. Oil prices averaged $

47.70 per barrel in June/July 2016, 37 percent above their first quarter average. According to the report (World Bank, 2016) , the oil price rebound was caused due to a number of supply disruptions that resulted in drying up of 2.5 million barrels per day of production during May and June. The disruptions were due to production losses in Canada due to wildfires, and in Nigeria due to militant attacks on oil infrastructure.

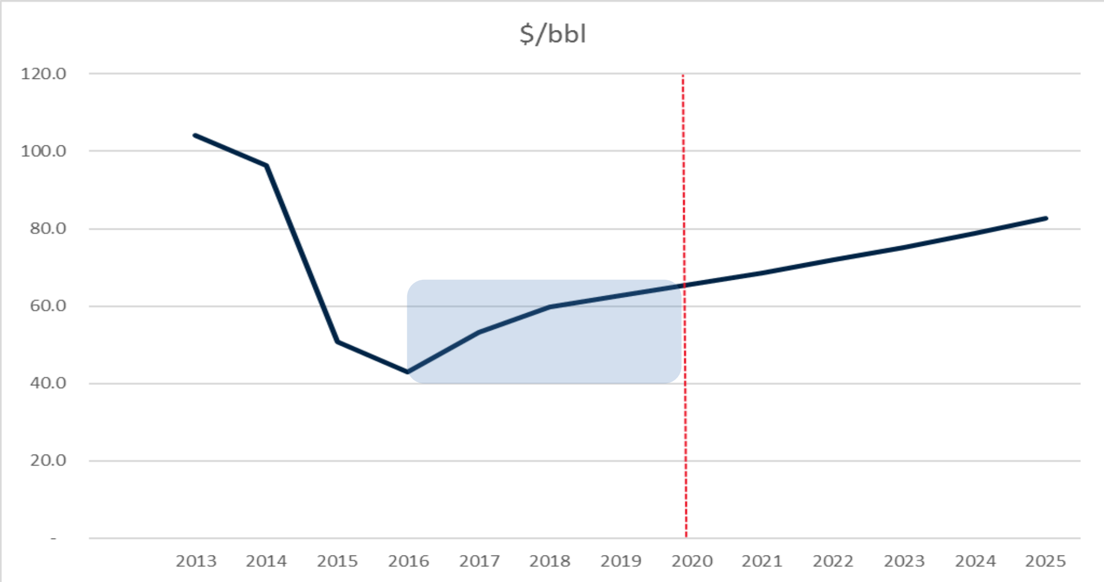


Figure 29: Crude oil price forecast

Source: (World Bank, 2016)

Even though some structural difference exists between oil benchmarks such as WTI, Brent and Dubai (and Oman) but the oil benchmarks are strongly co-related and is one of the indicators for crude being a global commodity. Due to strong co-relation, any of the three oil price benchmark could be used to anticipate changes in Japan LNG price. The above statement finds mention in the context that the Japan LNG prices are linked to J.C.C (Japan Custom Cleared - average import C.I.F piece of crude in Japan) which is in turn has pricing formula linked to Dubai oil benchmark (Koyama 2011).

Based on the report (World Bank, 2016) the development of Asian LNG price is relatively flat and the downward plunge is expected to flat out in the range of $7 to 8 per MMBtu this year itself. This price band, as shown in figure 30, for Japan LNG landed price is the reference value for calculation of arbitrage between the U.S Henry-Hub and the East Asia LNG market.

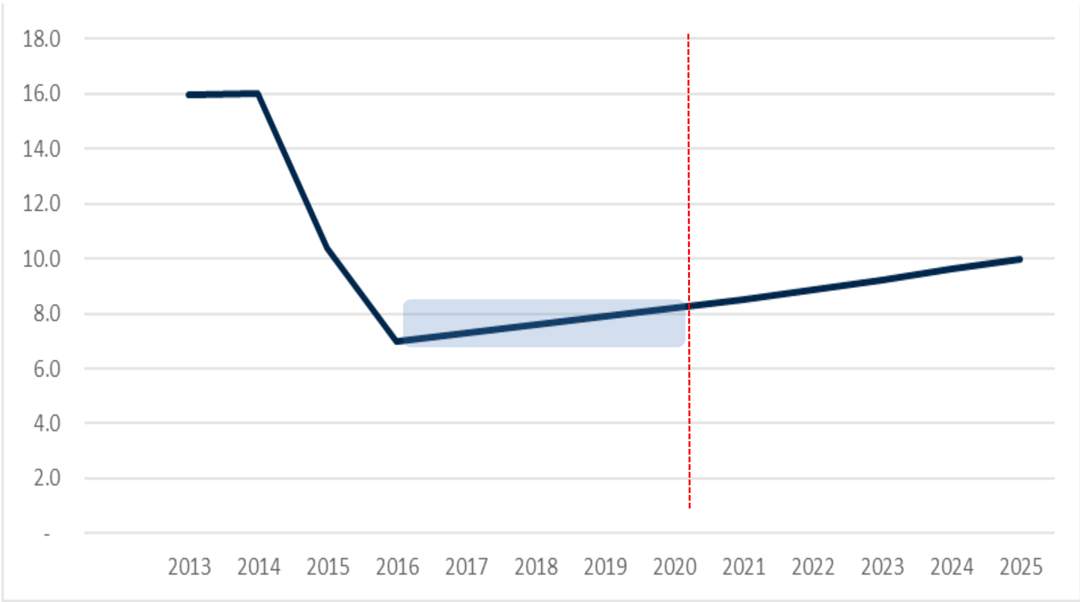


Figure 30: Japan LNG price forecast

Source: (World Bank, 2016)
Note: Price in $/MMBtu

In conclusion, there does exists a strong possibility that the LNG buyers in Asia continue with the oil-indexation. The low oil price is the prime reason as to why the buyers in Asia would continue to do so.

5.1.2. Will there be Henry-Hub Indexation for Asian LNG?

A strong possibility of the Henry-Hub indexation has also arisen as the U.S. is poised to become the 3rd largest L.N.G exporter in the world by 2020. Contracts concluded by U.S LNG Exporting companies, such as Cheniere Energy, have adopted Henry-Hub indexation. According to (EIA(a), 2015) nearly 80% of U.S. LNG export volume has been contracted directly to the Henry-Hub indexed pricing, or under a hybrid pricing mechanism linked to the Henry Hub price. These contracts price LNG at 115 percent of the Henry Hub spot price and charge a fixed liquefaction fee of $2.25-$3.5/MMBtu (Ripple, 2016). This price is F.O.B (Free on Board) meaning it does not include shipping and regasification costs.

$$L.N.G\ Price_{F.O.B} = 1.15\ (Henry\ Price_{Henry\ Hub}) + Constant$$ (Ripple, 2016).

The pricing is cost-plus, whereby the exporting company purchases natural gas from the national pipeline grid and then transports it through pipelines to the liquefaction facility- liquefies the gas to L.N.G and loads it on ship for sea-voyage.
The constant term in the above price equation accounts for the liquefaction cost incurred by the exporting company. For the U.S liquefaction projects the constant varies from $2.25 /MMBtu to $3.5 /MMBtu. The $2.25 /MMBtu liquefaction cost was applied in Cheniere-BG deal (Reuters, 2011). The LNG buyer, which could be a trader or an aggregator or a country, buys the L.N.G from the U.S. exporter at the F.O.B price and is then free to divert the cargo at price signals. Below two figures 31

and 32 are self-explanatory as to why U.S Henry-Hub pricing influence will increase in the Asian markets in the short-term.

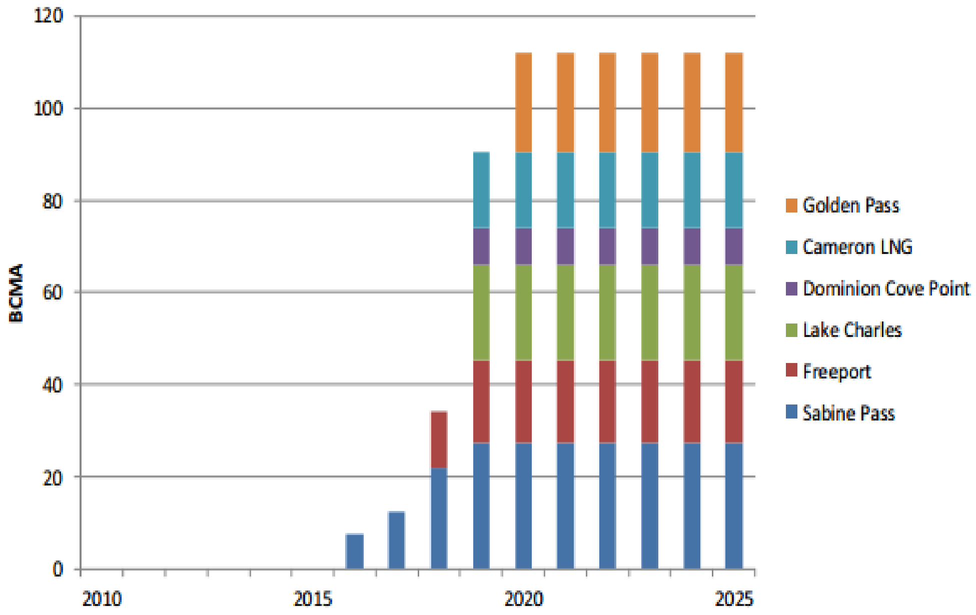


Figure 31: US Natural gas export terminals

Source: (Rogers & Stern, 2014)
Note: Cameroon LNG project has been put on hold in July 2016 [source: (LNGWORLDNEWS, 2016)]

The U.S. LNG export capacity will rise from literally zero in 2015 to approximately 110 Billion m^3 per annum capacity by 2020. This increase will account for nearly forty percent of global liquefaction capacity that will come online during the same period. Furthermore, most of the U.S. export volume has been contracted by Asian buyers and portfolio aggregators under the Henry-Hub pricing mechanism, reflecting the growing belief and reliance of major buyers on the U.S. Henry-Hub pricing formula.

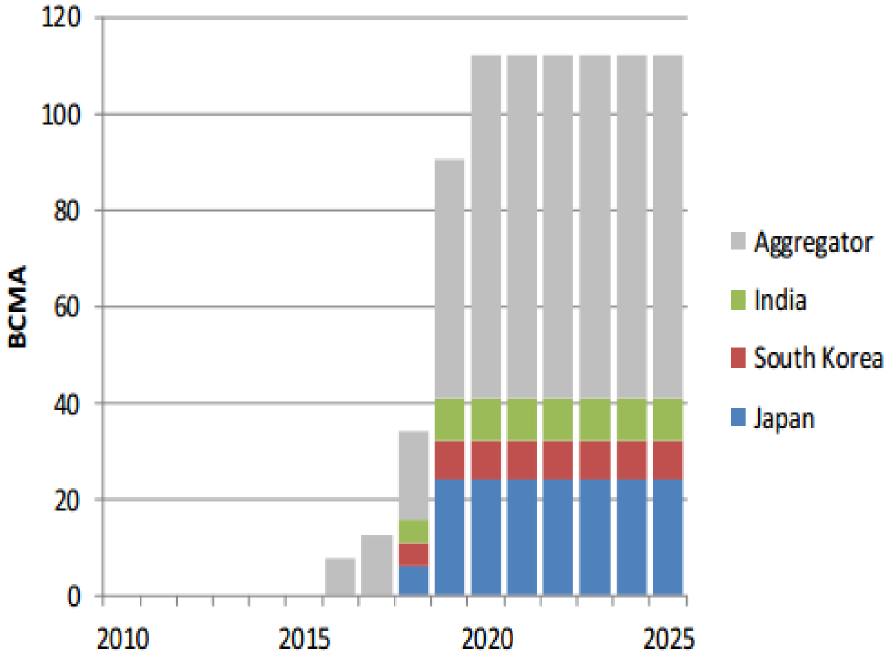


Figure 32: Asian Natural gas market demand

Source: (Rogers & Stern, 2014).

(Rogers & Stern, 2014) and (IEA/OECD, 2014) also identified the possibility of Henry-Hub indexation as an alternative to oil-indexed pricing in Asian LNG market. In conclusion, the likelihood of Henry-Hub indexation does exist and so has been considered as the second alternative pricing mechanism in the short term. Even though the Henry-Hub indexed pricing has gained popularity and is one of the most probable scenarios going forward in this research, it is important to underline that the Henry-Hub indexation is certainly not the long term solution of LNG pricing for the Asian buyers. To reiterate, the Henry-hub pricing formula is a likely scenario in the short term but not the best one in the longer horizon. (Rogers & Stern, 2014) and (Hashimoto, et al., 2016) have discussed the following drawback of Henry-Hub pricing. The Henry-Hub prices reflect the demand-supply fundamental of U.S domestic gas market and not the Asian market and those fundamentals can change independent of the Asian Market. Adopting the Henry-hub pricing reflects the inability to distinguish current low price level incentive from a stable price formation mechanism. The logical and most discussed long term solution is the development of Asian LNG trading hubs (Stern, 2016). However, the development of trading hubs is not expected to occur in the short time line of next four years. The development of similar trading hubs in U.S and Europe took more than 10 years (Stern & Rogers, 2011). Hence, the possibility of LNG trading Hubs in Asia has not been considered as an alternative in the short-term.

So, in the short-term the influence of Henry-Hub price indexation will increase on Asian LNG pricing mechanism. In this scenario of increasing usage of Henry-Hub indexation, it is first required to estimate the Henry-Hub prices in the short-term. In the next section 5.2, the research estimates the how the Henry-hub prices would evolve in the short-term.

5.2. *Changes (or not) in the Henry Hub prices up to 2020!*

In this section the objective is to establish and substantiate a realistic base for the evolution of U.S. Henry-Hub price in short-term, up to 2020. This base Henry-Hub price would then form the basis of Henry-Hub indexed LNG price for section 5.1.2. This section recycles and filters existing official projection and reports in order to establish the price base for Henry-Hub.

Henry Hub is a natural gas pipeline located in Louisiana and serves as the official delivery location for futures contracts and pricing point for natural gas futures on the New York Mercantile Exchange. Henry-Hub has access to many of the major gas markets in the United States. The hub connects to most intrastate and major interstate pipelines. By virtue of large pipeline connectivity, the Henry-Hub acts as active physical trading point. The Henry-hub prices are used as benchmarks for the entire North American natural gas market (Investopedia, 2016). As quoted by (EIA(c), 2016) "Henry-Hub natural gas spot prices varies as per assumptions about the availability of domestically produced natural gas, overseas demand for U.S.LNG, and domestic consumption trends*".* All else equal, the Henry-Hub price rises as demand for U.S. LNG exports rises. Also, with fall in available resource (unlikely) or increase in domestic demand the Henry-Hub price rises, all else equal. So, the exact impact of LNG exports on the Henry-Hub price depends on both domestic and international market factors.

As the horizon comes closer, the variability in a forecast reduces and probability of certain scenarios being reality inches closer to unity. In the paper "The Outlook for U.S. Gas Prices in 2020: Henry Hub at $3 or $10?" published in December 2011, (Michot 2011) concluded that Henry-Hub gas prices could credibly be as low as $3 /MMbtu, or as high as $10 /MMbtu in 2020 and argued that the likelihood of higher price late this decade, by 2020, is significantly higher than the $3-4 /MMbtu levels of 2011. Michelle Foss' study looked at the past five years of supply, demand and pricing which had been strongly impacted by the unconventional gas – and particularly shale gas. She was in particular sceptical of the U.S. Energy Information Agency's "conventional wisdom" which projected the prices to be around $4 /MMbtu by 2020. The argument being that such low prices would induce markets response of increase in LNG export to the international markets and lead to eventual rise of Henry-Hub price. Now at present in 2016 and looking forward into 2020, the chances of Henry-hub prices reaching the level of $10 /MMbtu, as forecasted by Michelle Foss, is nearly impossible.

However, the concern that domestic prices (U.S. Henry-Hub prices) would rise significantly, called for greater research into the matter. A recent exhaustive report "The Macroeconomic Impact of Increasing U.S. LNG Exports" prepared for Department of energy, U.S in October 2015 - by the Centre for Energy Studies (CES) at Rice University's Baker Institute and Oxford Economics concludes that the overall macroeconomic impacts of the U.S. LNG exports are marginally positive and there would only marginal increase in domestic (Henry-Hub) natural gas prices. The average henry hub price by 2020 is suggested to be around $4.5 /MMbtu after accounting for 18 possible scenarios. The highest Henry-hub price is expected to be around $ 5 /MMbtu in the reference case of LNG20_Ref20 which assumes higher level of international demand for U.S. LNG. (Leonardo Technologies, Inc, 2016). The weakened demand in the major importing region of Asia limits the possibility of above high demand scenario and the Henry-hub price should be around $4-4.5 /MMbtu by the end of this decade.

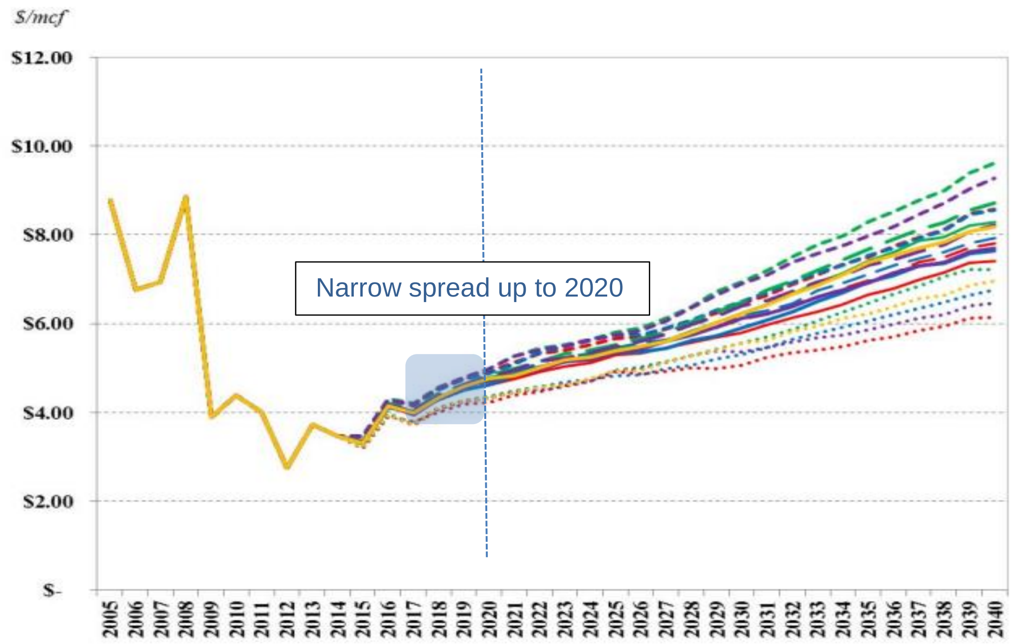


Figure 33: Henry-Hub price scenarios

Source: (Leonardo Technologies, Inc, 2016)
Note: [$/mcf to $/MMbtu conversion factor = 1.02]

Even the narrow price spread of Henry-hub price, as suggested by (Leonardo Technologies, Inc, 2016) needs further magnification since the regional price convergence has limited the potential arbitrage margins to a minimum. Even a $0.8 to 0.5 /MMBtu difference in the estimate of Henry-Hub price can limit the U.S – Asia arbitrage margin to zero. Figure 33 shows the converging trend of the prices in the export and import markets of U.S and Japan respectively. ∆ denotes the difference between Japan LNG and U.S Henry-Hub natural gas price. The sourced feed gas at Henry-Hub needs to be liquefied and transported in LNG vessels and finally re-gasified at import terminal before it could be fed to the end buyer. As it would be calculated in Chapter 6, a minimum cost of liquefaction and transportation (around $3-3.5 /MMbtu as indicated by red-zone in 33) when taken into account, a theoretical limit for U.S.- Asia price arbitrage is reached.

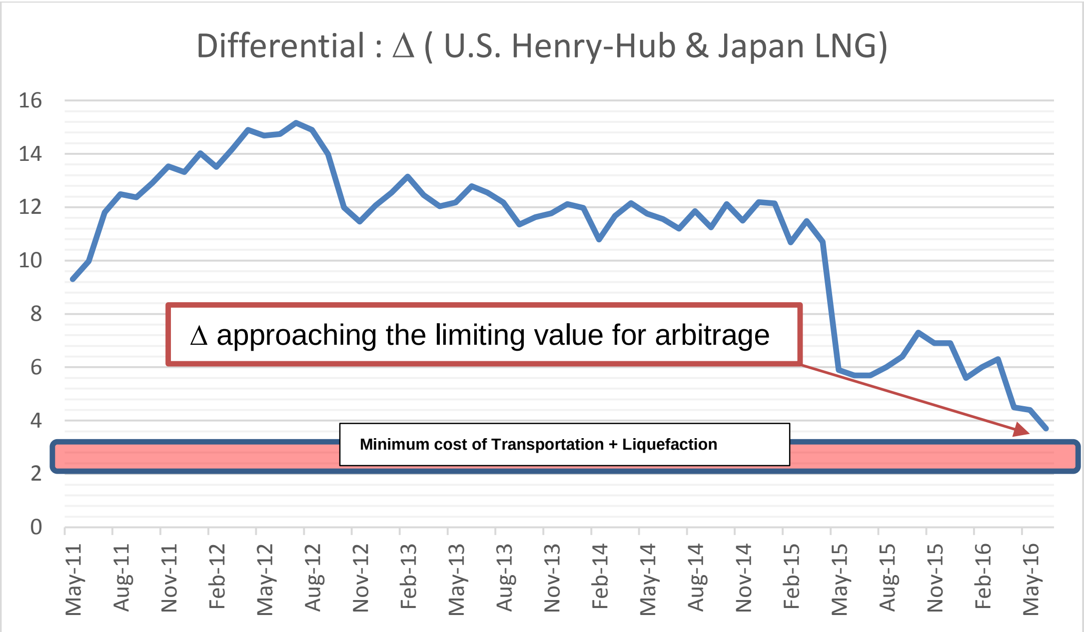


Figure 34: Natural gas price difference: US and Japan

Source: Authors via World bank data

In a high differential scenario, as it was in July 2014 till March 2015, marginal changes in cost/price for any of the components – such as marginal fluctuation in Henry hub price, fluctuations in shipping cost or in oil indexed Japan LNG prices - would not have mattered as the margin was sufficient enough to absorb any of those. But now in the new normal of low price environment and regional price convergence the margins are becoming razor thin and any fluctuation in any of the cost/price component can limit the arbitrage.

This differential of U.S Henry hub price and Japan LNG approaching a critical range explains the inclusion of Henry-Hub price as one of the major scenario determinants in this research. The scope of the report (Leonardo Technologies, Inc, 2016) is comprehensive and focuses on long term macroeconomic developments - up to 2040. The report result (Figure 33) helps the current research to a narrow down to realistic scenario of Henry-Hub pricing in the interval of $ 4 to 4.5/MMbtu. However, the shorter temporal scope of this research (short term- up to 2020) requires a better insight into the price development of U.S. Henry-Hub prices. The Commodity Market Outlook (World Bank, 2016) sees the Henry-Hub price developments in the short-term horizon as shown in figure 35.

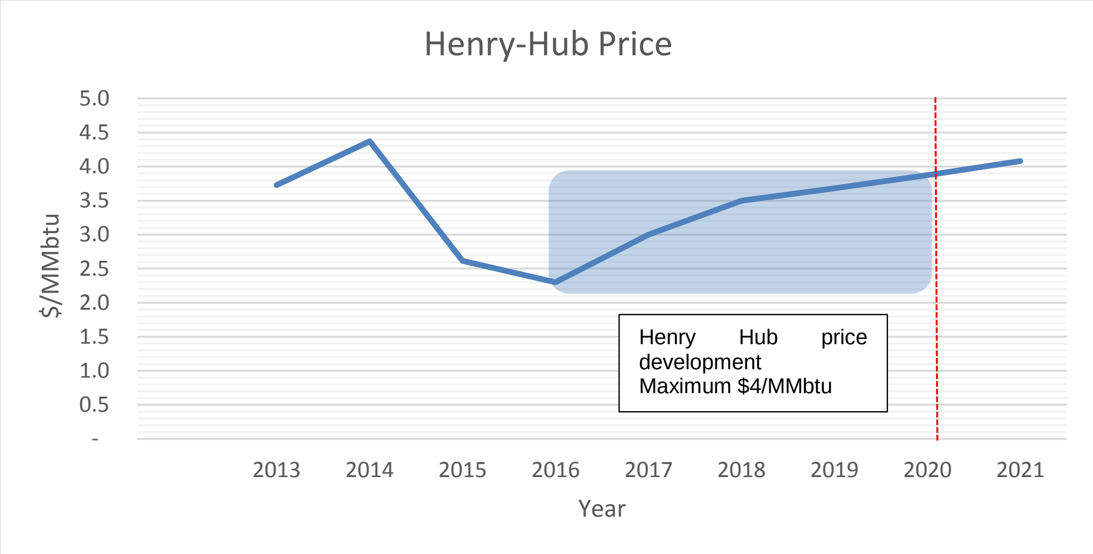


Figure 35: Henry-Hub price band

Source: Author via (World Bank, 2016)

A comparison of (World Bank, 2016) commodity outlook report and EIA 2013 forecast for low oil price environment shows that actual Henry hub price in the case of oil-price crash (2014-2016) has been lower than that forecasted by (EIA, 2013) – see figure 36. This could have been due to the fact that the dip in oil prices have been more than what was anticipated by EIA for low-oil scenario.

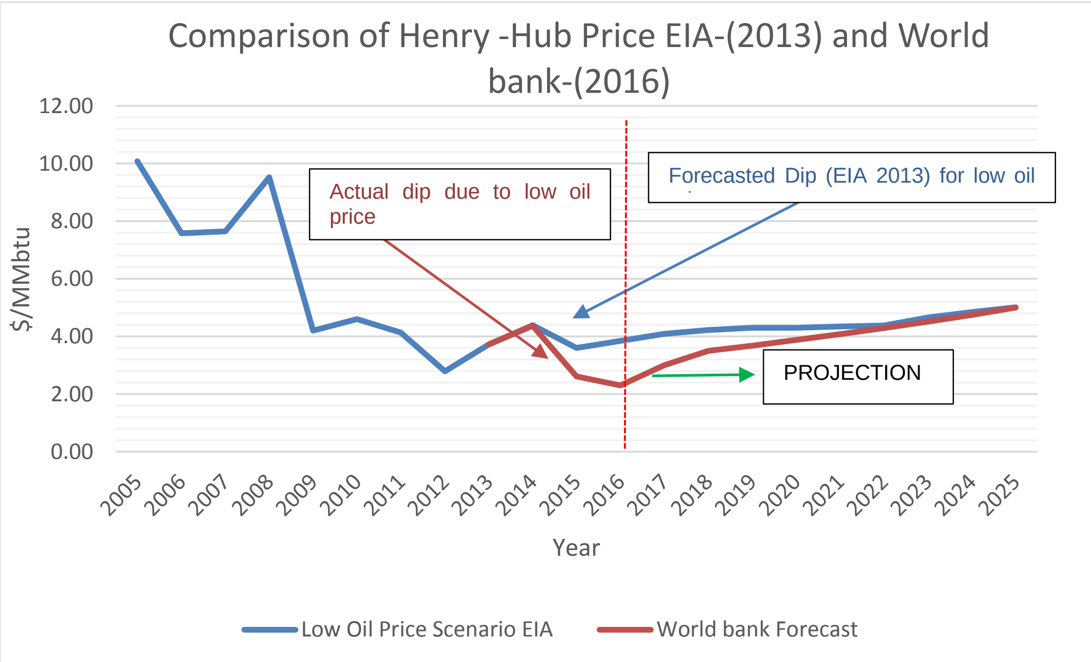


Figure 36: Comparison of Henry-Hub prices

Source: Author via World bank and EIA data.

Conclusively, all the above recent reports (Leonardo Technologies, Inc, 2016); (World Bank, 2016) and (EIA, 2013) suggest the U.S Henry-Hub prices to be around $4

/MMbtu by 2020.Again based on content analysis, this research builds up further that U.S. Henry-Hub price will be around $4 /MMBtu as it has been forecasted by (World Bank, 2016). The conclusion for this section is that the U.S Henry-Hub price will be rise very slowly from the present range of $2.4 /MMBtu to a maximum of $4 /MMBtu by the end of this decade.

Detailed in sub section 5.1.2, one of the probable scenario for the evolution of Japan LNG pricing is more linkage to Henry-Hub prices. In this scenario the F.O.B price for U.S LNG export follows a linear mathematical relation with the Henry-Hub price.

$$L.N.G\ Price_{F.O.B} = 1.15\ (Natural\ Gas\ Price_{Henry\ Hub}) + Constant$$

Source: (Archives/edgar/data, 2011)

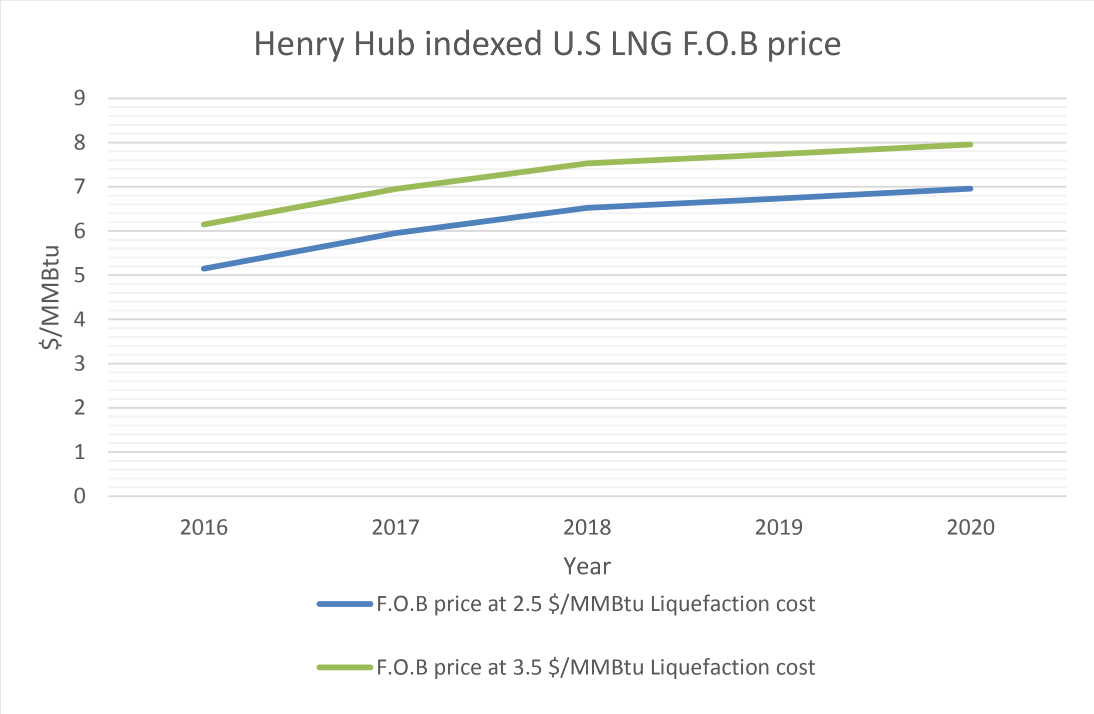


Figure 37: Henry-Hub indexed US LNG FOB price

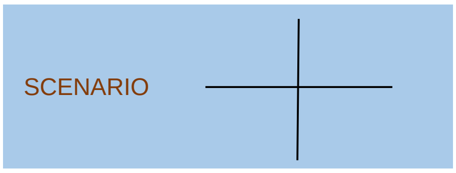
Source: Author based on World Bank Commodity Report 2016

Based on above the pricing relation the following price scenario for U.S LNG develops The constant for liquefaction cost varies from minimum of $2.25/MMBtu to a maximum of $3.5/MMBtu (Ripple, 2016), (Marketrealist, 2014); (Financial Times, 2016).

From the figure 37 it can be seen that the Henry-Hub indexed U.S LNG F.O.B price is also sensitive to the liquefaction cost. Further in this research, the F.O.B price corresponding to $2.5/MMBtu has been taken as a reference value for comparison and calculation. The sensitivity of U.S LNG F.O.B price to the liquefaction cost and its effect on the arbitrage margins in various scenarios is suggested as a topic for further research and has not been included here for brevity.

6. Scenario Development and Scenarios

Having discussed the logic, this sub-section will converge the analysis and results from Chapter 4 and Section 5.1-5.2 into the two main uncertainties. *This section will outline the answer to sub research question 5 "What could be possible scenarios for evolution of East Asia LNG pricing and trading by 2020?"*



The two main uncertainty, which further develops into scenario matrix, are summarized below:

- How will LNG pricing evolve in short term?

Based on the analysis and calculation in Section 5.1 and 5.2, one of the key uncertainty is how the Asian LNG pricing will evolve in the short-term. This key uncertainty, in turn, gives rise to two scenarios. One is that the Asian LNG pricing mechanism continues to be dominated by oil-indexed pricing. The likelihood of this scenario has emerged due to the recent oil-price crash which reduced the Asian LNG prices. The second probable scenario is Henry-Hub indexation of Asian LNG. The strong likelihood of this scenario is due to the exponential increase of U.S LNG export due to the shale gas revolution. Both the scenarios are expressed in $/MMBtu in figure 38.

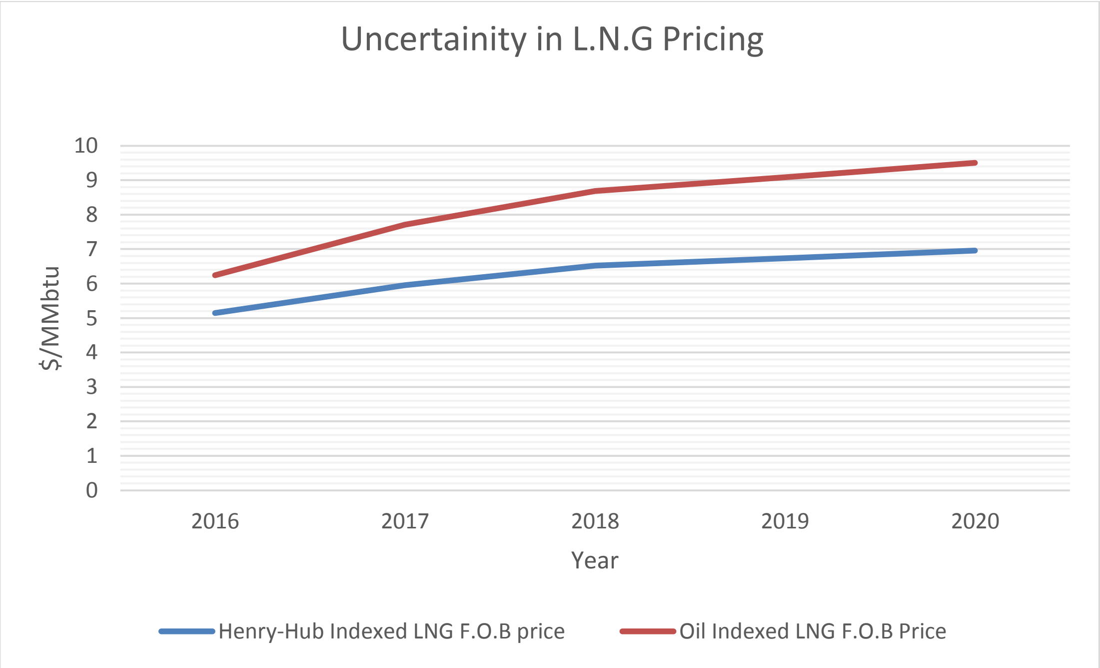


Figure 38: LNG price uncertainty

Source: Author

- How will LNG transportation cost evolve in short term?

Based on the analysis and calculation in Chapter 4, the second key uncertainty going forward in the short-term is the evolution of LNG transportation cost in the short-term. This key uncertainty, in turn, gives rise to two scenarios. One is LNG transportation cost in a low charter rate environment. The low charter rate environment is of 20,000 $/day rate. The second scenario of the LNG transportation cost in charter rate environment of $60,000 /day. In both the above scenarios, the expanded Panama Canal route is taken into account since the expanded canal can accommodate 90 percent of existing LNG fleet and most of U.S LNG export to the North Asian Countries-Japan, Taiwan and Korea, is expected to flow through this route. The two scenarios are expressed in $/MMBtu in the figure 39.

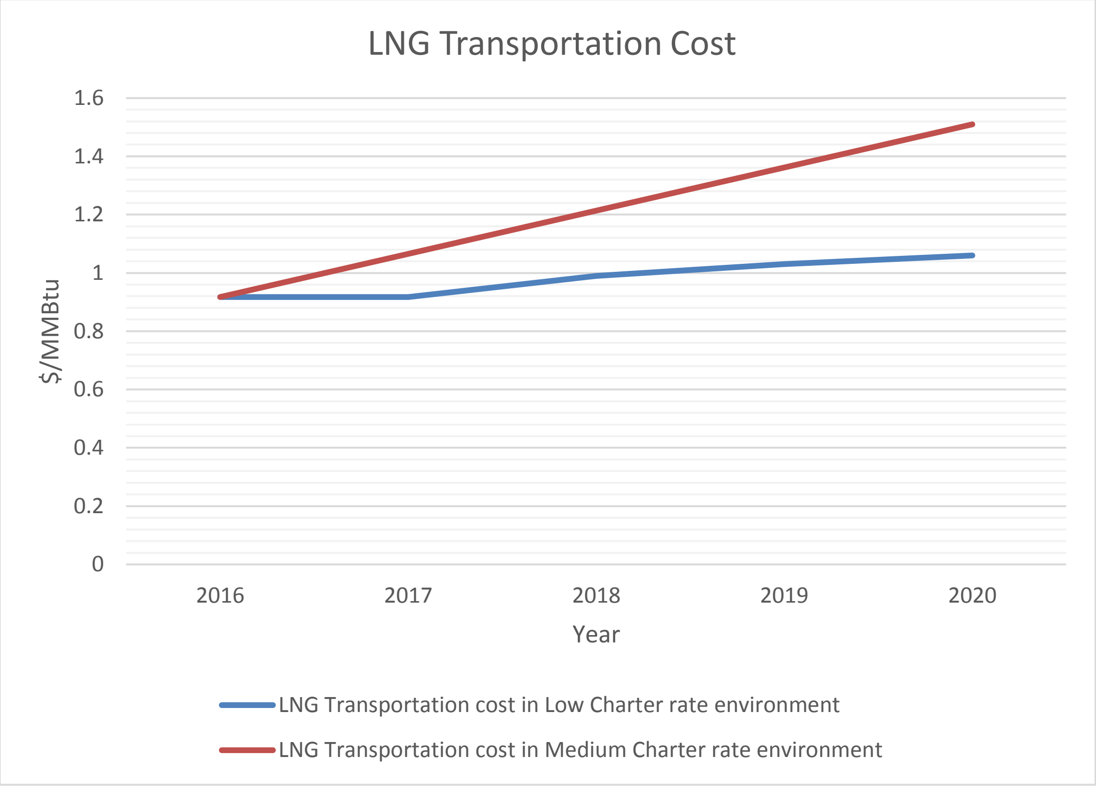


Figure 39: LNG transportation cost uncertainty

Source: Author

The above two key uncertainty results in the following four intermediate scenarios. It is important to underline that these are intermediate scenarios because when these four intermediate scenarios are compared to Japan LNG forward price (Figure 30), then the final scenario corresponding to arbitrage margins becomes evident (Figure 37).

- Intermediate Scenario 1 (Henry Hub pricing and Low Charter rate)
- Intermediate Scenario 2 (Henry Hub pricing and Medium Charter rate)
- Intermediate Scenario 3 (Oil-Indexed pricing and Medium Charter rate)
- Intermediate Scenario 4 (Oil Indexed pricing and Low Charter rate)

The objective of this research is to study how different scenarios will affect LNG trading houses. Out of the wide scope of trading domain, this research limits its scope to the changes in arbitrage margins. The arbitrage margin is the difference between the Japan LNG forward curve (Figure 30) and each of the four intermediate scenarios. The Japan LNG forward curve represents the price of LNG that the buyers would be willing to pay for LNG in the East Asian markets. The other four price curves represent the price which a LNG buyer would have to pay to buy U.S LNG at either Henry-Hub price or oil-linked price and transport it via expanded Panama Canal.

Figure 40 illustrates the comparison of Japan LNG forward curve with the four intermediate scenarios.

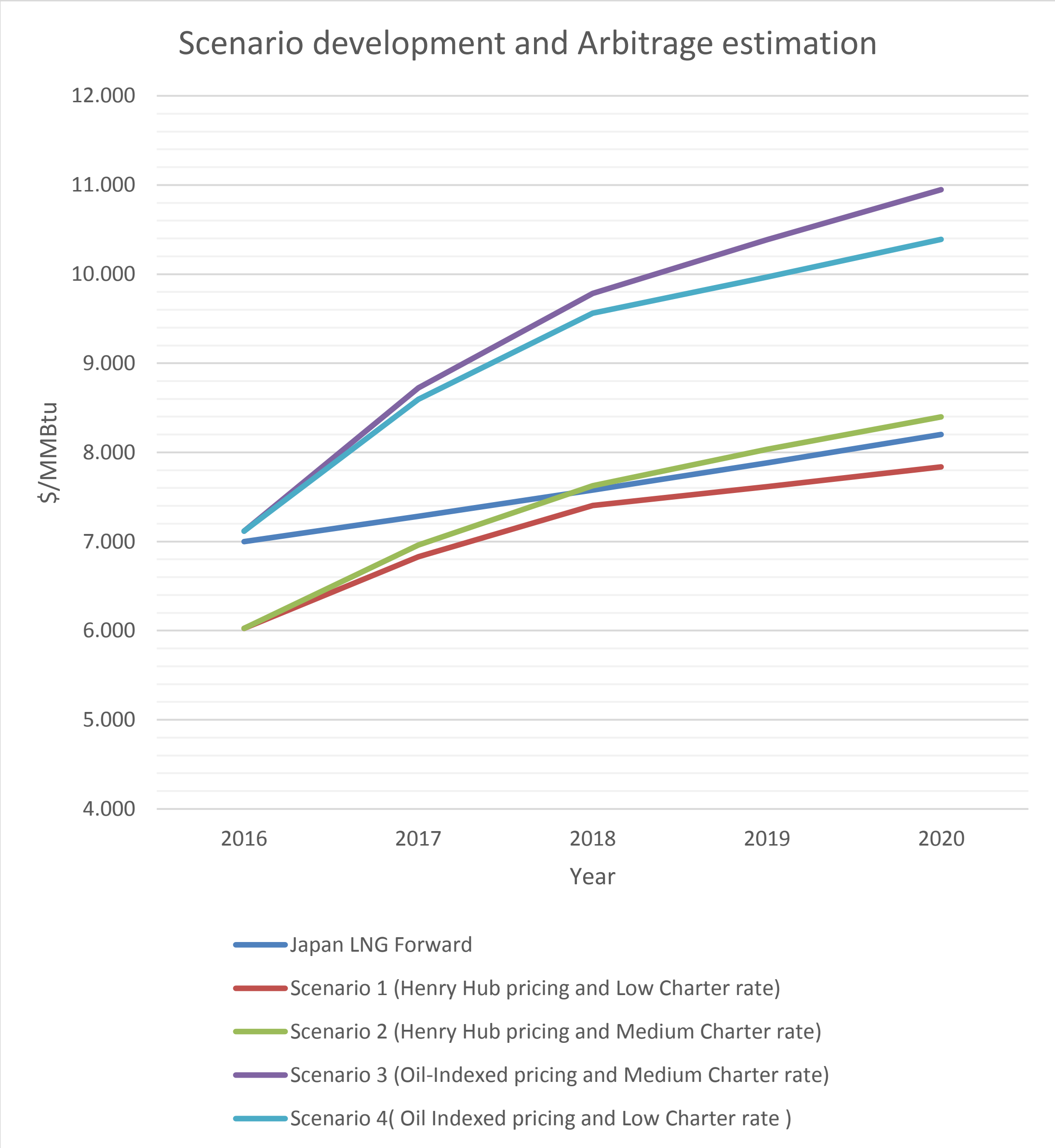


Figure 40: Scenario comparison

Source: Author

The difference between the Japan LNG forward price and the intermediate scenarios lead to the result table 8.

Year	Scenario 1 (Henry Hub pricing and Low Charter rate)	Scenario 2 (Henry Hub pricing and Medium Charter rate)	Scenario 3 (Oil-Indexed pricing and Medium Charter rate)	Scenario 4(Oil Indexed pricing and Low Charter rate)
2016	0.975	0.975	-0.118	-0.118
2017	0.453	0.323	-1.442	-1.312
2018	0.172	-0.048	-2.205	-1.985
2019	0.268	-0.152	-2.502	-2.082
2020	0.366	-0.194	-2.746	-2.186

Table 8: Japan LNG forward prices and Scenario based prices

Source: Author

Based on above result of arbitrage margins, the final scenario matrix takes form in figure 41. The Japan LNG price curve is the LNG landed price in the Japan, proxy for Asia-Pacific market. When the net buying price, as represented by 4 scenarios, is below the Japan LNG price curve then there exists a positive arbitrage margin. Conversely, when the net buying price is above the Japan LNG price curve, then there will be negative arbitrage margin.
Based on the scenario matrix and the implication, the four scenarios has been categorised under the following four headings. The final scenario matrix (Figure 41) has been named from the perspective of the LNG trading House.

Scenario 1 stands for “LITTLE JOY” as the LNG trading houses will need to adjust to the new normal of thin arbitrage margins. As compared to the other scenarios, this is the most joyous scenario for Traders in the short-term. This scenario results from the combination of Low Charter rate and Henry-Hub price indexation in relation to Japan LNG forward price. The resulting arbitrage margins would be small (up to about $0.5 /MMbtu) and just a fraction of the arbitrage margin that existing during 2012.

Scenario 2 is “TOO CLOSE FOR COMFORT” because even the Hub-indexed pricing will not maintain the positive arbitrage margin after 2018. This scenario arises from the combination of medium charter rate and Henry-Hub price indexation. In 2018, as the charter rate reaches $40,000/day (Figure 23) then the total cost of transporting LNG from the U.S Gulf coast to the North Asian LNG market when added to L.N.G bought at Henry-Hub price will become exceed the Japan LNG price (Figure 30).

Scenario 3 has been referred to as “RISING PRESSURE” because in this scenario the oil-linked LNG price starts to diverge more and more from the Japan LNG price. As a result, the LNG buyers will pressurise the exporters for renegotiation of LNG contract terms. Combination of oil-indexed pricing and rising charter rate results in Scenario 3. According to (Rogers & Stern, 2014), in case of oil-indexation the gradual rise of oil-prices will result in Japanese LNG buyers making losses and would demand price renegotiations. This renegotiation, in turn, would be resisted by suppliers due to high capital investments in projects and would not compromise on the oi-linked prices in their contracts. A LNG trading house would be caught up in the tug of war between the supplier and buyers. Parties would resort to litigation with unpredictable results, and hence the scenario “Rising Pressure”.

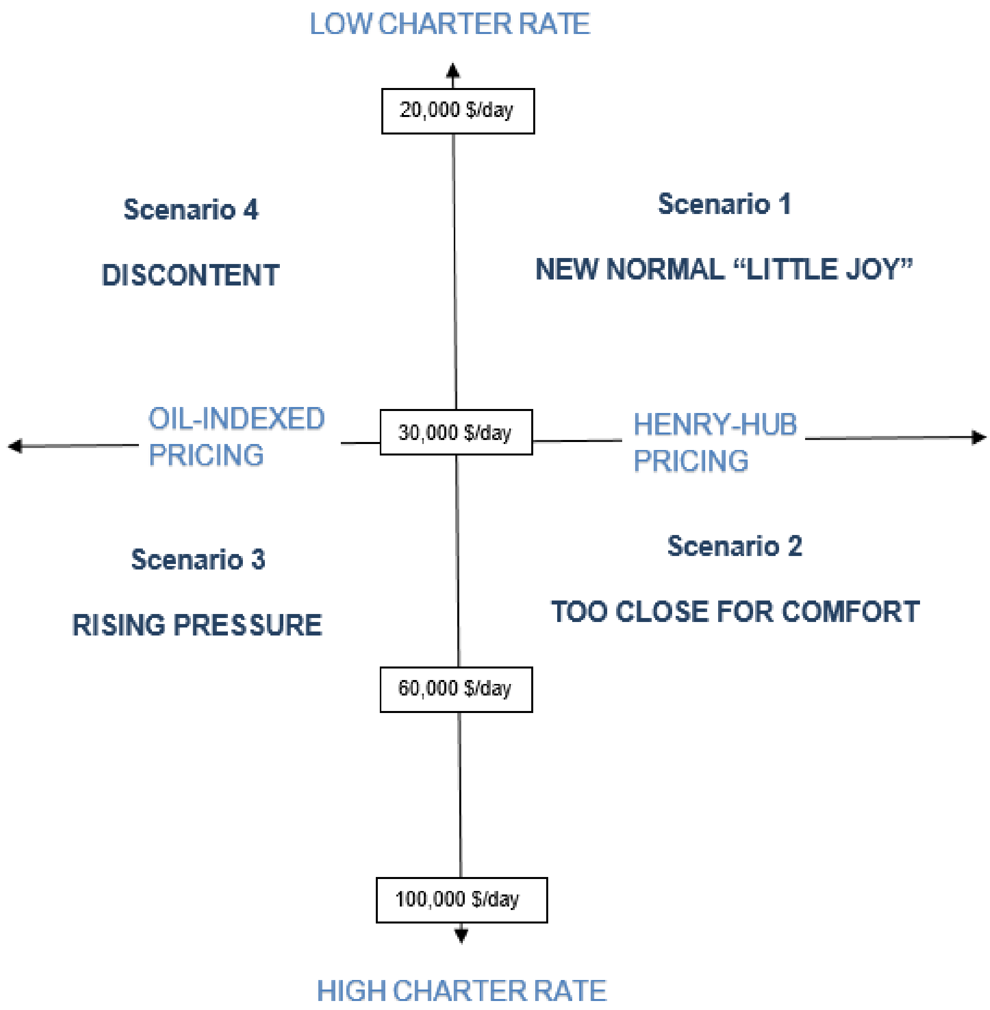


Figure 41: Final Scenario matrix

Source: Author

Scenario 4 signifies “Discontent” among the LNG buyers. Even in the low charter rate environment of $20,000 to 30,000 /day , the steadily rising oil price (Figure 29) will increase the oil-indexed LNG price and will inflate the negative arbitrage. Such a scenario has also been formulated by (Rogers & Stern, 2014), in which buyers continue to complain about oil indexed pricing but there is no change in the status quo. The buyers would then wait for the expiration of existing contracts which has oil-indexed pricing and then would renegotiate the pricing clause. For instance, India's biggest gas importer Petronet LNG renegotiated contract with Rasgas to supply LNG at $6-7 /MMBtu from 1st January 2016, which is much lower than initial contract price of $12-13 /MMBtu (Reuters(b), 2015).

7. Conclusion

This final chapter will summarize the result of this research and present the implications thereof. In addition, the limitations of this research will be mentioned as well as suggestions for further research related to the topic and field of study.

The research started with the objective to investigate the impact of U.S Shale gas export on Asian LNG pricing and implications on LNG Trading up to 2020. The main research question read "*What will be the impact of US Shale gas exports on Asian LNG pricing and trading by 2020?".*
Understanding the limitations of a forecasting methods for a complex and volatile system, this research employed 8 step scenario planning methodology to develop a realistic scenario matrix. Content analysis was used as tool for identifying key uncertainties. The result has been quantified in the table 9.

Year	"Little Joy"	"Too close for comfort"	"Rising Pressure"	"Discontent"
2016	0.975	0.975	-0.118	-0.118
2017	0.453	0.323	-1.442	-1.312
2018	0.172	-0.048	-2.205	-1.985
2019	0.268	-0.152	-2.502	-2.082
2020	0.366	-0.194	-2.746	-2.186

Table 9: Arbitrage Margin

Source: Author

The result shows that in the scenarios of oil-indexation - "Rising Pressure" and "Discontent", the negative arbitrage margin will foster discontent among the buyers and there will be increased pressure for renegotiation of the pricing clause. In other two scenarios pertaining to Henry-Hub indexation – "Little Joy" and "Too close for comfort", the low charter rate environment maintains positive arbitrage margin up to 2020 for the scenario of "Little Joy" but moderately rising charter rate would rob off the positive margin in 2018, as the charter rate reaches $40,000 /day. Conclusively, it is stated that the U.S shale gas export will increase the Henry-Hub influence on the Asian LNG pricing and the LNG Trading houses will have to accept and adjust as per the new normal of thin arbitrage margins between the U.S-East Asia LNG trade.

7.1. Findings and Implications

The next sub-section presents the findings and key-insights. *This section also marks the closure of the final sub research question 7 "What will be the implication of resulting scenarios on Asian LNG Pricing and Trading?"*

7.1.1. Key finding

The first key finding, is that the Henry Hub indexed LNG pricing (“Little Joy” and “Too close for comfort”) keeps the forward curves much closer to the Japan LNG price. In “Little Joy” scenario, there exists positive arbitrage margin up to 2020. As per results, the margin would be reduced to a minimum of about $0.22 /MMBtu in initial month of 2018. The arbitrage margin then again starts to increase after that. The steeper rise of U.S. Henry-Hub price up to 2018 pushes the margin to a minimum. In Scenario 2 “Too close for comfort” the year 2018 turn out to be the inflection point for the arbitrage between U.S LNG and Japan LNG price. The steeper rise of Henry-Hub price coupled with moderately rising charter rate overruns the Japan LNG price in 2018. Hence, 2018 will turn out to be an a rather watchful year for the U.S-Asian LNG trading.

The second key finding which explicitly stands out from the research is that the in continuation of oil-indexed pricing – “Rising Pressure” and “Discontent” – the Asian buyer will pay more than then existing Japan LNG price. Today, the low oil price around $40-43 /barrel has resulted in near convergence of the Japan LNG market price and the oil-indexed price. As a result, the buyers are not complaining as they are not paying any Asian premium as of now. However, as the oil price would steadily rise from $40 /per barrel to the $63 /barrel by 2020 (Figure 29) the oil-indexed LNG price would also rise. Furthermore, the rise of oil-indexed LNG price would be steeper than the Japan LNG price curve and the negative difference between two would increase up to $2 /MMBtu by 2020. This conclusion of increasing negative differential is significant because few long term sale & purchase contracts- which are linked to oil- will expire in 2018-2019. Expiration will result in more available volume. The new projects in Australia and the U.S. will continue to saturate the Asian LNG market, and the less stellar demand fundamental will maintain the downward pressure on the spot price. This will invoke the buyers to renegotiate their deals with suppliers. The above conclusion should be one of the basis for renegotiation of new contract structure having shorter term and a pricing mechanism away from oil-indexation. Buyers, who are traders, portfolio players or a country, could push harder to change the pricing structure of their deals from an oil-based indexation to Henry Hub indexation as to protect against the divergence in oil and gas prices.

7.1.2. Implication on Asian LNG pricing

The result (table 9) shows that the usage of Henry-Hub indexation will maintain positive arbitrage margin for the U.S. LNG export to East Asian markets. The positive margin will continue till 2020 in the low charter rate environment of $20,000 /day however, will reach the inflection point in 2018 for the medium charter rate environment. This when compared to negative arbitrage margin for both oil-indexed pricing scenarios, then clearly the buyers will mount greater pressure on the suppliers to either stick to Henry-Hub pricing or will negotiate to delink the LNG price from the oil-price. Hence, in the short term the influence of Henry-Hub indexation will increase on the Asian LNG pricing.

7.1.3. Implication on LNG Trading

In 2015, Goldman Sachs Group Inc. estimated that Global trade in LNG will exceed $120 billion by end of 2015 and overtake iron ore as the most valuable commodity after oil (Bloomberg, 2015). In 2016, Liquefied natural gas (LNG) indeed became the second most significant traded commodity with the annual trade value of more than 150 billion dollars, next to that of crude oil (Ministry of Economy, Trade and Industry-Japan, 2016). For such a significant commodity which is characterized by increasing value and volume, but decreasing arbitrage margins a key implication which surfaces up is that LNG trading houses should expand to take up and trade more LNG volumes. Increased traded LNG volume at low arbitrage margins can maintain the revenue for the trading houses. Shell $52 Billion acquisition of British gas, early in 2016, is an indication that bigger LNG volume will matter in coming days. The deal has positioned Shell as leader in LNG portfolio. BG's LNG portfolio combined with Shell's account for almost 16% of the global LNG market (The Guardian, 2015). There would be more optimization of assets so as to squeeze some extra margin from the converging and low gas prices. Merger as above, would mean a flexible and better utilization of the shipping fleet.

The difficult environment of thin margins will also encourage logistical co-operation between LNG trading houses. The co-operation could come in form of cargo swap and vessels pooling. The concept of cargo swap as a measure to reduce inefficiency was also discussed by Zhi Xin Chong, Principal Analyst for Asia Gas & Power and LNG Corporate service at Wood Mackenzie, in the referred corporate video (Wood Mackenzie, 2016). An instance of inefficiency is delivery of Australian LNG to South America while cargoes from North America being shipped to East Asia. Better co-ordination and cargo swap among LNG players would reduce inefficiencies and improve profits.

Vessels pooled under a single charterer could allow for better utilization of a chartered vessel for the participants. To the best of Authors knowledge this concept has not been yet discussed for LNG fleet but similar pooling agreements exists in Bulk shipping. Conceptually, the individual trading houses would be operating individually but would charter vessel under the umbrella term of 'single charterer'. Testing the utility of this concept has been proposed as further research.

7.2. Early Indications and Key Insight

The purpose of "early indications" is to select the scenario which is most likely to occur out of the four scenarios identified in the scenario matrix. This is the last refinement step and it filters the most probable scenario so that a suitable strategy can be adopted. Early indicators appear in form of reporting, publications, news and announcements.

7.2.1. Early Indication

According to statement released by the rating agency FITCH on 13th May 2016, reported by (Reuters(a), 2016) - "the emergence of US liquefied natural gas as alternative in an already oversupplied market, will cause convergence between natural gas prices at major hubs and weaken the link between gas and oil prices". Similar conclusion was voiced by (Timera Energy, 2016) regarding increasing Henry-

Hub influence on Atlantic markets. In regard to the charter rate development (Drewry, 2016), in the latest LNG forecaster (28th July 2016), indicates that the LNG shipping market would get balanced in 2018-see figure 22. (Tradewinds, 2016) on July 28th reported that LNG charter rates would slowly improve in coming year.

Clearly, the above indications point towards the scenario of "Too close for comfort", which is combination of Henry-Hub indexation and moderately growing charter rate.

7.2.2. Key Insight

This scenario "Too close for comfort" is one of the most probable scenarios going forward, indicated by "Early Indications" in Section 7.2.1. and hence the best strategy for the LNG trading houses should be to move forward in view of "Too Close for Comfort".

The strategic insight that this research offers to the Trading house, in view of "Too close for comfort" scenario, is to time-charter vessels in the current low-charter rate environment. This will allow the trading houses to maintain the charter cost around $20,000 /day and hence maintain the positive margins in 2018, even when the LNG market spot rate rises up-to $40,000 /day (Figure 23). In the new normal of low and regional price convergence the ship-owners loss is traders gain. The independent LNG commodity houses such as Trafigura, Glencore etc. have not yet invested in shipping assets yet and should refrain from doing so in the short-term. However, they should maintain optionality by opportunistically term-chartering the vessels. Major oil and Gas company such as Shell which has LNG trading desk and also has shipping arm that owns shipping assets and charters as well, could pro-actively time charter vessels in this low price environment and then can sub-charter to other trading houses later.

7.3. Limitations

Even though the results of this paper are significant, there are certain limitations. This section briefly underlines the nature of limitations, the extent to which these were a problem, as well as justification of chosen alternative.

Methodological limitation
The most advised procedure for scenario development is through exhaustive primary research which involves stakeholder interviews and feedbacks. The purpose of primary research is to brainstorm every possible "external factor" and then reach to "key uncertainties". Identification of the critical uncertainties is an exhaustive exercise which involves interviews and feedbacks from industry participants. Primary research includes interview and feedbacks form the stake-holders, directly and indirectly involved organization such as N.G.O.'s. The use of primary research would have had indeed expanded the spectrum of this research. It was discussed briefly in section 1.5. that LNG market is a complex system where too many factors influence each other. So the more factors are included the better the scenario planning would be. However, due to time and resource limitation this research builds on content-analysis technique for scenario building. The external factor pertaining to geo-politics and

environmental regulatory measures have not been included in this research and are part of methodological limitations.

Result limitation
The close result of arbitrage margins asks for sensitivity analysis. It was identified in section 5.2 that in case of Henry-Hub pricing the U.S. LNG becomes sensitive to liquefaction cost. However, the sensitivity for liquefaction cost could be included in this research as the value varies from contract to contract and the U.S LNG supplier can even forego the liquefaction cost and continue to export in order to cover only capital cost.

7.4. Suggestion for Future Research

Narrowing down the scope of any research is the first step towards writing it. Trimming the scope is a necessity because of limited resource available for a research. However, this step also leaves behind few factors and limits the direction of a research. Some of those factors have been presented here as suggestion for future research. The future research is an extension of research limitations. This is because some of future research suggestions arise out of the research limitations. In reference to section 7.3, firstly the future research should adopt primary research method as the tool to develop scenarios.

Next suggestion on future research is to build further on the result of this research. This research result shows that 2018 is poised to be the year which requires strategic planning from the LNG trading houses. The result is significant but if the result could be even zoomed up to the monthly timeline then the strategic action can be delayed even further and LNG trading houses could maintain flexibility up till last moments. For instance – if a LNG trading house can time-charter a vessel for lesser duration, knowing that spot charter rate would increase from March-2018, then the results of research would become much more usable.

Third suggestion on future research is to test the hypothesis that increased logistical and contractual co-operation between LNG trading houses could lead to better results and to what extent. Addressing the research limitation, it would also be interesting to see how U.S LNG competes with other LNG supply sources in the event of a geo-political and strategical move. Such moves can come from Qatar, Australia and Russia. The future research could also include the impact of India rising as big LNG demand centre and emerging niche markets in South-east Asia.

Lastly, the impact of changes in Global LNG market on the development of Asian LNG trading hubs is suggested for future research.

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