(Independent Study Proposal)

The Analysis of Long Term LNG Contract Pricing Structure

Mr. Yossaran Pichiansoontorn

A Independent Study Proposal Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Science in Finance
Department of Banking and Finance
FACULTY OF COMMERCE AND ACCOUNTANCY
Chulalongkorn University
Academic Year 2019

(โครงร่างสารนิพนธ์)

The Analysis of Long Term LNG Contract Pricing Structure

นายยศสรัล พิเชียรสุนทร

โครงร่างสารนิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
สาขาวิชาการเงิน ภาควิชาการธนาคารและการเงิน
คณะพาณิชยศาสตร์และการบัญชี จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2562

Independent Study Proposal Title	The Analysis of Long Term LNG Contract Pricing Structure
By	Mr. Yossaran Pichiansoontorn
Field of Study	Finance
Thesis Advisor	Narapong Srivisal, Ph.D.

Accepted by the FACULTY OF COMMERCE AND ACCOUNTANCY, Chulalongkorn University in Partial Fulfillment of the Requirement for the Master of Science

.... Dean of the FACULTY OF COMMERCE AND ACCOUNTANCY
(Associate Professor WILERT PURIWAT)

INDEPENDENT STUDY PROPOSAL COMMITTEE

.... Chairman
()

.... Thesis Advisor
(Narapong Srivisal, Ph.D.)

.... Examiner
(Associate Professor VIMUT VANITCHAREARNTHUM)

.... Examiner
(Assistant Professor ANIRUT PISEDTASALASAI)

TABLE OF CONTENTS

Page

ABSTRACT

This research investigates contributing factors, which could impact LNG pricing structure and components (Constant and Slope) in long term contract LNG. The findings suggest that firstly, oil price volatility has no influence on both selection of index and adopting price protected pricing structure. Secondly, the more active Oil Futures market decreases probability of contracting price protected formula as it serves same objective on price risk reduction. Additionally, it increases level of Slope but decreases Constant components, indicating price relies more on Slope rather than Constant when hedge ability increase or Futures market is more functioning. Thirdly, Slope components are obviously set in reciprocating to Constant (Based Price). The greater the Constant, the lower Slope is distinctly observed. Fourthly, Buyer's Equity ownership in Seller's project induce more probability in Gas Index, and has statistical influence on choosing price protected formula rather than the typical straight line. In addition, equity ownership appears to benefit on seller's projects' by lowering Slope component. Fifthly, Buyer group Utilities and NOGC significantly has greater slopes compared to other buyer type. However, the result does not find both Utilities and NOGC has lower Constant, in reciprocation. . Sixthly, price settings within the 2-year periods of Fukishima nuclear incident (2011-2012) result in significant numbers of price protected contracts and higher value in Slope component. Lastly, the macroeconomics control variables GDP growth and Baltic Dry Index are positive with Slope, indicating when economic turns well, increasing risk premium embedded in more volatile component can be observed.

1. INTRODUCTION

1.1. Background, Significance of the Problem and Objective

Importance of International Gas Market

In the past decade, the global use of natural gas has increased by 24 percent, and natural gas took part of 23% of global primary energy demand and increasing its importance (BP, 2018). Natural gas accounts for 30 percent less carbon-intensive than oil and 50 % less than coal (Vivoda, 2019). Natural gas has more relatively high reserves-to production ratio than oil, and its reserves are scattered around the world, whereas oil reserves are narrower. Liquefied Natural Gas (LNG) is natural gas in liquid form with reduced volume about 600 times through plant processing. Shipper can send LNG cargoes worldwide and increase world's supply of energy. The price of natural gas is a significant economic interest for various stakeholders. LNG value chain involves Oil and gas upstream, downstream and shipping industries, regasification plant to the end users in heating market, industrial applications and electricity generation (Utilities sector). Consequently, understanding the drivers of natural gas prices is relevant to both a macro and micro economics perspectives.

LNG Trading

Initially, natural gas is traded locally in European and US markets, using gas pipeline network for gas transportation. Hub pricing, for example, North British Point (NBP) for UK, Title Transfer Facility (TTF) for Netherland, and Henry Hub (HH) for United States, are virtual trading point for gas trading in their networks. Later in 1970, LNG cargoes became available for transportation overseas through shipping across the globe. LNG being traded worldwide requires to reflect market fundamental and hence needs benchmark, which is upon mutual agreement between buyers and sellers. Therefore, energy commodity linkage concept was introduced to support pricing structure in long term LNG contracts. When crude oil was the main competing fuel to gas in power generation in 1970 and so on, oil price index was largely introduced into Japanese LNG long term contracts (Stern, 2014). A cost pass- through mechanism is clearly adopted in Japan, where their Utilities companies can adjust and pass their gas and power tariffs to end customers at the same margin as the cost movements in average import LNG costs, which is irrespective to an individual buyer's actual purchase costs. Following Japan, Korea and Taiwan imported LNG in 1986 and 1990, respectively. They also adopt pricing based on Japan Customs Cleared Crude (JCC) Oil Price, or the average price of crude oils imported into Japan, until now. In late 1990, Brent Oil Price based pricing become another main index for Asia Pacific region. The index is normally related to timely adjustment term with oil price i.e. lagging 3-6 month average prices (Stern, 2014). The index or slope or the magnitude to which the LNG price would change in response to a change in crude oil prices whether JCC or Brent. The “Slope” in contracts are normally negotiated with “Constant” or “Base Price” in the contracts. These two components are negotiated together until meeting satisfaction which may result in price premium and price discount in the contract (Choi, 2017; Stern, 2014; Doh, 2005). However, none of these literature explain what factors contribution to slope and constant, rather than dealing through negotiation.

Gas-indexed or hub-based pricing was as well introduced as alternative pricing based to reflect LNG price with local market e.g. US’s Henry Hub. Since there is no hub index available in Asia region, but HH is adopted for contracts in Asia, this causes wide debates on gas linked contracts for Asian countries do not present market fundamental geographically. However, increasing number of gas linked contract in Asia is still continued. From Wood Mackenzie’s database, there are approximately 500 for the oil-linked contracts, while more than 160 contracts under gas-linked scheme. At the present, there are increasing number in LNG projects and long term contracts to supply global demand, mostly substitution of coal fuel (BP, 2018).

LNG Contract Pricing Structure and Components

LNG is commonly priced in unit of USD/ Million British Thermal Unit (USD/MMBTU). Traditionally most LNG contracts have been indexed to crude oil via a simple linear relationship or linked to a Gas Pricing Point (e.g. HH). Contract structures vary and are dependent on the terms negotiated by buyers and sellers, but typically they can be generalized into the following categories:

Oil Indexed

1. **Straight Line**: based on a slope (m), oil price (x) and a constant (c): $y = mx + c$

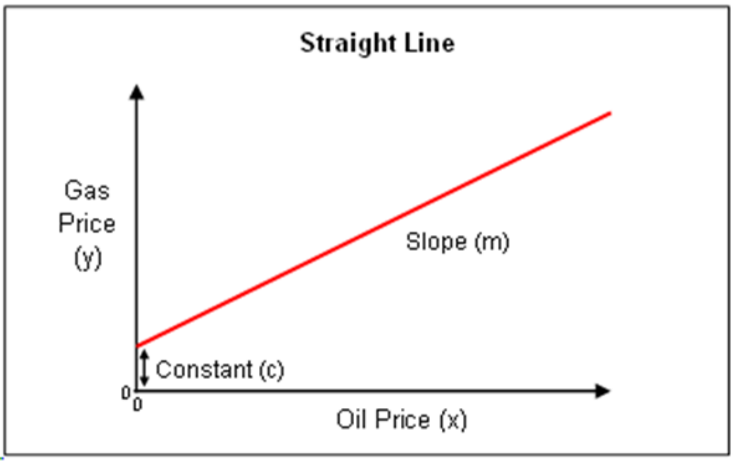


Figure 1: Typical Straight Line Pricing Structure for Oil-indexed Contract

(Source: Wood Mackenzie)

2. **Ceiling & Floor**: a straight line based on a slope (m) and a constant (c) with lower (floor) and upper (ceiling) limits: $y = mx + c$ (Floor, Ceiling)

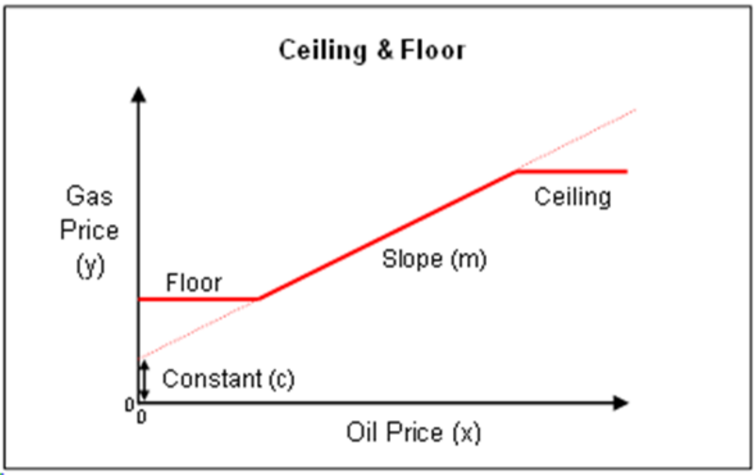


Figure 2: Typical Ceiling and Floor Pricing Structure for Oil-indexed Contract

(Source: Wood Mackenzie)

3. **S Curve**: a series of straight lines forming an S shape. Different gradients apply at lower and upper inflexion points:

$y = mL\ x + cL$; for lower bound

$y = m\ x + c$; for normal range of slope

$y = mU\,x + cU$; for upper bound

Where mL and mU are lower than m.

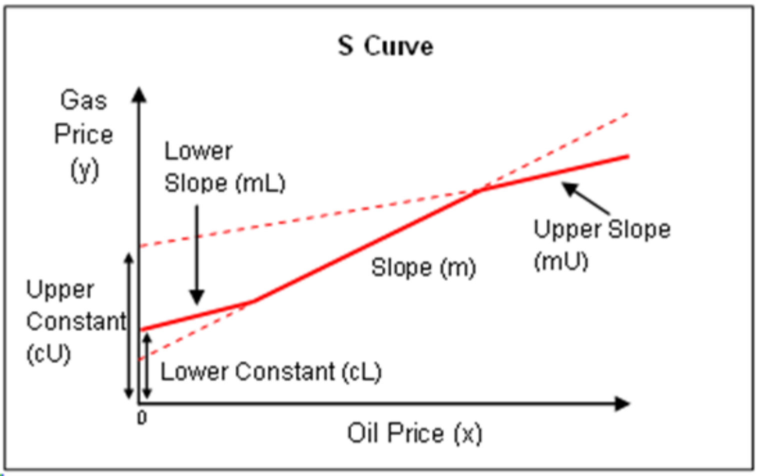


Figure 3: Typical S-Curve Pricing Structure for Oil-indexed Contract

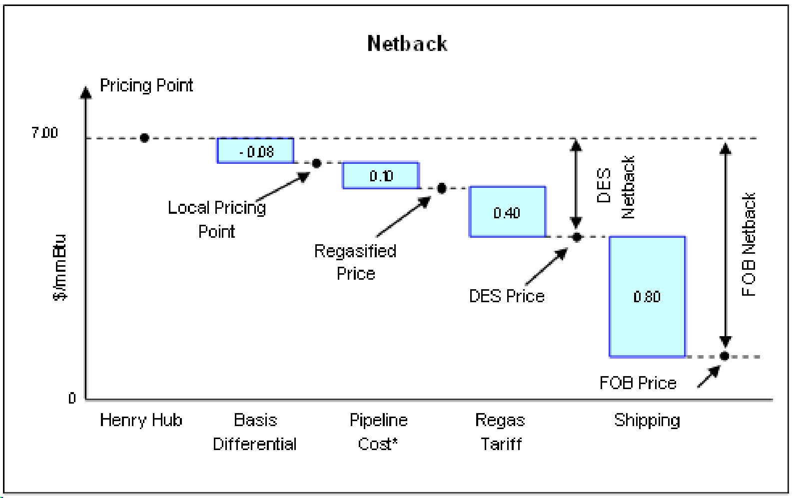
(Source: Wood Mackenzie)

S-Curve and Ceiling & Floor pricing structure can be viewed as "price protected formula" as upper and lower bounds are for controlling LNG price not to become too high or too low during extreme high or low oil price respectively.

<u>Gas Indexed</u>

1. **% Linkage**: LNG price is based on a percentage of the Gas Pricing Point (e.g. Henry Hub) for example, a DES price at x% of HH.

2. **Netback**: Based upon a calculation netting off costs/differentials i.e. basis differentials, transport costs, regasification tariffs, and shipping from the market pricing point (e.g. Henry Hub) to the delivery point.



* From Trading Point to Regasification Terminal.

Figure 4: Net Back Pricing Structure for Gas Contract

(Source: Wood Mackenzie)

LNG prices which commonly includes transportation or shipping cost to the delivery point in case of Delivery Ex-Ship (DES) contracts, while Free-on-Board (FOB) buyer has to pay the shipping cost and gains ownership of the goods as soon as it leaves its point of origin. When liquefied natural gas is to send out in gaseous phase, it has to pass regasification process to back to natural gas at atmospheric temperature. It incurs cost of regassified at LNG terminal and commonly require pipeline cost access, which is owned by the state or the country.

Objective of the study

As insight on long term pricing structure is limited, this research offers to investigate contributing factors, which could impact LNG pricing structure and components in long term contract LNG, at point of the time contracts are being negotiated and signed. The objective of the study can be categorized into 3 groups:

1. What conditions influence buyers and sellers to adopt "Oil-Indexed" or "Gas-Indexed"?

2. What conditions influence them to adopt straight line or price protected formula?

3. What factors contribute to determination of pricing components, i.e. m and c?

2. LITERATURE REVIEW

2.1 Concept, Theory and Relevant Research

Uncertainty in Oil and Gas prices can affect investment decision and value of the firm. Oil price volatility impact investment decisions because higher oil price volatility affect marginal product of capital. In addition, gas sector volatility is of interest because it affects decisions made by producers and consumers and also influences investors' decision in gas-related investments, portfolio allocation and risk management (Lin, 2013). Some studies which relate oil price volatility to investment find that increases in oil price uncertainty raise the value of waiting. Hence, firms postpone their investment decisions when they face increased uncertainty (Yoon and Ratti, 2011). Oil and gas price volatility both demonstrate influence on investment decision. In this research context, such energy commodity price volatility will induce long term contract LNG buyers and sellers' decision making on pricing formula and greatness of relationship with benchmarked commodity i.e. slope and %linkage, for oil and gas indexation, respectively.

As oil and gas price movement creates uncertainty, price risk management is particular in focus. Various studies pointed out that energy price fluctuation would urge oil and gas firms' decision to hedge price risk (Choi 2018; Lin, 2013; Jin, 2006). As their output products are directly exposed to market price, their cash-flow's volatilities generally from sales of oil and gas, are their main concerns for current and future investments. In addition, it is highly likely that firms observed oil and gas price volatility in the near past, foreseeing persistence in oil price volatilities, would even more increase their incentives to hedge price risk or increase hedging likelihood (Choi, 2018; Jin, 2006). In term of project financing, most of oil and gas project developments are funded by high proportion of loans and less equity. The larger fraction of risk are transferred to the Lenders. Consequently, the lenders are exposed to a high level of credit risks given that a project loan's repayment is mainly contributed from the project's future cash flows. (Choi, 2018; Pierru, 2013). Given the large amount of funding associated with high risk, lenders would often request firmed commercial contracts with buyers, and observing whether project's exposure to price risk is managed with offtake contracts (i.e. Futures) to reduce cash-flow risk to acceptable level.

Oil and gas price has been debated for their fundamental difference. Battern (2017) applied Vector Autoregression (VAR) Model on crude oil and gas price and found that determination crude oil and natural gas price become independent, and strongly arise when demand and supply shock during financial crisis in 2008 and natural disaster e.g. Hurricane Katrina and Tohoku earthquake. Moreover, a nexus of literature has recently trended to investigate natural gas pricing mechanisms. Some conducted empirical tests whether gas and oil prices have been fundamentally decoupled. The contribution of these studies is an insight on divergence in the price of oil and gas, which are in different markets. Such diverging fundamental in oil and gas indicates that arise difference in contracting long term LNG. Some papers suggest that hub-based pricing e.g. Henry Hub (HH) reflect better fundamental of gas market (Shi, 2016; Zhang, 2018). However, oil indexed contracts still dominate contract numbers so far.

Apart from price risk, contract risk is another essential matter for long term LNG contracts. Stern (2014), explained the potential rational of risk inherent in long term natural gas contract are that: the exporters (Sellers) mostly bear price risk commenced in the contract, would be sufficient to remunerate the investment in production and transportation of gas to the delivery points. While importers (Buyers) mainly hold the quantity or volume risk i.e. nominating volume commitment in the contracts. Long-term LNG contracts have "Take-or-pay" clauses with specific minimum annual quantity similar to pipeline gas. This obligates Buyers for annual committed volume and guarantee sellers in remunerating revenue from offtake volumes. Otherwise, Buyers have to pay for not accepting that volume and redeem it in the next agreed period. When pricing is negotiated, long term contract LNG pricing shall reflect these risks among counter parties. Doh (2005) indicated market conditions influence both buyers and sellers when they negotiate the price formula. Consequently, negotiation powers will be reflected in the LNG price through price premium or price discount against the long-run average price formula.

Project financial risk is another concern as Seller has to invest in LNG infrastructures and gas pipeline projects, which are commonly capital-intensive, and usually funded through project finance. A project is therefore set up for individual or sponsored funding through debt financing (levered funding) or equity financing. As the result, project cost would certainly influence LNG price negotiation with Buyer. Project cost may not be exactly observable by Buyer. Pierru et al. (2013) found that projects located in risky countries and larger projects tend to exhibit lower debt ratios and less-concentrated equity ownerships. In other words, projects are more financed with equity in risky countries or larger projects due to information asymmetry to risk averse fund suppliers, resulting in higher cost of debt. Hence, equity ownership is meant to alleviate the asymmetry viewed by outsiders. Particular for this study, Buyer's greater equity ownership in Seller's project should affect the LNG contract price premium since Buyer's true project value should be examined through ownership participation, before final investment decision is commercially made. The results could be in price premium or discount reflecting the project cost. Nevertheless, project sponsorship to support funding of the project could increase premium since lenders may still require to fund cost overrun but still in acceptable return (Clews, 2016).

Moreover, this study includes other unique characteristics of buyer groups i.e. Utilities, National Oil and Gas Company, International Oil and Gas Company, which have difference in business nature and policy. For example, Utilities buyers have lower risk of offtake volume exceeding commitment since its nature is to produce electricity serving public demand. Therefore, some cost of LNG can pass through customer via electricity cost (Stern, 2014). While National Oil and Gas companies have governed energy policy and have diversified energy supplies, which might trade-off with higher LNG prices from different sources. Although none of previous study empirically finds whether each buyer group relies LNG pricing on indexation slope or constant component. Vivoda (2019) studied five major LNG importers in Asia i.e. Japan, Korea, China, India and Taiwan. Their policy makers encourage improving their LNG supply portfolios, but study however does not result in lower prices. In other words, securing new multiple sources would not lower overall cost of LNG import. This implies supply diversification is trade-off with price premium in new long term LNG supply.

Literature gap and contribution

The large volume of literature studies relationship between natural gas and crude oil price, which both potentially adopted as indexation into long term contract LNG. Various studies are also debated on what are influential factors that drive LNG price and conclude what indexation of LNG should adopt in the long run. Nevertheless, none of them observes at pricing formula's component level in individual contracts, whilst Buyers and Sellers consider them as an essential part of contract set up and negotiation. Furthermore, there is none of empirical evidence for the effect of oil and gas price volatility, different buyer groups, and equity ownership in LNG projects, macroeconomics factors etc. on long term LNG contract pricing structure and its pricing components. Yet, explanation to support findings are also required.

The contribution of this study is to gain an insight in what are drivers or circumstances that influence long term LNG pricing formulas while contracts are set up and signed. As LNG demand and supply are substantially growing as important fuel source across the globe and increasing numbers in long term contracts, understanding LNG contracting mechanism will be advantageous to energy policy makers, buyers, sellers, and to the public knowledge.

2.2 Research Hypothesis and Conceptual Framework

The research examines the effect of external factors that should influence buyers' and sellers' on adjusting long term LNG contract pricing formula e.g. Structure, Indexation, Slope, Constant. Net Back cost regime is not examined in this research as cost is publically declared.

The main assumption is that LNG Buyer and Seller are both rational to reach equilibrium in making LNG contracts, selecting indexation and pricing formula structure, adjusting satisfactory of Slope and Constant. Such equilibrium may occur in overpricing or underpricing to subsidize risks i.e. seller's required investments, market environment, buyer's characteristics, etc. This empirical study aims to unfold and explain these inherent risks.

Research Question No.1: What conditions influence buyers and sellers to adopt "Oil-Indexed" or "Gas-Indexed"?

H 1.1: Oil Price Volatility is negatively associated with probability of contracting based on oil as opposed to gas.

H 1.2: Gas Price Volatility is positively associated with probability of contracting based on oil as opposed to gas.

Volatility in energy prices is important in influencing risk and strategic investment decisions (Henriques and Sadorsky, 2011), and according to Stern (2014) the sellers expose to the price risk for remunerating required investment. Higher oil and gas price volatility shall result in higher uncertainty for investment return. Therefore, opposing in choosing indexation while higher volatility is perceived, and could more possibly be selected by naturally risk averse sellers and buyers.

Research Question No.2: What conditions influence them to adopt straight line or price protected formula?

H 2.1: Oil Price Volatility is positively associated with probability of contracting based on Price Protected Formula, as opposed to the straight line.

Similar plausible explanations for H1.1 and 1.2 above could support H 2.1 that, counterparties, which are naturally risk averse to price risk fluctuations, should select price protected formula more than straight line one.

H 2.2: Equity Ownership in seller's project is positively correlated with probability of contracting based on Price Protected Formula, as opposed to the straight line.

It is usually that projects or companies producing and supplying LNG are set up as separate corporate identity, owned by single or jointed venture by various companies. The plant and facility are assets under Seller's company limited. Equity Ownership in seller's project means that designated LNG buyer in the contract has equity participation or share fraction in project.

An increase ownership in Seller's project means buyer gaining more control and visibility in project cost valuation and should dominate contracting of unique terms. Since non-straight line formula is outnumbered by another one, it convinces that more concentrated ownership participation influence counterparties to select formula with price protection ability, which is obviously a plus to seller's project economics mutually shared by buyers.

Research Question No. 3: What determine components in pricing formula of Oil or Gas Indexed Long Term LNG Contract i.e. Slope and Constant?

H 3.1: Slope is negatively correlated with greatness of Constant in the Oil Indexed LNG pricing formula.

There is high possibility that Slope and Constant have inter-relationship. A numbers of literature and academic publications (Choi, 2017; Clews, 2016; Stern 2014) cited that Slope and Constant could be a trade-off of each other. In other words, greater number in one component will result in less another one. Stern (2014) highlighted that constant is based price and slope or index is variable components adjusted on commodity prices. Both numbers are from negotiation power between two parties. Choi (2017) pointed that Constant or premium term is established along with the Slope or index. However, none of these studies finds empirical relationship between these two components.

H3.2: Oil Price Volatility is positively correlated with Slope in the Oil Indexed LNG pricing formula.

H3.3: Oil Price Volatility is positively correlated with Constant in the Oil Indexed LNG pricing formula.

When volatility is high, both buyers and sellers should look for premium or extra margin to guarantee required return. That is, greatness of both Slope and Constant may increase from observation of high price fluctuation in the past and add extra margin to these components.

H 3.4: Buyer's % equity participation in Sellers is positively correlated with Constant in the Oil Indexed LNG pricing formula.

Referring to price risk that holds by Seller, equity participation owned by Buyer should indicate confidence in remunerating required return from investment as funding sponsorship (Clews, 2016) and should result in greater constant in price formula.

H 3.5: Buyer group Utilities is positively correlated with Slope in the Oil Indexed LNG pricing formula.

It is expected that Utilities buyer group is willing to have their price closes to oil market price (whether JCC or Brent) as much as possible. As LNG is competing fuel for electricity generation to oil, so they should select their price formula closer to the index so they may not need to compensate additional price premium or higher margin constituted in Base Price. LNG price is therefore moved with market demand-supply mechanism as electricity tariffs, and Utilities buyer group can steadily earn revenue from margin between oil price and electricity, and pass additional cost incurred by oil market price fluctuation to the end users e.g. household electricity cost in Japan, Taiwan, and Republic of Korea (Stern, 2014).

H 3.6: Buyer group NOGC is positively associated with Constant in the Oil Indexed LNG pricing formula.

According to Vivoda (2019), 5 major Asia LNG import countries are moving toward LNG portfolio diversification but trade-off with higher LNG prices. It hypothesizes that policy makers or NOGC would compensate securing LNG supply sources and price stabilization, with additional premium (or higher level of constant) paid.

3. RESEARCH METHOD

3.1 Data Sample

This research examines long term contract LNG pricing structure using indicative data from Wood Mackenzie, the well-recognized Energy Consultant, who owns proprietary' information gathered from a range of sources and networking. Such information are reserved for indicative purpose, and widely accepted in the Oil and Gas industry. The data are filtered with "operational" and "under construction" contract status are included in the study, but "mothballed" or "possible" contract status are excluded. The information inside each contract includes:

- Supply Region, Buyer Company, Buyer Type, Year Contract Signed, Year First Delivery
- Pricing Structure, Type of Indexation, Underlying Benchmarked Commodities
- Slope, Constant, Ceiling and Floor

Above variables are main sources of dependent and independents variables, while control variables are retrieved from different sources shown in ***section 3.5***.

3.2 Descriptive Statistics for Long Term Contract LNG

Figure 5 illustrates relationship between Slope (m) and Constant (c), which could be set in reciprocating of each other (Choi, 2017; Stern, 2014; Doh, 2005). The actual data from Wood Mackenzie are plotted, showing correlation between Slope and Constant is negative. However, no empirical evidence on this matter so far.

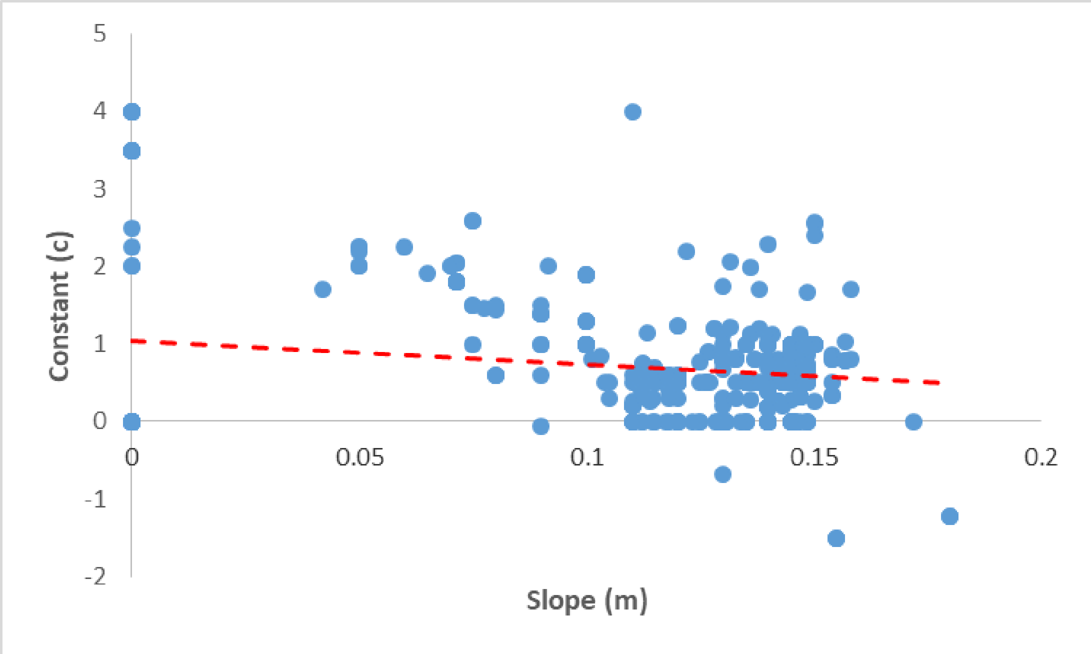


Figure 5: Plot of Slope (m) and Constant (c)

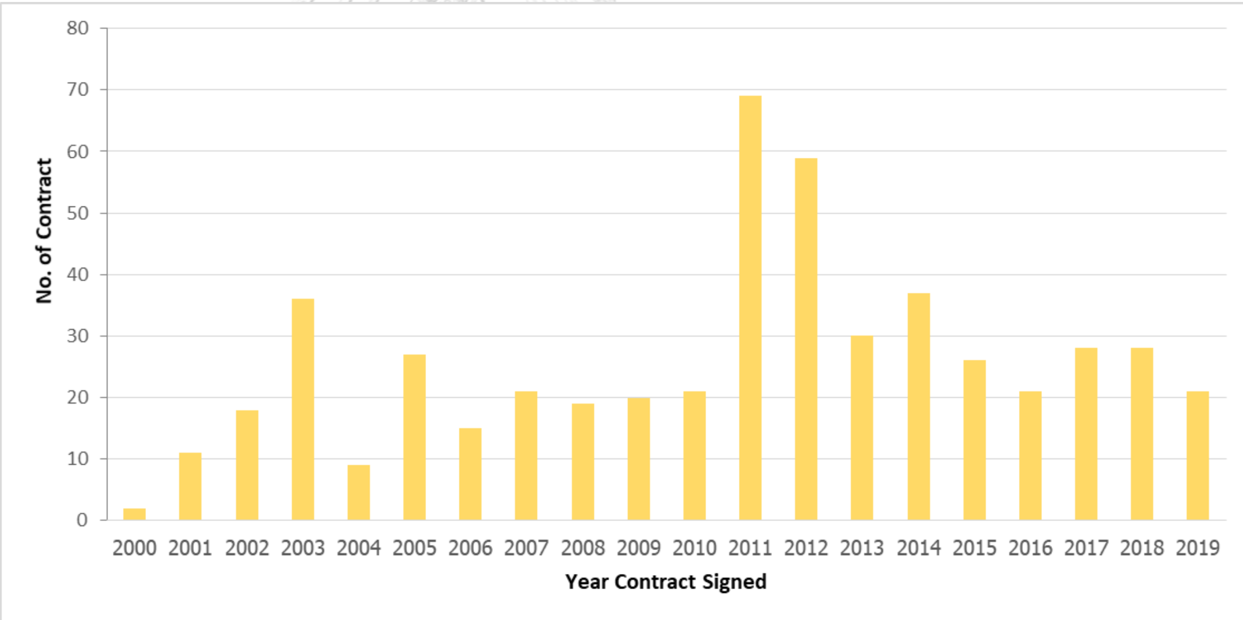


Figure 6: Year and No. of Contract Signed

Figure 6 illustrates the numbers of long term LNG contracts signed each year during 2011-2019. The numbers are steady except the period of 2011 and 2012 when earthquake took place in Japan and caused Fukushima Nuclear Power Plant to fail in March 2011. This incident resulted in great demand shock for imported fuel such as

LNG to substitute nuclear power. Spot LNG price was up high to 11$/MMBTU. Most countries in Asia and other parts of the world looked for long term LNG in shifting from nuclear power to gas-powered (Vivoda, 2019). Several studies are also well aware in this LNG demand shocking event that could specifically appear in 2011-2012 (Choi 2018, Zhang 2017; Shi 2016). Later than 2012, no. of contract resume to decline its normal level.

3.3 Independent variables

OILVOL is calculated from average monthly volatility of JCC and Brent crude oil prices for 3 year preceding before year contract signed, while GASVOL represents Henry Hub gas price for similar period, which are collected from Thomson Reuters Eikon. The dummy variables of different Buyers: Utilities, National Oil and Gas Company (NOGC), and International Oil and Gas Company (IOC) over 500 companies worldwide are used. These parameters are from Wood Mackenzie's LNG Tool database. In addition, %equity in Seller's individual project (EQUI) is manually collected from the same source. ***Table 1*** summarizes all Independent Variables in abbreviations and data sources.

Table 1: Independent variables

Variables	Description	Unit	Data Source
OILVOL	Average Monthly Oil Price Volatility before signing contract	$/BBL	Thomson Reuters Eikon
GASVOL	Average Monthly Gas Price Volatility before signing contract	$/MMBTU	Thomson Reuters Eikon
EQUI	%Equity Participation owned by Buyer in Seller's project.	%	Wood Mackenzie
UTIL	Dummy Variable taking numerical of "1" if Buyer Group is "Utilities"	-	Wood Mackenzie
NOGC	Dummy Variable taking numerical of "1" if Buyer Group is "National Oil and Gas Company"	-	Wood Mackenzie
IOC	Dummy Variable taking numerical of "1" if Buyer Group is "International Oil and Gas Company"	-	Wood Mackenzie

3.4 Dependent variables

The interest dependent variables comprises of slope and constant from Oil linked long term contract LNG pricing structure from individual contracts. The values of m and for specific contracts are from Wood Mackenzie's LNG Tool database. Furthermore, this research will observe probability of contracting whether in Oil or Gas linked contract is written as INDEX, while the probability is between 0-1, and STRUC is also a binary choice variable in analyzing probability of contracting with type of structure whether Straight Line or other priced protect formula i.e. S-Curve or Ceiling and Floor Pricing Structure. ***Table 2*** summarizes all Dependent Variables in abbreviations and data sources. LNG price in DES contract requires to deduct transportation cost to generally standardize it as FOB prices. Transportation cost is also provided by Wood Mackenzie.

Table 2: Dependent variables

Variables	Description	Unit	Data Source
SLOPE	Slope (m) or multiple in Oil Linked Contract	BBL/MMBTU	Wood Mackenzie
CONS	Constant (c) in Oil Linked Contract	$/MMBTU	Wood Mackenzie
INDEX	Binary choice variable whereas; Gas Linked Contract = 0 Oil Linked Contract = 1	-	Wood Mackenzie
STRUC	Binary choice variable whereas; Oil Linked Contract with *Straight Line Pricing Structure* = 0 Oil Linked Contract with *S-Curve or Ceiling and Floor Pricing Structure* (Price Protected formula) = 1	-	Wood Mackenzie

3.5 Control variables

A set of control variables comprised of possible influential factors on LNG product prices, demand and supply in global macroeconomics level, which are Real Global Gross Domestic Product growth (GDP), Global Inflation Rate (INFL) and Baltic Dry Index (BAL). GDP and INFL are average growth rate, calculated from past three year average figures before the year contract signed, while BAL represent average shipping cost preceding 3 years before contract is signed. Since shipping cost (BAL) is highly volatile and fluctuated along with the economic condition without trend, the average level is used instead of growth rate. In addition, control variable on alternative instrument for hedging risk, which are widely available in the market for Brent Oil and Henry Hub Gas, shown in BFUT and HHFUT, respectively. The Intercontinental Exchange (ICE) trading volume data base can represent both of these commodities' futures due to high liquidity, and particular active in energy commodities globally. However, JCC Futures products is not available in the market. EVENT dummy variable represents group of contracts which are signed during 2011-2012 around the concern of Fukushima nuclear power-plant incident, causing LNG price shock around the globe. This variable would control time-fixed effect that could impact long term LNG pricing in such period. ***Table 3*** summarizes all Control Variables in abbreviations and data sources.

Table 3: Control variables

Variables	Description	Unit of variables	Data Source
GDP	Logarithm of Real Global Gross Domestic Product (GDP CVM)	Log (Billion USD)	Bloomberg
BAL	Baltic Dry Index	-	Bloomberg
INFL	Global Inflation Rate	%	Bloomberg
BFUT	Annual trading volume of Brent Futures Contract under ICE	Million Contract	ICE
HHFUT	Annual trading volume of Henry Hub Futures Contract under ICE	Million Contract	ICE
EVENT	Dummy Variable taking numerical of "1" if contract is signed during 2011-2012	-	Wood Mackenzie

Table 4: Descriptive Statistics for Independent, Dependent and Control Variables

Variable	Obs	Unit	Mean	Std. Dev.	Min	Max
SLOPE	518	BBL/MMBTU	.112	.049	0	.18
CONS	518	$/MMBTU	.703	.788	-1.5	4
OILVOL	518	$/BBL	14.191	7.465	3.339	26.642
GASVOL	518	$/MMBTU	1.159	.681	.432	2.599
EQUI	518	Percentage Point	.032	.102	0	.74
GDP	518	Percentage Point	.149	.096	-.012	.331
BAL	518	-	2166.516	1269.356	740.333	5315.667
INFL	518	Percentage Point	3.932	.814	2.8	6.3
BFUT	518	10^6 Contract	125.583	71.237	17.298	241.538
HHFUT	518	10^6 Contract	70.996	83.012	0	239.803

Remark: No. of Oil Linked Contract is 448, while Gas's is 70. (Total 518 contracts).

4. METHODOLOGY

The empirical tests are based on the binary choice logistic model (Logit) and OLS linear models for related hypotheses shown in ***Table 5***. The Model 1 and 2 investigate influential factors on probability of choosing index and price structure, respectively. Model 3-4 observe relationship between Slope and Constant. Since it is expected that Slope and Constant are correlated, Slope and Constant in Model 5 or 6 are jointly-observed in the same system in Seemingly Unrelated Regression (S.U.R.) models, using Seemingly Unrelated Regression Estimator or "S.U.R.E." to perform regression. The study of dummy variable buyer groups UTIL and NOGC are in Model 4 and 6 as extension to its original model 3, respectively.

Table 5 Summary of Model and Related Hypotheses.

Model No.	Type of Regression Model	Regressant	Related Hypotheses
Model 1	Logistic (Logit) Model	Pr(INDEX)	1.1, 1.2
Model 2	Logistic (Logit) Model	Pr(STRUC)	2.1, 2.2
Model 3	OLS Linear Model	SLOPE	3.1, 3.2
Model 4 **(Extension of Model 3)**	OLS Linear Model	SLOPE	3.1, 3.2, 3.5
Model 5	S.U.R. Linear Model	SLOPE	3.2
		CONSTANT	3.3, 3.4
Model 6 **(Extension of Model 5)**	S.U.R. Linear Model	SLOPE	3.2, 3.5, 3.6
		CONSTANT	3.3, 3.4, 3.5, 3.6

Model 1: Probability in Contracting Oil Index

Model 1 is logistic regression model on probability of contracting oil or gas index following hypotheses H1.1 and H1.2. It is expected that $OILVOL_i$ is negatively correlated with $INDEX_i$, while $GASVOL_i$ is positively correlated with $INDEX_i$.

$$INDEX_i = 1(\beta_0 + \beta_1 OILVOL_i + \beta_2 GASVOL_i + \beta_3 EQUI_i + \beta_4 z_i + \varepsilon_i)$$

$$\varepsilon \sim iid\ Logistic\ Distribution$$

- Where f is Logistic Function for Binary Choice Regression Model
- Where $INDEX_i$ is binary choice variable of indexation used in the contract
  - If f =1, Oil Indexed contract is selected.
  - If f =0, Gas Indexed contract is selected.

- Where z is a vector of control variables consisting of GDP_i , BAL_i , $INFL_i$, $POST_i$, $BFUT_i$ and $HHFUT_i$

Model 2: Probability in Contracting Price Protected Formula

Model 2 is logistic regression model on probability of contracting price protected formula following hypotheses H2.1. $OILVOL_i$ is interest variable and expected to positive correlated with $STRUC_i$.

$$STRUC_i = 1(\beta_0 + \beta_1 OILVOL_i + \beta_2 EQUI_i + \beta_3 z_i + \varepsilon_i)$$

$$\varepsilon \sim iid\ Logistic\ Distribution$$

- Where f is Logistic Function for Binary Choice Regression Model
- Where $STRUC_i$ is binary choice variable of indexation used in the contract
    - If f =1, Price Protected Formula is selected.
    - If f =0, Straight Line Formula is selected.
- Where z is a vector of control variables consisting of GDP_i, BAL_i, $INFL_i$, $POST_i$, and $BFUT_i$

Model 3: Investigation of Slope Setting

In Model 3 and 4, Constant ($CONS_i$) is observed as regressor of Slope ($SLOPE_i$) under linear model. While Model 4 is an extension of Model 3 by adding Buyer Group dummy variables. Model 3 is to test hypotheses 3.1 and 3.2 whereas $CONS_i$ and $OILVOL_i$ are both anticipated to have positive correlation with $SLOPE_i$.

$$SLOPE_i = \beta_0 + \beta_1 OILVOL_i + \beta_2 EQUI_i + \beta_3 CONS_i + \beta_4 z_i + \varepsilon_i$$

- Linear Model using OLS estimator
- Where z is a vector of control variables consisting of GDP_i, BAL_i, $INFL_i$, $POST_i$, and $BFUT_i$

Model 4: Investigation of Slope Setting with Buyer Groups

Model 3 is to test hypotheses 3.1 and 3.2 whereas $CONS_i$ and $OILVOL_i$ are both anticipated to have positive correlation with $SLOPE_i$. Additionally, UTIL and NOGC are expected having positive and negative correlation with $SLOPE_i$, respectively.

$$SLOPE_i = \beta_0 + \beta_1 OILVOL_i + \beta_2 EQUI_i + \beta_3 CONS_i + \beta_3 z_i + \Phi_1 UTIL + \Phi_2 NOGC + \varepsilon_i$$

- Linear Model using OLS estimator
- Where z is a vector of control variables consisting of $GDP_i, BAL_i, INFL_i, POST_i$, and $BFUT_i$

<u>Model 5: Co-observation of Slope and Constant</u>

Hypotheses H3.2, H3.3, and H3.4 are tested under Model 5 with expectation that $OILVOL_i$ is positively correlated with SLOPE, whereas $OILVOL_i$ and $EQUI_i$ are expected showing positively correlation with $CONS_i$.

$$SLOPE_i = \beta_0 + \beta_1 OILVOL_i + \beta_2 EQUI_i + \beta_3 z_i + \varepsilon_i$$

$$CONS_i = \beta_0 + \beta_1 OILVOL_i + \beta_2 EQUI_i + \beta_3 z_i + \varepsilon_i$$

- $SLOPE_i$ *and* $CONS_i$ are co-observed in the same system as S.U.R. Linear Model using S.U.R.E. estimator.
- Where z is a vector of control variables consisting of $GDP_i, BAL_i, INFL_i, POST_i$, and $BFUT_i$

<u>Model 6: Co-observation of Slope and Constant with Buyer Groups</u>

Extension to Model 5, these pairs of model introduce sets of coefficients and Dummy Variables for buyer groups (UTIL, NOGC and IOC), in addition to aforementioned models, while adding null and alternative hypotheses for these variables. Slope and Constant in Model 5 and 6 are also co-observed in the same system, using S.U.R.E estimator.

For Slope, Hypotheses H3.2 is also tested under Model 6 with expectation that $OILVOL_i$ is positively correlated with $SLOPE_i$. In addition, variable of interest, UTIL and NOGC are expected having positive and negative correlation with SLOPE, respectively, following H3.5 and H3.6. For Constant, Hypotheses H3.3 and H3.4 are also conducted, expecting $OILVOL_i$ and $EQUI_i$ are positively correlation with $CONS_i$, adding hypotheses testing for H3.5 and 3.6, of which UTIL and NOGC are expected to have negative and positive correlation with $CONS_i$, respectively.

$$SLOPE_i = \beta_0 + \beta_1 OILVOL_i + \beta_2 EQUI_i + \beta_3 z_i + \Phi_1 UTIL + \Phi_2 NOGC + \varepsilon_i$$

$$CONS_i = \beta_0 + \beta_1 OILVOL_i + \beta_2 EQUI_i + \beta_3 z_i + \Phi_1 UTIL + \Phi_2 NOGC + \varepsilon_i$$

- $SLOPE_i$ and $CONS_i$ are co-observed in the same system as S.U.R. Linear Model using S.U.R.E. estimator.
- Where z is a vector of control variables consisting of $GDP_i, BAL_i, INFL_i, POST_i$, and $BFUT_i$

Table 6: Pairwise Correlation for Logistic Regression Model 1

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) INDEX	1.000									
(2) OILVOL	0.057	1.000								
(3) GASVOL	0.184	0.080	1.000							
(4) EQUI	-0.148	-0.033	0.062	1.000						
(5) GDP	0.151	0.107	0.596	-0.064	1.000					
(6) BAL	0.197	0.355	0.807	0.002	0.822	1.000				
(7) INFL	0.136	0.091	0.034	-0.047	0.318	0.343	1.000			
(8) BFUT	-0.185	0.243	-0.748	-0.021	-0.484	-0.539	-0.362	1.000		
(9) HHFUT	-0.240	-0.117	-0.597	-0.033	-0.333	-0.572	-0.579	0.771	1.000	
(10) EVENT	0.030	0.336	-0.385	-0.006	-0.009	-0.076	0.498	0.109	-0.299	1.000

Obs: 518

Table 7: Pairwise Correlation for Logistic Regression Model 2

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) STRUC	1.000								
(2) OILVOL	0.037	1.000							
(3) GASVOL	0.030	0.081	1.000						
(4) EQUI	0.126	0.000	0.051	1.000					
(5) GDP	0.083	0.146	0.613	-0.041	1.000				
(6) BAL	0.072	0.372	0.804	0.020	0.836	1.000			
(7) INFL	0.296	0.110	0.005	-0.043	0.298	0.321	1.000		
(8) BFUT	-0.191	0.245	-0.743	0.037	-0.479	-0.528	-0.337	1.000	
(9) EVENT	0.286	0.337	-0.424	0.001	-0.046	-0.122	0.480	0.151	1.000

Obs: 448

Table 8: Pairwise Correlation for Model 3-6

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) SLOPE	1.000										
(2) CONS	-0.349	1.000									
(3) OILVOL	0.277	-0.240	1.000								
(4) EQUI	-0.154	0.074	-0.079	1.000							
(5) GDP	0.395	0.060	0.145	-0.065	1.000						
(6) BAL	0.336	0.097	0.393	-0.031	0.837	1.000					
(7) INFL	0.122	0.078	-0.012	-0.033	0.316	0.349	1.000				
(8) BFUT	0.011	-0.435	0.187	0.022	-0.514	-0.562	-0.400	1.000			
(9) EVENT	0.255	-0.108	0.254	-0.098	-0.010	-0.069	0.419	0.086	1.000		
(10) UTIL	0.266	0.010	-0.001	-0.325	0.190	0.187	0.165	-0.231	0.163	1.000	
(11) NOGC	-0.050	-0.066	0.124	-0.061	-0.145	-0.118	-0.172	0.244	-0.154	-0.638	1.000

Obs: 355

5. EMPIRICAL RESULTS AND DISCUSSION

Logistic regression results for Model 1 and 2 are shown in ***Table 9***. First model suggests that Oil Price Volatility (OILVOL) does not play role in probability of contracting with whether oil and gas index. The result cannot reject null hypothesis for hypothesis H1.1 as well as H1.2 since gas volatility has no influence. The evidence also presents a surprise fact that EQUI has statically significant on Index probability as every 1% of increased equity ownership in Seller's project would result in 3 times higher of choosing gas index. This unique preference is found in large multinational Oil and Gas Company purchasing LNG from North America in most Henry Hub basis. These Buyers usually have share in Seller's project as their long term investment. Lastly, active in Henry Hub futures market increase probability in contracting Gas Index. Counterparties can exploit futures to control price risk when Gas Index is selected.

<u>Table 9: Logistic Regression on Index Selection Probability (Model 1 and 2)</u>

VARIABLES	(Model 1) INDEX	Odd Ratio	(Model 2) STRUC	Odd Ratio
OILVOL	0.012	1.012	0.017	1.017
	(0.027)		(0.047)	
GASVOL	0.158	1.171	-	
	(1.212)			
EQUI	-3.332***	0.036***	4.661***	105.742***
	(1.037)		(1.454)	
GDP	7.852	2570.871	4.890	132.954
	(5.311)		(3.849)	
BAL	-0.000	1	-0.000	1
	(0.000)		(0.000)	
INFL	-0.056	0.946	0.395*	1.484
	(0.427)		(0.213)	
BFUT	0.009	1.009	-0.018***	0.982***
	(0.007)		(0.0049)	
HHFUT	-0.016**	0.984	-	
	(0.006)			
EVENT	-1.165	0.312	2.062***	7.862***
	(0.780)		(0.556)	
Constant	1.733	5.658	-2.187**	0.112**
	(2.575)		(0.932)	
Observations	518	-	448	-

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

About probability in pricing structure (Model 2), it is expected from Hypothesis H2.1 that OILVOL has positively significance on probability in adopting Price Protected Structure, but it does not. Nevertheless, EQUI has positively strong explanatory power to STRUC. Greater equity participation in seller's project (EQUI) offers more chance in contracting Price Protected Structure, corresponding to Hypothesis H2.2 that because of contract amount with this type of structure having a lot less number compared to straight line structure, price protected structure can be viewed as unique circumstances through ownership and negotiation to reduce cash-flow risk level from remunerating return from sales (Choi, 2018), favoring seller while buyer gets mutual benefit through equity ownership.

The possible explanation for INFL is, increase in inflation in the economy would increase price level in aggregate, and such condition would cause more possibility of extreme price and thus LNG price demands protection.

BFUT increases probability of contracting Straight Line Structure, conforming to its implication as ability in hedging is more active. More active futures market means that liquidity in matching contracts are effective so that who enter futures contract can be done under specified date and maturity. Price risk should be minimized from exposing extreme price conditions. This function works as same as price stabilizing in price protected model. Therefore availability of Oil Futures offer an alternative to non-straight line pricing regimes.

Contracts signed during and a year after Fukushima nuclear disaster (2011-2012) show significantly and positively associated with price protected structure. This implies LNG pricing is affected by demand shock from that incident in more protective manner.

Investigation of relationship between SLOPE and CONSTANT are conducted in Model 3, and afterwards include Dummy Variable Buyer group UTIL and NOGC in Model 4. The regression model results are displayed in ***Table 10***, respectively. Following the Hypothesis H3.1 development, base price or Constant term should be set up prior to Slope. Slope can be viewed as variable cost and multiplier to selected commodity index. Range of base price in $/MMBTU between -1 to 4 is a huge larger portion to Slope between 0-1.8. There could be exceptional case that Base Price is set at 0 or minus, but in general, base price or constant shall generally indicate core part in sales price for remunerating required return. Therefore, CONS is set as explanatory variable to SLOPE. Based on Model 3, the result obviously suggests that Slope has inverse or reciprocating relationship with Constant. CONS is negatively correlated with SLOPE at 99% confidence level. By comparison, one unit of Constant increase would reduce Slope by 0.012 unit.

OILVOL does not support Hypothesis H3.2 as expected, showing no significance correlation between Oil Price Volatility and Slope. Other interesting variables are GDP and BAL, indicating how well is economics condition and general shipping market bellwether, are positively correlated with Slope. In other words, they increase Slope in good market conditions. Furthermore, BFUT found its ability to increase Slope when market trading on Oil Futures are more active, but this may not has economic significance (less than 3 decimal points). Further models i.e. 5-6 also demonstrate the same explanatory power of GDP, BAL and BFUT variables on Slope.

Table 10: Linear Regression on Slope with Buyer Group Dummy Variables (Model 3 and 4)

VARIABLES	(Model 3) SLOPE	(Model 4) SLOPE
OILVOL	-0.000	-0.000
	(0.000)	(0.000)
EQUI	-0.025**	0.006
	(0.013)	(0.014)
GDP	0.066***	0.070***
	(0.019)	(0.019)
BAL	0.000**	0.000*
	(0.000)	(0.000)
INFL	-0.003*	-0.003*
	(0.002)	(0.001)
UTIL	-	0.015***
		(0.003)
NOGC	-	0.012***
		(0.004)
CONS	-0.012***	-0.011***
	(0.002)	(0.002)

VARIABLES	(Model 3) SLOPE	(Model 4) SLOPE
BFUT	0.000*	0.000*
	(0.000)	(0.000)
EVENT	0.016***	0.015***
	(0.003)	(0.003)
Constant	0.124***	0.111***
	(0.007)	(0.008)
Observations	355	355
R-squared	0.371	0.412

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

EQUI appears having statistically influence on Slope positively at 5% significant level when Constant term is controlled. This gains author's insight that equity ownership would reduce price premium embedded in Slope. On the contrary to Hypothesis H3.4, equity ownership in seller project does not mean to subsidize cost overrun but buyers would gain benefit from price discount in Slope. This finding conforms to result in Model 5 in subsequent section.

Model 4 also pointed that Slope has inverse relationship with Constant. From ***Table 10***, CONS is negatively correlated with SLOPE at 99% confidence level, implying one unit of Constant increase would reduce Slope by 0.011 unit. Effect of UTIL on SLOPE is valid at 1% significance level, supporting Hypothesis H3.5 that buyer group Utilities has larger components of Slope than NOGC and IOC. Whereas NOGC also appears to have positive correlation with SLOPE at 5% significant level but its effect is marginally less than UTIL. At this point, it can conclude that while controlling Constant Utilities or NOGC has greater Slope than IOC buyer group. The further investigation on buyer group will be more in Model 5-8 when Constant does not represent as control variable.

EVENT or contracts signed within the 2-year periods of Fukushima nuclear disaster (2011-2012) show significantly and positively associated with Slope for both Model 3 and 4 and continue its validity in Model 5 and 6 when Constant is not controlled. It signifies that both counterparties agreed with higher premium in long term contract as LNG demand is suddenly increased from such incident, less nuclear power importance, and more reliance in imported LNG, especially in Asia region.

Model 5 are performed under Seemingly Unrelated Equation (S.U.R.E.) regression on Slope and Constant. OILVOL does not show significantly positive correlation with Slope as hypothesized in Hypothesis H3.2. On the other hand, Oil price fluctuation would decrease in Constant at tiny margin i.e. small price discount. Although this finding turns out surprisingly and contrast to H3.2, one possible explanation is price discount is given to Buyer as they dominate Seller over negotiation during Oil Price volatility is high. Price reduction is enough to convince Buyer to settle contracts in a midst of high price oscillation.

BFUT has positive correlation on SLOPE and negative correlation with CONS with statistical significance at 1%, respectively. This implies increase Oil price futures traded globally (in this case: Brent Oil Futures) would induce counterparties to put price premium in Slope and reduce Constant. Nevertheless, its effect on both SLOPE and CONS could be not economically significant (effect is less than 3 decimal points).

Adding Dummy Variable Buyer group UTIL (Utilities) and NOGC (National Oil and Gas Company) are performed under Model 6. It suggests that Utilities buyer are positively correlated with SLOPE, which is consistent to Hypothesis H3.5 that Utilities buyers in some Asia developed countries can pass-through cost to end users, so that they will require their pricing structure closes to commodity market price in order to earn margin from power tariff, which normally adjusted to imported energy commodities' prices. However, it is no statistically significant negative correlation between UTIL and CONS, in reciprocation. Another Buyer group, NOGC also has positive correlation with SLOPE or base price at significant level of 1%. This does not conform to Hypothesis H3.6 that NOGC would prefer imported commodity price stabilization and would trade-off higher price to secure energy supply (Vivoda, 2019). The result suggest that aggregate NOGC prefer to have their imported price close to world market. Price stabilization could be through specific energy policy in individual countries and cannot be observed in this study. Similar to UTIL, it has no evidence supports NOGC has lower Constant in reply.

GDP and BAL are negatively correlated with CONS whereas they are positive with SLOPE. It suggests that when these economic indicators turn out well, particularly GDP positively growth, during contracts negotiated and signed, contract counter parties significantly adopt less Constant but more Slope (Index), which is volatile component. In other words, risk seeking in price holds along with economics condition.

Table 11: Seemingly Unrelated Equation (S.U.R.E.) regression on Slope and Constant with Buyer Group Dummy Variables (Model 5 and 6)

	(Model 5)		(Model 6)	
VARIABLES	SLOPE	CONS	SLOPE	CONS
OILVOL	0.000	-0.012**	0.000	-0.013**
	(0.000)	(0.006)	(0.000)	(0.006)
EQUI	-0.031**	0.474	0.002	0.370
	(0.013)	(0.363)	(0.015)	(0.411)
UTIL	-	-	0.015***	-0.062
			(0.003)	(0.088)
NOGC	-	-	0.012***	0.038
			(0.004)	(0.110)
GDP	0.081***	-1.312**	0.085***	-1.336**
	(0.020)	(0.545)	(0.019)	(0.544)
BAL	0.000*	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
INFL	-0.002	-0.071	-0.002	-0.074*
	(0.001)	(0.044)	(0.002)	(0.044)
BFUT	0.000***	-0.004***	0.000***	-0.000***
	(0.000)	(0.001)	(0.000)	(0.000)
EVENT	0.016***	0.041	0.014***	0.067
	(0.003)	(0.091)	(0.003)	(0.093)
Constant	0.105***	1.672***	0.091***	1.732***
	(0.007)	(0.195)	(0.007)	(0.209)
Observations	355	355	355	355
R-squared	0.301	0.249	0.346	0.252

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6. CONCLUSION

The findings suggest that firstly, oil price volatility has no influence on both selection of index and adopting price protected pricing structure. Surprisingly, higher oil price volatility causes price discount or reduction in Constant. Secondly, the more active Oil Futures market decreases probability of contracting price protected formula as it serves same objective on price risk reduction. Additionally, it increases level of

Slope but decreases Constant components, indicating price relies more on Slope rather than Constant when hedge ability increase or Futures market is more functioning. Thirdly, Slope components are obviously set in reciprocating to Constant (Based Price). The greater the Constant, the lower Slope is distinctly observed. Fourthly, Buyer's Equity ownership in Seller's project induce more probability in Gas Index, and has statistical influence on choosing price protected formula rather than the typical straight line. In addition, equity ownership appears to benefit on seller's projects' by lowering Slope component. Therefore, the final price paid by Buyer would decrease through ownership. Fifthly, Buyer group Utilities and NOGC significantly has greater slopes compared to other buyer type. However, the result does not find both Utilities and NOGC has lower Constant, in reciprocation. This finding corresponds to Utilities buyer group having cost-pass-through ability, as setting greater slope, price will rely on Oil price even more. Furthermore, it empirically finds that NOGC set import LNG price closer to the index rather than fixed price. In aggregate, commodity price subsidizing is not the case for NOGC. Sixthly, price settings within the 2-year periods of Fukishima nuclear incident (2011-2012) result in significant numbers of price protected contracts and higher value in Slope component. It obviously shows that demand shock causing LNG pricing with more protection and premium. Lastly, the macroeconomic control variables GDP growth and Baltic Dry Index are positive with Slope, indicating when economic turns well, increasing risk premium embedded in more volatile component can be observed.

The study unfolds several aspects of long term LNG pricing, which would benefit policy makers and contract counterparties to understand factors and risks i.e. commodity price, financing, regulation and nature of Buyer etc., which are reflected in LNG price though structures and components. These can be evidently explained by the study other than plain negotiation talks.

The study unfolds several aspects of long term LNG pricing, which would benefit policy makers and contract counterparties to understand factors and risks i.e. commodity price, financing, regulation and nature of Buyer etc., which are reflected in LNG price though structures and components. These can be evidently explained other than plain negotiation talks.

Appendix 1: Example of Long Term LNG Contract

Contract (Seller:Buyer)	Year Signed	Duration	Index	Slope	Constant	Ceiling & Floor	S-Curve
A:B	2000	20 Years	Oil -JCC	0.0915	2	-	-
C:D	2012	15 Years	Oil -JCC	0.1485	1	-	Lower-bound Slope: 0.115 Upper-bound Slope: 0.115
E:F	2008	20 Years	Oil-Brent	0.145	0.6	-	Lower-bound Slope: 0.105 Upper-bound Slope: 0.105
G:H	2015	20 Years	Oil-Brent	0.12	1.24	Max: 12$/MMBTU Min: 3$/MMBTU	-
I:J	2018	20 ears	Gas-Henry Hub	1.15	-	-	-

REFERENCES

Batten, J. A., Ciner, C., & Lucey, B. M. (2017). The dynamic linkages between crude oil and natural gas markets. *Energy Economics, 62*, 155-170.

BP, B. Statistical Review of World Energy 67th edition (2018). *Availabe in https://www. bp. com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review/bp-stats-review-2018-full-report. pdf.*

Choi, B., & Kim, S. T. (2018). Price volatility and risk management of oil and gas companies: Evidence from oil and gas project finance deals. *Energy Economics, 76*, 594-605.

Choi, G., & Heo, E. (2017). Estimating the price premium of LNG in Korea and Japan: The price formula approach. *Energy Policy, 109*, 676-684.

Clews, R. (2016). *Project finance for the international petroleum industry*: Academic Press.

Doh, H. (2005). Optimal Pricing and Risk-sharing in Long-term LNG Constract.

Henriques, I., & Sadorsky, P. (2011). The effect of oil price volatility on strategic investment. *Energy Economics, 33*(1), 79-87.

Jin, Y., & Jorion, P. (2006). Firm value and hedging: Evidence from US oil and gas producers. *The journal of Finance, 61*(2), 893-919.

Lin, B., & Wesseh Jr, P. K. (2013). What causes price volatility and regime shifts in the natural gas market. *Energy, 55*, 553-563.

Pierru, A., Roussanaly, S., & Sabathier, J. (2013). Capital structure in LNG infrastructures and gas pipelines projects: Empirical evidences and methodological issues. *Energy Policy, 61*, 285-291.

Shi, X., & Variam, H. M. P. (2016). Gas and LNG trading hubs, hub indexation and destination flexibility in East Asia. *Energy Policy, 96*, 587-596.

Stern, J. (2014). International gas pricing in Europe and Asia: A crisis of fundamentals. *Energy Policy, 64*, 43-48.

Vivoda, V. (2019). LNG import diversification and energy security in Asia. *Energy Policy, 129*, 967-974.

Yoon, K. H., & Ratti, R. A. (2011). Energy price uncertainty, energy intensity and firm investment. *Energy Economics, 33*(1), 67-78.

Zhang, D., Shi, M., & Shi, X. (2018). Oil indexation, market fundamentals, and natural gas prices: An investigation of the Asian premium in natural gas trade. *Energy Economics, 69*, 33-41.

VITA

NAME	Yossaran Pichiansoontorn
DATE OF BIRTH	10 January 1987
PLACE OF BIRTH	Bangkok, Thailand
INSTITUTIONS ATTENDED	Chulalongkorn University B.Sc. Chemical Engineering M.Eng. Chemical Engineering
HOME ADDRESS	49 Soi Lat Pla Khao 27 Lad Prao Bangkok 10230
PUBLICATION	-
AWARD RECEIVED	Elected as student prefect for Faculty of Science, Chulalongkorn University (2009)