The Economics of LNG Export Contract Flexibility: a quantitative approach

Yichi Zhang (Shebazhang@gmail.com) Supervisors: Dr. Pierre Noel, Dr. Chi-Kong, Chyong

INTRODUCTION

- An interesting phenomenon discussed by many researchers and traders in the global liquefied natural gas (LNG) industry is the price divergence in different regions worldwide. The price of gas in Pacific Asia is currently almost four times that of the gas price in the US: This large price spread opens up alluring arbitrage opportunities. If the price difference between the spot markets and the original cargo is higher than the diversion costs, profit remains.
- One barrier of competition and arbitrage in the global LNG market is the take-or-pay (ToP) long term contracts (LTC) linked to the oil price. The destination clause and volume constraints prevent long-term contracts to flow into the market driven spot market. The market liberalisation status for gas market all over the world is different. US and UK have the most liquid and mature gas trading hub; with Continental Europe is catching up. The import to Asian Pacific countries rely largely on LTC, with the fist hub JKM launched in 2009.
- The debate about whether gas market should keep the oil-indexed pricing scheme is heated. Some researchers have explored the rationality of keeping long-term contracts; some have calculated the value of arbitrage between two specific countries. There is a gap that few works have been done about valuing the whole market efficiency and the benefits of LTC flexibility to the key stakeholders.

RESEARCH OBJECTIVE

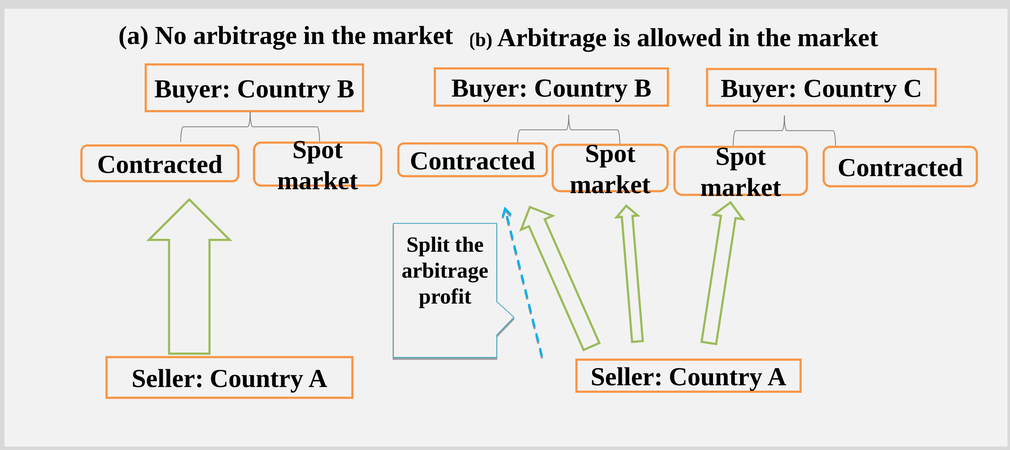
The aim of this project is to explore the value the flexibility of oil-indexed long-term contracts to the stakeholders (both producers and consumers) in the gas industry. 100% flexible long-term contracts mean contracts with 0% ToP and free destination clauses. This is an entirely liberalised gas market with the gas price decoupled from oil price. 0% flexibility means that the long-term contracts have very strict terms about the destination of the gas supply: producers have to provide 100% of the gas based on the contracts and are not allowed to divert gas to anywhere else. For contracts whose flexibility is between 0% and 100%,producers are allowed to divert the gas to take arbitrage opportunities as long as they have fulfilled the minimum ToP conditions. To explore the economic value of long-term contract flexibility, an analysis to the following questions is presented:

- Compared with 0% flexible contracts, will a more flexible long-term contract scheme improve the overall market efficiency? Who will benefit and who will lose in this shift?
- How does the market power of stakeholders affect the value of flexibility?
- How do price trends in long-term contracts and spot markets influence the value of flexibility? What are the most likely paths for the LTC and spot prices in different markets all over the world?

METHODS

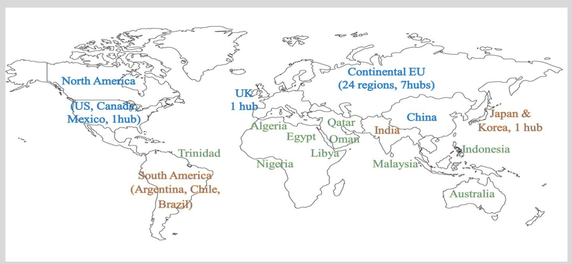
• Arbitrage Model

In this project, it is assumed that arbitrage is initiated by the producer. For example, the seller country A has signed a contract with a buyer country B. If the destination clause of the contract is fixed, there is no possibility for the seller to take the advantage of arbitrage. In a world where arbitrage is encouraged and the destination clause is flexible, the seller can choose to divert part of the contracted gas to the local gas market in country B. If the prices in other markets, say country C, are higher than both the contracted and spot price of original destination and even high enough to cover the diversion cost, the seller will benefit to divert LNG cargo to country C. The profits from the arbitrage are split between the producer and first buyers in many cases. In addition, the initial buyer often has a veto over the diversion



• Global Gas Equilibrium Model

- This simple arbitrage model actually rests on a larger overall model about the supply chain of the whole gas market. Key market players in a gas model include producers, suppliers, traders, consumers, pipelines transmitters, and LNG operators. An equilibrium is reached when each market player optimize the profit. By establishing a long-term LNG contract database in this model, we compare the differences in some key economic indicators with different levels of contract flexibility so as to explore the value of contract flexibility.



Objective function:

$$\pi_n = \sum_{n' \in N'} P_{ns} \times S_{ncS} + p_{nS} \times S_n^{dom} + \sum_{n' \in N'} P_{ncL}^{*} \times S_{ncL}^{*} \times \alpha_{nn'}^{*} - TPC_n(q_{zn}) - \sum_{n \in N} \sum_{n' \in N'} Xl_{nn'}(p_{n'}^{regas} + p_n^{liq} + SC_{nn'}^{*}) - \sum_{n \in N} \sum_{n' \in N'} X_{nn'} tc_{nn'}^{*}$$

S_{ncS} is the export sale in the spot market c; S_{ncL}^{*} is the long-term sale in market c; S_n^{dom} is the domestic sales; p_{nS} is the spot price in market c, P_{ncL}^{*} is the contracted price; TPC is the production cost; $p_{n'}^{regas}$ is the regasification price; p_n^{liq} is the liquefaction cost; $SC_{nn'}^{*}$ is the shipping cost; $tc_{nn'}^{*}$ is the transmission cost for pipeline; $Xl_{nn'}$ is the shipping quantity for LNG ; $X_{nn'}$ is the shipping quantity for pipeline

• Simulating the Gas Price

- To investigate the arbitrage potential between spot market and long term contracts gas, it is important to estimate the price differences among different gas markets in the near future. A pricing model, which integrates not only stochastic variability but also the price convergence, is mean-revering model. The price in the future can be predicted by the price in the past. The formula for the mean-reversion method is :

$$P_{t+1} - P_t = \lambda \times (\mu - P_t) + \sigma \times \varepsilon_t \Delta t$$

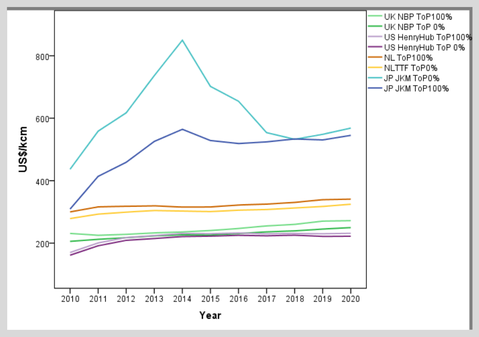
P_t is the price at time t; λ is the mean reversion rate; μ is the mean parameter; σ is the volatility; ε_t is the random deviation N~(0,1)

RESULTS

• Price: Decreasing spot price

- On average, The gas price in all spot markets decrease as the long-term contracts become more flexible. This is due to the increase in spot gas supply when gas relieved from long-term contracts goes to the spot market. The size of change differs considerably among different markets, especially between Japan and North America.

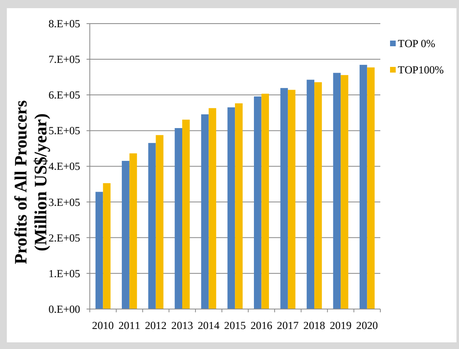
Fig3 Simulated Price with ToP 0% and ToP100%



• Producer profit

- The mean profits of all producers all over the world with ToP 0% and ToP 100% are shown in Figure ?From year 2010 to 2016, the profit when ToP is 100% is larger than that when ToP is 0%, which indicates that producers don't gain from flexible long-term contracts at that time. From 2017 to 2020 LTC flexibility improve the profits of producers. Whether the value of LTC flexibility to producer profit is positive depends on the downward drift in the spot price and the upward drift by the arbitrage opportunity.

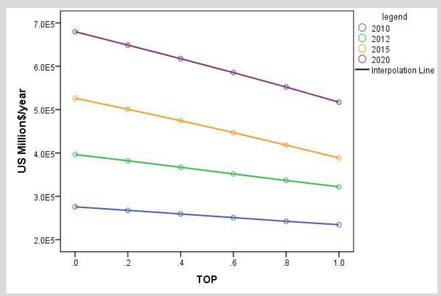
Fig4 Producer Profit with ToP 0% and ToP100%



• Consumer surplus

- Consumer surplus is a measure of the benefits consumers obtain from purchasing a good. It is defined as the difference between the total amount that consumers are prepared to pay and the total amount that they actually pay .The consumer surplus appears to have an almost linear relationship with the TOP. Higher TOP means lower consumer surplus. Besides, what is also worth mentioning is the consumer surplus keeps increasing as time goes.

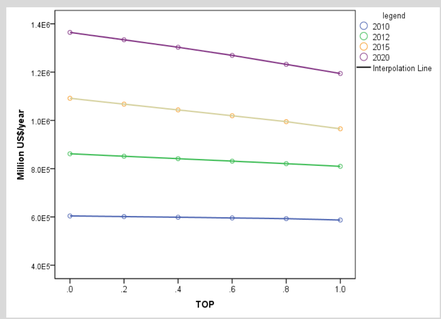
Fig 5 Consumer Surplus (ToP from 0 to 100%)



• Social welfare

- With perfectly competitive traders, social welfare, the addition of producer profit and consumer surplus, is an important indicator about market efficiency. Compared to the mean social welfare when the flexibility of LTC is 0 (TOP is 100%), the value when the flexibility is 100% (TOP is 0%) is constantly higher from 2010 to 2020. The percentage change ranges from the lowest 2.87% in 2010 to the highest 15.20% in 2010.

Fig 6 Social Welfare (ToP from 0 to 100%)



CONCLUSION

With the aim of valuing the long-term LNG contract flexibility, we construct a large-scale global gas equilibrium model with LTC database. based on an existent EU model. To simulate the gas price in the spot and contracted price, a mean reversion method with Monte Carlo he timeframe of the model is 2010 and 2020. The model shows that the market efficiency is likely to increase together with the flexibility of LTC. Consumers have a very large probability to gain more by enjoying the reduction in spot price. Whether producers can gain is uncertain. In some years, the total profit of producers increases as the LTC becomes more flexible; in other years, the total profits decrease. The differences in producer profits are a result of the downward drift of the spot price reduction and the upward drift of the arbitrage opportunity.

RREFERENCE: Chyong, C. and B. Hobbs, *Strategic Eurasian Natural Gas Model for Energy Security and Policy Analysis*, in *EPRG Working Paper Series*2011, University of Cambridge.