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Guide To: Pricing and Risk Management in the LNG Market

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ABSTRACT

Derivatives pricing theory assumes that markets are perfectly liquid and complete. The LNG market is neither of these. So how can LNG supply contracts be priced, and more importantly how can they be effectively dynamically hedged? What does this imply in terms of trading strategy constraints? This paper aims to answer these questions.

1. Introduction

Fig 1.0 LNG vessel

Trading in Commodities differs from other asset classes in that in most cases the products are physically delivered. This introduces a number of risks. This paper focuses on the financial exposure of specifically LNG deals and how to hedge it. The LNG market is interesting as it is a market that is currently in flux. At this time of writing there is no global spot market for LNG but there are moves (admittedly slowly) in this direction.

2. The LNG Supply Chain

2.1 Overview

In order to transport natural gas (NG) across long distances there are two methods: pipelines and shipping. For regions where it would not be practical or cost effective to build a pipeline then shipping is used. The shipping process involves the following steps:

1. The NG is piped from the upstream gas processing facilities to a liquefaction plant.
2. The NG is then cooled down to -162 ºC. This converts the gas to a liquid (LNG) which has the benefit that it occupies 600 times less space, so it is much easier to store and transport.
3. The LNG is pumped from the liquefaction storage facility to a ship and sent to the buyer's destination.
4. The LNG cargo is discharged into the buyer's regasification facility and converted back into a gas.

Fig 2.0 The LNG Value Chain. Sourced from (pttlng, 2015)

Currently the global LNG market can be divided into two separate geographic regions: The Pacific Basin and the Atlantic Basin. The Atlantic Basin can be considered all land masses that lie within or adjacent to the Atlantic Ocean. Similarly the Pacific Basin includes all land masses bordering the Pacific Ocean (Risk.net, 2015). At the time of writing it is expected that LNG exports from the USA will start in Q4 2015.

Fig 3.0 Global LNG flows – sourced from (BP Statistical Review of World Energy, 2014)

3. Long Term Contracts

3.1 The Sale and Purchase Agreement (SPA)

Most LNG contracts in the world are Sale and Purchase Agreements (SPAs). These are long term (~20 years) contracts and involve the shipping of multiple cargos. These contracts have become increasingly sophisticated over the years and contain legal provisions for all aspects of the delivery process and what the remedies are in case of something going wrong. Generally these contracts are priced off oil and a more detailed explanation of this is covered in section 5.

3.2 Delivery Terms

Most LNG cargoes are delivered under a few main types of contract terms: FOB, DAP (to replace older DES), CIF, and CFR. In 2014 most cargoes were either FOB or DAP (GIIGNL, 2015). From (Cogan, 2006) the definitions are summarised below:

FOB stands for "Free on Board" and means that the gas is deemed "delivered" at the loading point (the ship) and the buyer becomes responsible for the shipping.

DAP stands for "Delivered at Place" and means that the gas is deemed "delivered" at the delivery point. The seller remains responsible for the goods until they are delivered to the destination. However these costs are passed on the buyer. Sometimes the literature refers to DES which is the old and now defunct incoterm.

CIF stands for "Cost, Insurance, Freight" and is similar to DES in that the seller must arrange the freight, but the difference is that the title is transferred at point of loading.

CFR stands for "Cost and Freight" and is similar to CIF in that the seller must arrange the freight, but the difference is that the buyer must insure the cargo.

3.3 Take or Pay

A take or pay clause is an option in a contract that allows a buyer to pay a penalty in order not to be sent a cargo. They would only do this under two circumstances: if they had a problem at the delivery terminal and could not physically "take" the cargo, or if the payoff looked likely to make a large loss. If the later happens then long term contracts usually have renegotiation clauses in the event of major changes in market conditions.

2.3 Diversion Rights

Diversion rights give the buyer the right to nominate a different destination for the cargo (foenerjul10_01). There are several reasons why a buyer may wish to do this. It may be to minimise terminal costs by selecting the cheapest terminal. It may be to avoid a paying out in a "take or pay" clause by selecting an alternative terminal if unable to accept delivery in the original. Finally a speculative buyer may wish to maximise profits by nominating the destination with the highest local hub gas price or lowest terminal costs.

4. The Spot Market

LNG has been traditionally sold under long term contracts, however as new sources of supply and demand appeared, and new market participants have entered, then a spot market has evolved. Cargoes initially sold under long term SPAs are moved into the spot market where buyers and sellers seek to achieve the best value (Platts, 2015). According to Platts the spot market represents about 20% of all LNG volume produced each year.

The JKM curve is the Japan Korea Marker and is the Platts LNG benchmark price. Launched in 2009 it represents the market price for spot (up to 3 months forward) delivered cargoes. The problem with JKM at present is it is not very liquid (Gas Strategies, 2014). From a trading perspective you need a global supply and demand model to identify buyer sentiment. This is reasonably complex to model.

The process of moving a cargo from a long term contract to a spot contract is called novation. One of the benefits of this approach is that the spot contracts can be standardised with the use of Master Agreement templates, but this is not always used. There can be issues for trades of spot cargoes however. Not all LNG is of the same quality in the world. Ships are not compatible with all terminals. Buyers will have different credit worthiness, and there may be other contractual limitations.

As well as buying JKM spot contracts directly for physical delivery it is possible to buy financially settled futures contracts with a JKM underlying on exchanges like the ICE.

5. Pricing and Hedging

5.1 Overview

There are several ways to price LNG cargoes. One method is to use net-forward pricing. For net-forward pricing the price is determined by the source hub gas price plus the additional costs. For the case of FOB cargoes then this is just the liquefaction and LNG delivery-to-ship costs but for CIF cargoes this also includes the transportation costs. Another method is to use the spot market and the spot LNG curve directly (Platts, 2015). The final option is to price off either: oil, oil distillates, or oil index curves.

One useful concept to know in pricing is that of Oil Parity (LNG - wiki, 2015). Since most gas contracts are priced based off an oil underlying there is an implied relationship between oil and gas. If the price of LNG is equal to the price of crude oil in a barrel equivalent basis then we have Oil Parity. If the price of LNG exceeds oil then the situation is called Broken Parity. However this link between oil and gas prices is weak (Ramberg and Parsons, 2012) and in the authors opinion is one of the flaws in LNG pricing.

Fig 4.0 Gas and LNG prices. Sourced from (Platts, Heren, Petroleum Association of Japan and Bloomberg as of 6th March, 2014)

5.1 One Cargo without a Diversion Clause

Consider one cargo sold under an SPA agreement with no diversion clause. There is no general formula but a broadly most cargoes can be priced like so:

1. **Determine the base price**. This is a price based off the underlying oil, oil distillate, or oil index curve using the oil index standard formula (Wingas, 2015). This formula is an average over the prices in the pricing period (with a possible time lag), and is valid for the validity period. For the European market most contracts are priced off Brent on either a (6,0,1) or (3,0,1) basis. Which means prices off the past 6 or 3 months with no time lag and valid for the next month.

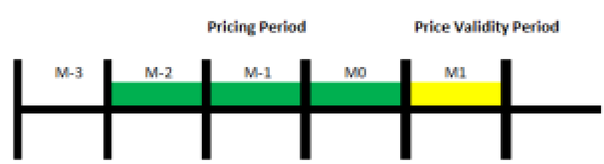

Fig 5.0 A cargo priced of a (3,0,1) structure.

2. **Apply a scaling factor and a constant**. This formula can also be conditional on the base price and leads to an s-curve.

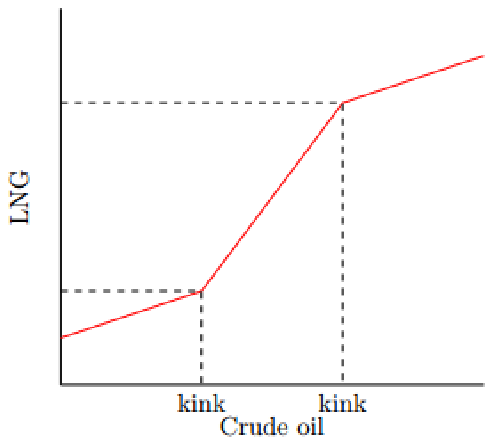

Fig 6.0 Hypothetical s-curve – sourced from (Baker, James A, 2014)

For cargoes going to terminals where the destination gas hub is denominated in something other than USD (e.g. NBP in the UK) then we have the additional exchange rate risk to factor in.

So how can we hedge our cargo? From the buyers perspective the cargo is equivalent to holding a short position in the underlying and a long position in the destination gas HUB. If the LNG cargo price is less than the destination hub price then you have made a profit. Now the assumption in most of these contracts is that oil and gas are almost perfectly correlated. So theoretically our cargo is already hedged in terms of basis risk. However in the case of the recent 2014 oil crash this correlation broke down and some LNG contracts became hugely profitable for the buyers. There is also a time spread exposure as the delivery is in the future, and a possible interest rate risk for non USD denominated destinations. The FX risk can be hedged with FX futures.

For the spot market you have a direct exposure to the spot curve move. For example if you bought a JKM cargo on the spot market you have a net long position and you would need to hedge this. Due to the illiquidity of the spot market, hedging is performed with more liquid gas market such as Henry Hub. For JKM exchange traded futures you are exposed to margin risk which can be hedged in a similar way to the physical case by selling futures in gas.

5.2 Introducing the Diversion Clause

We now get a bit more complicated, and consider pricing a cargo with an option to divert to different destinations. Let's flesh out a toy example. Suppose that there is a contract for one LNG cargo on a DES basis that originates from Qatar and can be delivered either to the UK or to Japan. On the nomination date the buyer can choose to nominate delivery to either the UK or to Japan.

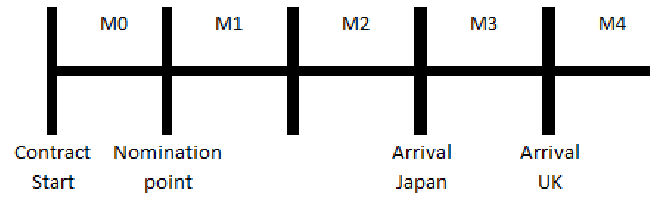

Fig 7.0 Single cargo with diversion optionality.

Say that the Qatari cargo is based on a Brent crude underlying and the UK and Japanese destination legs are priced off NBP and JKM. The legs are defined as:

$$L1 = f(Brent)$$
$$L2 = g(NBP).GBPUSD$$
$$L3 = h(JKM)$$

We assume that the additional costs (liquefaction and shipping) are included into the L1 price. We have the additional FX exchange rate risk with NBP. If we don't exercise the option then the cargo goes to Japan and the net present value of the final payoff is:

$$Payoff1 = NPV(L3) - NPV(L1)$$

If we do exercise the option then the final payoff is:

$$Payoff2 = NPV(L2) - NPV(L1)$$

We have to exercise (nominate) before expiry so this becomes a free boundary problem .With any free boundary problem the idea is to select the optimal exercise plan. So on the nomination day, we have an option to exercise or not. With perfect hindsight we would choose the exercise strategy that gives us the maximum return. This would be to exercise if:

$$Payoff2 > Payoff1$$

But we don't have the benefit of a time machine so we must choose an exercise plan that on average gives us the maximum return. We only have the information that is available to us at the start of the contract. So must define a level "x" to exercise on if:

$$L2_{tn} - L3_{tn} > x$$

Where:

$L2_{tn}$ *is the net present value of Leg 2 at nomination time.*
$L3_{tn}$ *is the net present value of Leg 3 at nomination time.*

So the price of the derivative contract would therefore be the expected value of the payoff with the optimal exercise level "x".

$$\mathbb{E}[Max_x(Payoff1, Payoff2)\backslash\mathcal{F}_t]$$

There are various techniques for solving such problems, which are beyond the scope of this paper. Please refer to (Doubble, 2007) .

So how can we hedge a contract with diversion optionality?

After the nomination window the option becomes like a regular cargo with a basis risk and a time spread risk. The time spread could be hedged by selling a forward on the destination gas asset. Before nomination you would need to calculate the delta sensitivities with your option pricing model to the underlyings (Brent, JMK, NBP, FX). Delta hedging would involve synthetically selling the option by trading the underlyings.

5.3 More Advanced Contacts

In practice real contracts are much more complex than this and normally have a strip of cargoes and potentially multiple destinations, as well as a take-or-pay clause. There can also be clause for the supplier to cancel or suspend a cargo. But with an appropriate valuation model all of this embedded optionality can be valued and hedged. Well they can be hedged in theory, but in practice you don’t see futures contracts going out 20 years. This means that you won’t see the long dated cargoes being hedged. It could be argued that the renegotiation clause in the SPA is a built in long term hedge.

6. Credit Risk

As a seller of LNG cargoes, one has to consider the non-payment risk of the client. With the old style long term oil linked contract market to low risk clients, payment was typically 10 to 30 days from transfer of title (Shearer and Tusiani, 2007). As noted in section 3.2 these transfer points are different for different cargo types (FOB, CIF etc). As the size of the market increased, and less credit-worthy organisations became involved then new terms started getting added to the contracts. These generally require the buyer to provide a letter of credit from a financial institution or some other form of payment insurance. In the worst case prepayment would be required.

7. Trading Strategy

The fundamental way to trade LNG (as opposed to the technical way) is to have a global S&D (Supply and Demand) forecast model. Having this view gives a price forecast. Armed with a directional view, a speculator could buy or sell a futures contract on the JKM spot market. Although a single outright position will lead to greater profits if the market view is correct, it would be more common to see spreads (bull or bear) traded (Schwager, 1984). For markets that don’t have a clearly defined spot mechanism, we have seen in section 5 that a trader can replicate a synthetic cargo by buying or selling the underlyings. With LNG trading liquidity must be taken into account. Hedging an illiquid LNG contract with a basket of liquid futures contracts will result in periods where the position is unhedged. This could cause problems in periods of high volatility.

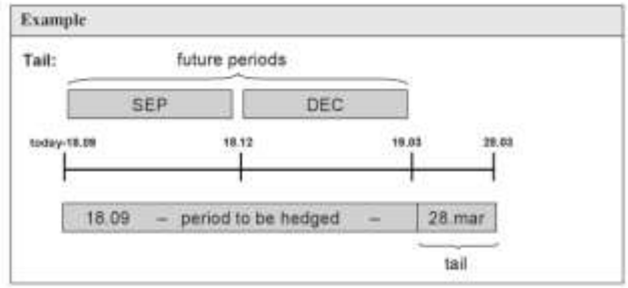

Fig 8.0 Effects of not being hedged for the whole time period. Sourced from (Enthofer, Hannes, 2013)

In practice an LNG trading desk would not look at single deals, but instead try to optimise their entire portfolio. One way to do this is to use a simulation based approach. The underlyings (Brent, JKM, NBP, FX etc) could be simulated forward in time, and the rolling intrinsic value of the entire portfolio could be calculated. It would be then possible to determine an optimal hedging strategy that, “on average” provides the maximum return with the lowest risk. A full treatment of portfolio optimisation is beyond the scope of this paper.

8. Conclusion

From the inherently complex nature of long term SPAs it is vitally important to have an appropriate valuation model that captures the embedded optionality. From this model, the exposure can be correctly incorporated into a Value at Risk (VaR) system. However that is not the end of the story as VaR would have failed to capture the oil price crash of 2014 and the breakdown in correlation between gas and oil prices. This is why it is important to conduct stress testing. Stress testing over real historical scenarios is one thing but it is also important to consider new scenarios which could happen. With regards to the spot market the issue is liquidity. VaR in its pure form does not take liquidity into account, but there are simple measures such as forcing a longer time horizon for illiquid markets.

As well as a short time horizon view with VaR it is also important to look further out and analyse the potential Earnings at Risk (EaR) over a much longer period. This will help identify potential future spikes in risk that need to be hedged. A portfolio optimisation system could leverage this technology to determine an optimal hedging strategy.

A middle office risk function must be kept separate form the trading function but there is information that a trading team has that could be potentially beneficial to a risk team. Potentially a trading team will possess an S&D (Supply and Demand) based forecasting model. This could be used to produce price forecasts, which could be added to the list of stress scenarios for calculating a risk capital requirement. Trading teams are usually reluctant to divulge this kind of information so it may be difficult to implement in practice.

Appendix A. Barrel of Oil Equivalent Pricing Formula

Say the price of JKM for delivery one month from now is $7.279 / MM Btu. Then from (Energy Conversion, 2015):

1 MMBtu = 0.18013586919434 boe

So 1 boe = (1 / 0.18013586919434) * 7.279 = $40.43

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