

Price discrimination and limits to arbitrage: An analysis of global LNG markets

Robert A. Ritz

Faculty of Economics & Energy Policy Research Group (EPRG)
University of Cambridge

EARIE 2014 – Milan

rar36@cam.ac.uk

August 2014

Large growth in LNG volumes for several reasons

- Increased infrastructure investment (liquefaction & regasification)
- Larger LNG shipping fleet & lower transport costs

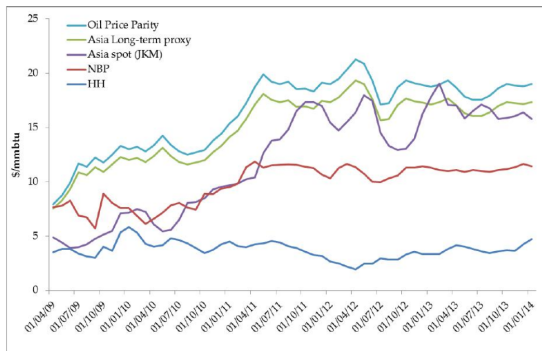
LNG connects previously separate geographies

- More flexible contracting between buyers & sellers
 - Ongoing shift away from bilateral long-term contracts
 - Short-term LNG ↑10-fold since 2000 (now >25% of total)
- Significant proportion of gas trade now between regions

⇒ **Widespread conjecture of global gas price convergence**

Price non-convergence: Irrationality?

Some commentators argue LNG players acting “irrationally”



- Major exporters sell short-term LNG to both Asia & Europe
- Forgone profit = $|\text{Price differential}| \times \text{Quantity sold to Europe?}$
 - Up to \$100m *per day* for Qatar (Japan vs UK)

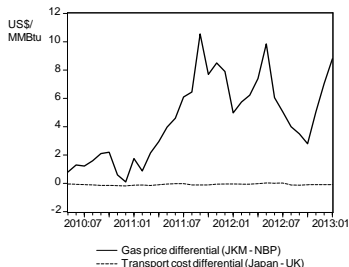
⇒ **LNG exporters failing to engage in price arbitrage?**

An explanation based on transport costs?

Competitive model predicts netbacks equalized across markets

- Regional price differential = difference in transport costs

Figure: Qatar LNG short-term sales to Japan & UK



⇒ **Competitive model cannot explain observed gas prices**

This paper: *Rationalizing LNG prices & trade flows with market power*

Several reasons for recent US price divergence

- 1 Large-scale shale gas has pushed down US natural gas prices
- 2 Infrastructure reflects vision of US as major LNG *importer*

⇒ US market largely isolated from the rest of the world

What if the US becomes a large LNG exporter?

- US & non-US prices will not necessarily converge (or netbacks)
- Any model of US LNG exports likely incomplete without market power
 - Recent model-based simulation for US Department of Energy: Incorporates general-equilibrium effects—but assumes that LNG producers do not respond strategically to US market entry...

A model of a profit-maximizing LNG exporter

Producer k 's problem: Choose short-term exports to $M \geq 2$ export markets to maximize profits subject to any capacity constraint:

$$\max_{\{x_\ell^k\}_{\ell=1}^M} \Pi^k = \sum_{\ell=1}^M p_\ell^k x_\ell^k - C^k(\sum_{\ell=1}^M (x_\ell^k + y_\ell^k)) - \sum_{\ell=1}^M \tau_\ell^k x_\ell^k$$

subject to $\sum_{\ell=1}^M (x_\ell^k + y_\ell^k) \leq \bar{Q}^k$ (with shadow value $\lambda^k \geq 0$)

- **Producer k 's demand** $p_\ell^k(x_\ell^k, y_\ell^k, X_\ell^{-k}, Y_\ell^{-k}; \theta_\ell)$ in market ℓ
 - x_ℓ^k = k 's short-term sales; y_ℓ^k = k 's long-term commitments
 - X_ℓ^{-k} = others' short-term sales; Y_ℓ^{-k} = others' commitments
 - θ_ℓ = state of market ℓ (business cycle, prices of substitutes (coal, oil, etc.), demand shocks, weather, etc.)
- **Production costs** $C^k(\sum_{\ell=1}^M (x_\ell^k + y_\ell^k))$ for all $M \geq 2$ markets
- **Transport costs** τ_ℓ^k per unit of output sold to market ℓ

Profit-maximization (nothing else) implies first-order condition

$$MR_i^k - MC^k - \tau_i^k - \lambda^k = 0 \text{ for market } i$$

$$\implies MR_i^k - \tau_i^k = MR_j^k - \tau_j^k \text{ for any two markets } i \text{ and } j$$

(Regardless of whether capacity-constrained or not)

\implies **Producer equalizes marginal revenues** (net of transport costs)

- **Equal marginal revenues does not imply equal prices**

- Prices *optimally* far apart if demand conditions very different

A result on price differences across markets

Proposition Profit-maximizing prices in any two export markets, i and j , satisfy

$$\frac{(p_i^k - p_j^k)}{p_j^k} = \frac{\eta_i^k}{(\eta_i^k - 1)} \left[\left(\frac{1}{\eta_i^k} - \frac{1}{\eta_j^k} \right) + \frac{(\tau_i^k - \tau_j^k)}{p_j^k} \right]$$

where (η_i^k, η_j^k) are producer k 's price elasticities of demand.

- **Simple-yet-general result** on price differences across markets:
 - Weak assumptions on demands and costs
 - No assumptions on mode of competition
 - e.g., perfect competition, Cournot-Nash, monopoly, dominant firm

Key point: Market power easily rationalizes observed prices

Four special cases of the model

1. **Perfect competition** ($\eta_i^k \rightarrow \infty$ and $\eta_j^k \rightarrow \infty$)

$$\Delta p_{i,j}^k = \Delta \tau_{i,j}^k$$

2. **Symmetric transport costs** ($\tau_i^k = \tau_j^k$)

$$\Delta p_{i,j}^k > 0 \iff \eta_i^k < \eta_j^k \implies \text{sign}(\Delta p_{i,j}^k) \neq \text{sign}(\Delta \tau_{i,j}^k)$$

3. **Symmetric demand elasticities** ($\eta_i^k = \eta_j^k = \hat{\eta}^k < \infty$)

$$\Delta p_{i,j}^k = \frac{\hat{\eta}^k}{(\hat{\eta}^k - 1)} \Delta \tau_{i,j}^k \implies \text{var}(\Delta p_{i,j}^k) > \text{var}(\Delta \tau_{i,j}^k)$$

4. **Weak-and-near & strong-and-far market** ($\eta_i^k < \eta_j^k$ and $\tau_i^k \geq \tau_j^k$)

$$\Delta p_{i,j}^k > 0$$

\implies *Relative demand conditions matter* (in addition to transport costs)

Applying the result to LNG markets

Asian LNG prices recently much higher than in Europe. Why?

Asian markets: “Low” price elasticities

- Fukushima sharply increased Japanese LNG import demand
- More generally, greater concerns about “security of supply”

European markets: “High” price elasticities

- Since 2011 significantly higher imports of coal from US
- More generally, better substitution possibilities to pipeline gas

Numerical example: Let $\tau_i^k \approx \tau_j^k$, $(\eta_i^k, \eta_j^k) = (2, 9) \implies p_i^k / p_j^k \approx \frac{16}{9}$

- In general, no *unique* pair (η_i^k, η_j^k) to rationalize (p_i^k, p_j^k)

NB. None of these arguments valid under perfect competition

Various ways to estimate producer-specific elasticities:

1 Econometric methods

- Estimate η_i^k using time-series data on prices & quantities

2 First-order conditions

- If not capacity-constrained, then $\eta_i^k = p_i^k / [(p_i^k - \tau_i^k) - MC^k]$

3 Model of competition

- If Cournot-Nash competition, then $\eta_i^k = \eta_i / s_i^k$
 - $\eta_i =$ market-level price elasticity of demand
 - $s_i^k =$ market share of producer k in market i
 - $\left. \begin{array}{l} \eta_i = \frac{1}{2} \text{ \& } (s_i^k, s_j^k) = (25\%, 5\frac{5}{9}\%) \\ s_i^k = s_j^k = 10\% \text{ \& } (\eta_i, \eta_j) = (\frac{1}{5}, \frac{9}{10}) \end{array} \right\} \implies (\eta_i^k, \eta_j^k) = (2, 9)$

NB. Limited data availability for LNG markets...

Case study: Price-cost margins for Qatar

Inputs (prices & costs)

IEA estimates: Indicative unit cost for production, liquefaction & regasification = \$3.00/MMBtu (in 2008 US\$)

⇒ $MC^k = 3.90$ (for 2012) & not capacity-constrained ($\lambda^k = 0$)

- **Japan:** Price $p_i^k = 16$ & transport cost $t_i^k = 2.10$
- **UK:** Price $p_j^k = 9$ & transport cost $t_j^k = 2.15$

Results (“market power”)

Define price-cost margin $L_i^k \equiv [(p_i^k - t_i^k) - MC^k] / p_i^k$

- **Qatar-to-Japan:** $L_i^k \simeq 63\%$
- **Qatar-to-UK:** $L_j^k \simeq 33\%$

⇒ **Significant mark-ups to both markets, twice as high for Japan**

- **Contractual constraints**

- Some destination restrictions persist despite greater flexibility
- LNG exporters may restrict resale onto commodity exchanges

- **Shipping capacity**

- Larger LNG fleet—but only small proportion is uncommitted
- Shipping market unable or unwilling to provide transport

- **Vertical issues**

- Redirecting cargo forgoes LNG buyer's downstream surplus
- Complex ownership arrangements along LNG supply chain

JP Morgan Cazenove 2012 LNG industry report

“The entry barriers to LNG trading are surprisingly high—new entrants require more than just experienced traders and trading systems.

They must have access to cargoes, but the market’s liquidity is typically held captive by the LNG liquefaction owners/upstream suppliers who are understandably very reluctant to release volumes for traders to trade with. Traders must also have access to shipping, either via owned vessels or the charter market.

Furthermore, certain ships can unload at certain terminals (e.g., many import terminals cannot accommodate Q-Max vessels). This can make it even more difficult to efficiently connect volumes to buyers.”

- **Other arbitrage considerations:** Time, risk, units, market power

- **Theory literature on third-degree price discrimination**

- “Uniform pricing” versus price discrimination \iff
Unconstrained pricing versus perfect & costless arbitrage
 - Consumer typically benefit in aggregate but some lose
 - Monopoly worse off but oligopoly may be better off
 - Welfare impact ambiguous—depends on fine details

- **Application to LNG markets currently very limited**

- 1 Unrealistic market structures (monopoly or price-setting duopoly)
- 2 All markets remain served despite increased arbitrage
- 3 Producers have identical marginal cost for each market
- 4 No long-term contracts or complex ownership structure
- 5 No dynamic perspective on incentives for investment