Emerging Natural Gas Fundamentals:
LNG Exports and Other Margins of Response

A Follow-Up Discussion of
US LNG Exports in an International Context

Presentation at
USAEE Houston Chapter Luncheon

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December 12, 2013

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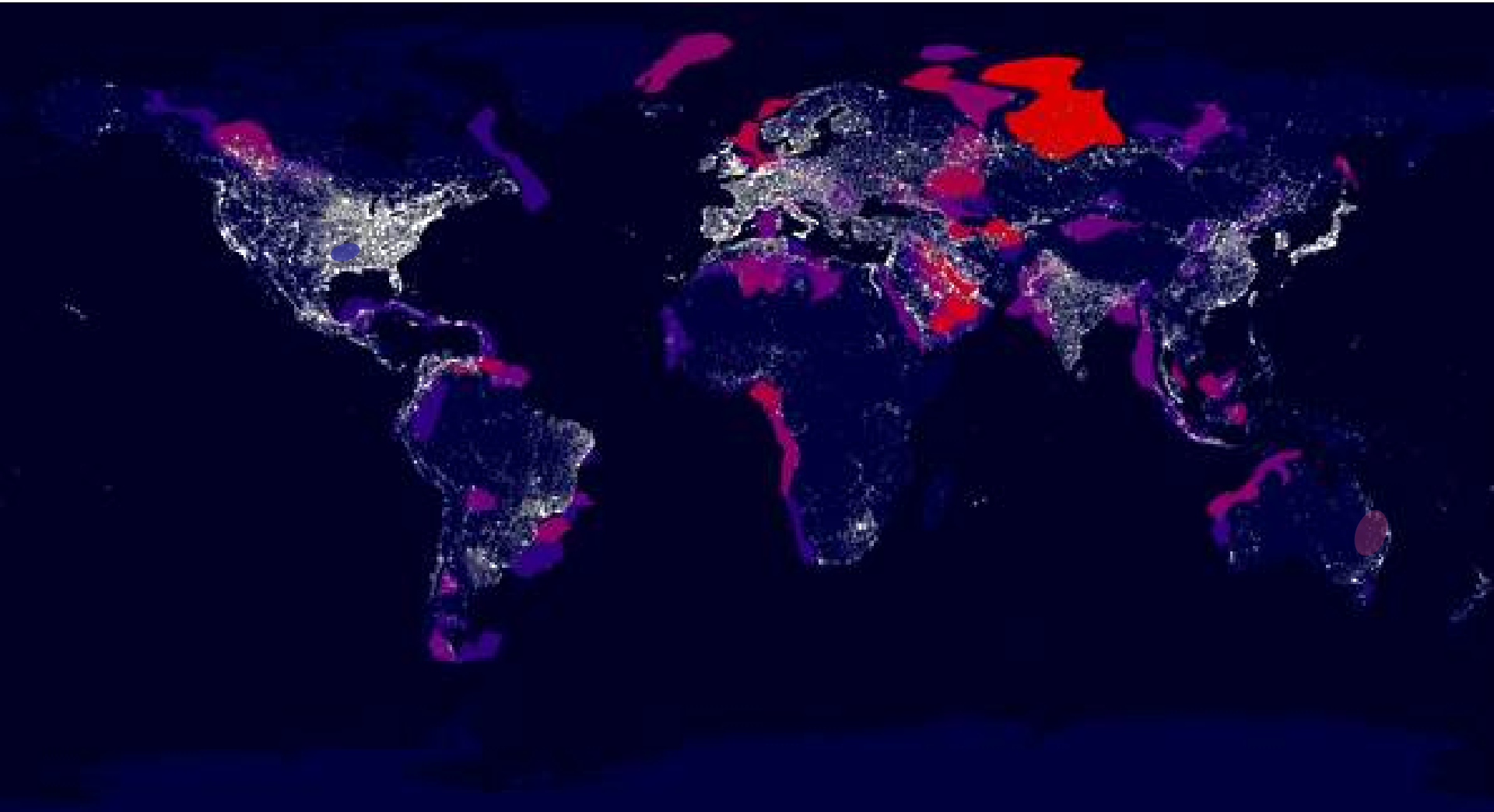
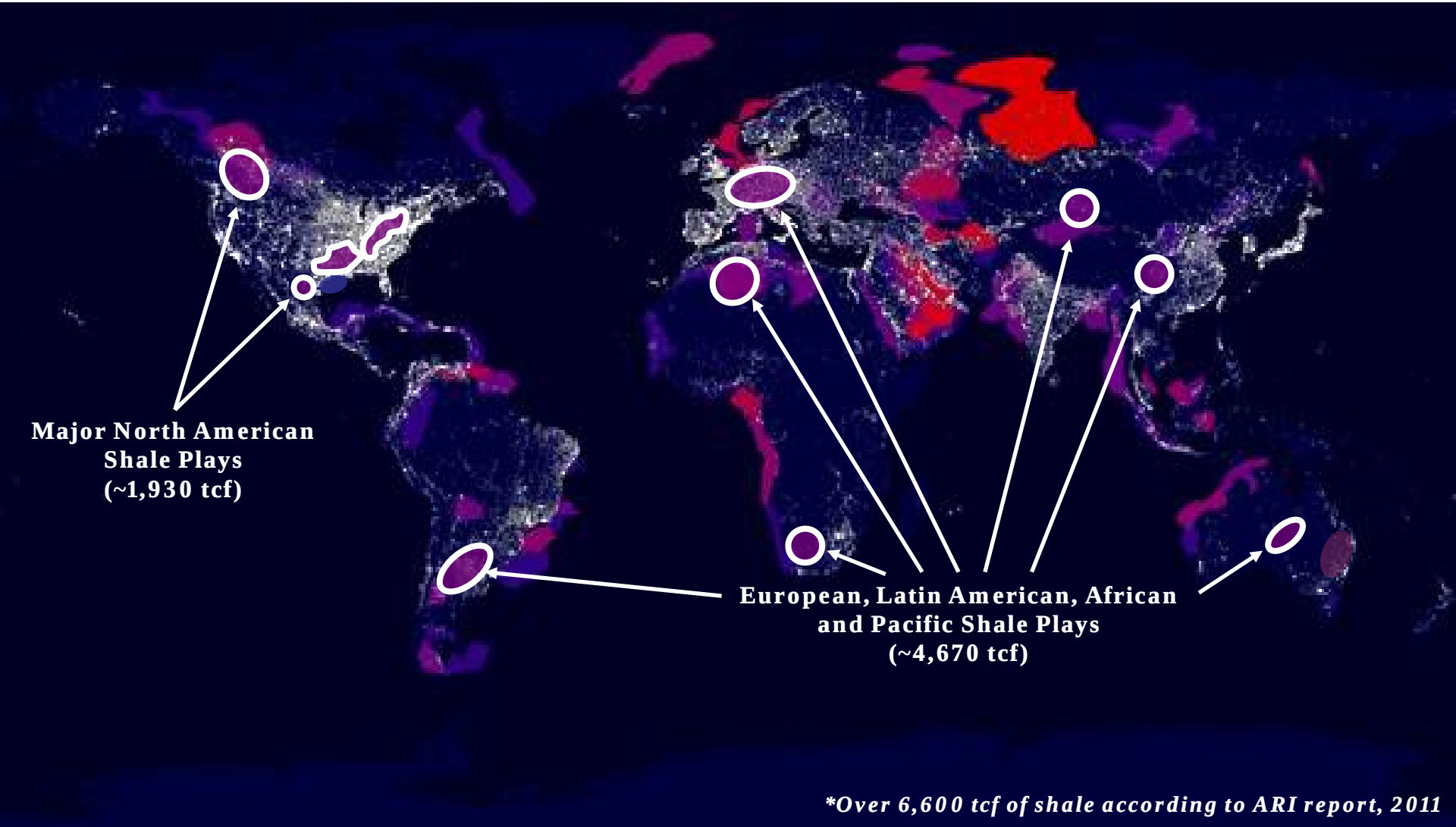
The “50,000 Foot” view in 2000: Shifting Global LNG Landscape – All aboard for LNG supply to North America



The difference a decade makes: Shale emerges – LNG from North America?



**Over 6,600 tcf of shale according to ARI report, 2011*

Broad Implications of US Shale Gas

- Expansion of production from US shale plays has rendered the utilization of LNG import capacity in the US very low.
- It has had an impact on the relative price of oil and gas, and it has raised the possibility of US LNG exports.
- But, when weighing all demand responses, and thus market impacts, the focus should not be on just exports.
- Shale gas makes the supply curve more elastic. This mitigates the potential for sustained long term increases in price and has implications for fungibility and price volatility.
- This has bearing on many margins of demand response.
- Indeed, multiple sectors are important for the longer term implications of shale.

Modeling Well Decline in Shale Plays: How do shale wells behave, and what are the Long Term Possibilities?

"Panel Analysis of Well Production History in the Barnett Shale"

Our work with the UT BEG shale study

- The primary purpose of the empirical analysis is to test the statistical validity of the proposed methodology (REI) for modeling well production.
- The REI method proposes production, denoted $q_{t,i}$, can be modeled as

$$q_{t,i} = \frac{k \cdot REI_i}{t_i^{0.5}}$$

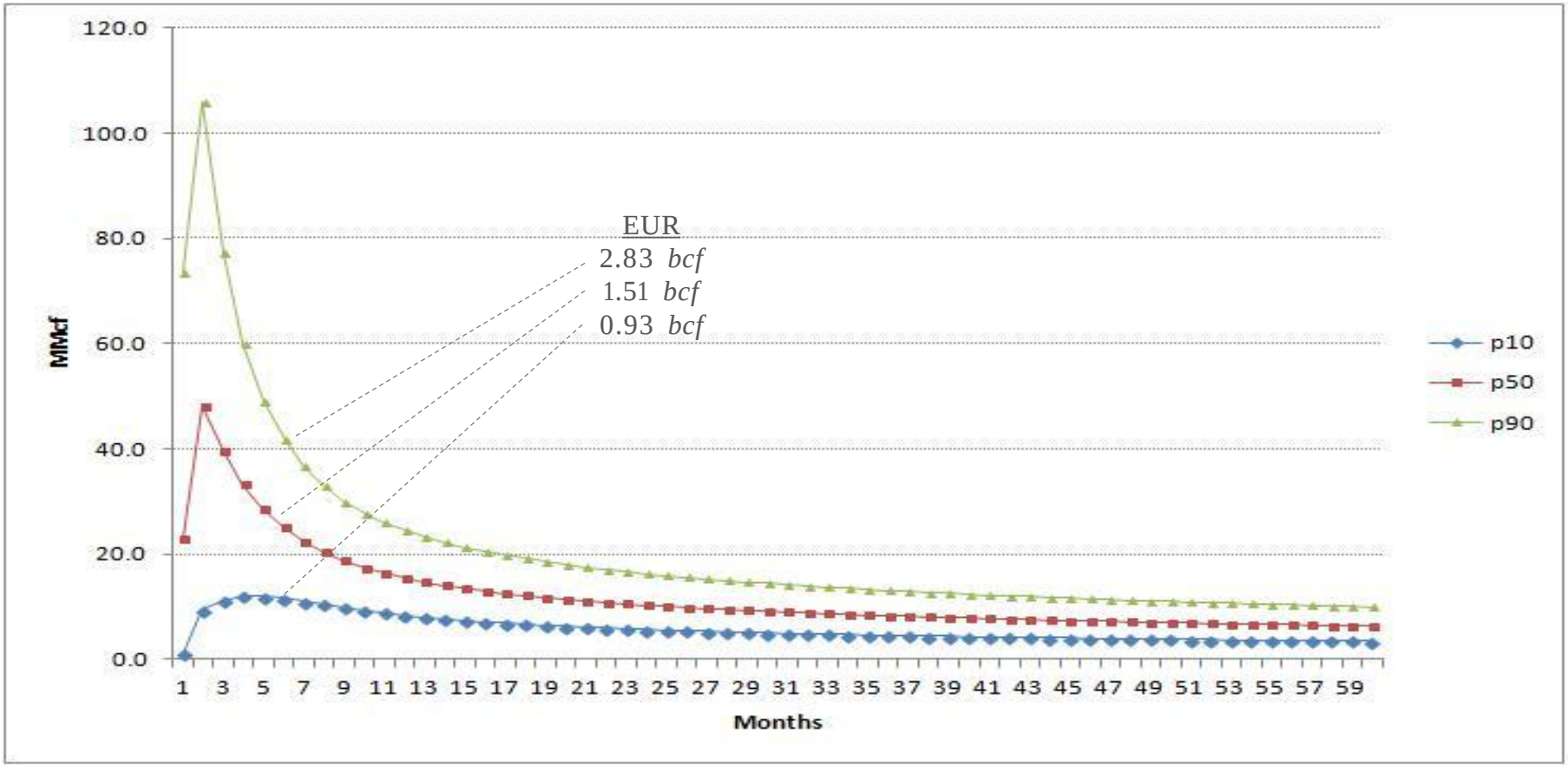
- The above equation can be transformed into

$$\ln q_{t,i} = \ln\left(k \cdot REI_i\right) + \rho \ln t_i$$

- where the term $\ln\left(k \cdot REI_i\right)$ is well-specific. Moreover, we can test whether or not $\rho = -0.5$.
- The hypothesis cannot be rejected:
  - Horizontal well: $\rho = -0.501$
  - Vertical well: $\rho = -0.498$

Implications for Production Sustainability

- Well-specific EURs can vary within a shale play substantially
  - Ultimately, profitability matters, as there is little debate about resource scale
  - Some wells are profitable at $2.65/mcf, others need $8.10... median is $4.85.



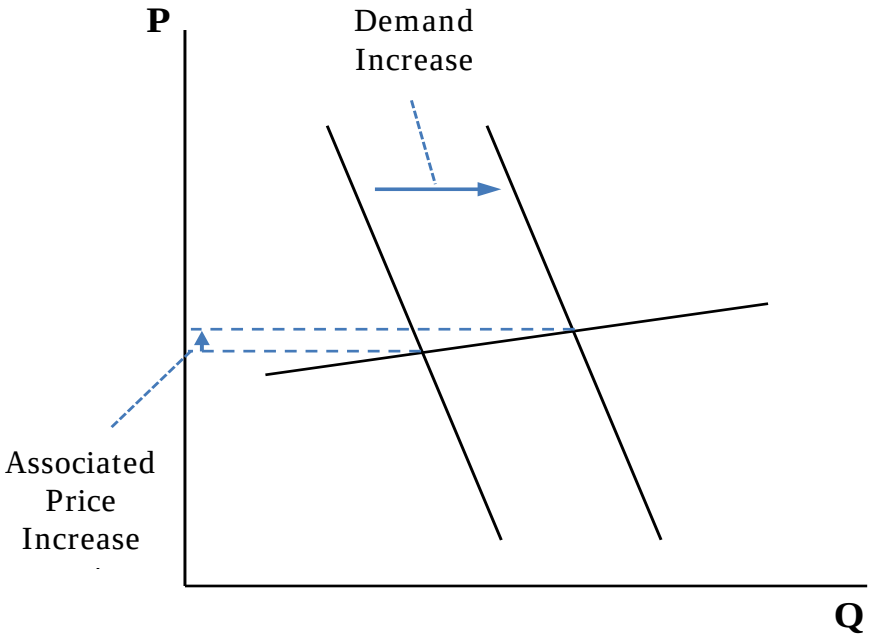
Implications for Price, Margins of Demand Response, and the Ripple Effects to International Gas Markets

The U.S. Demand Response…

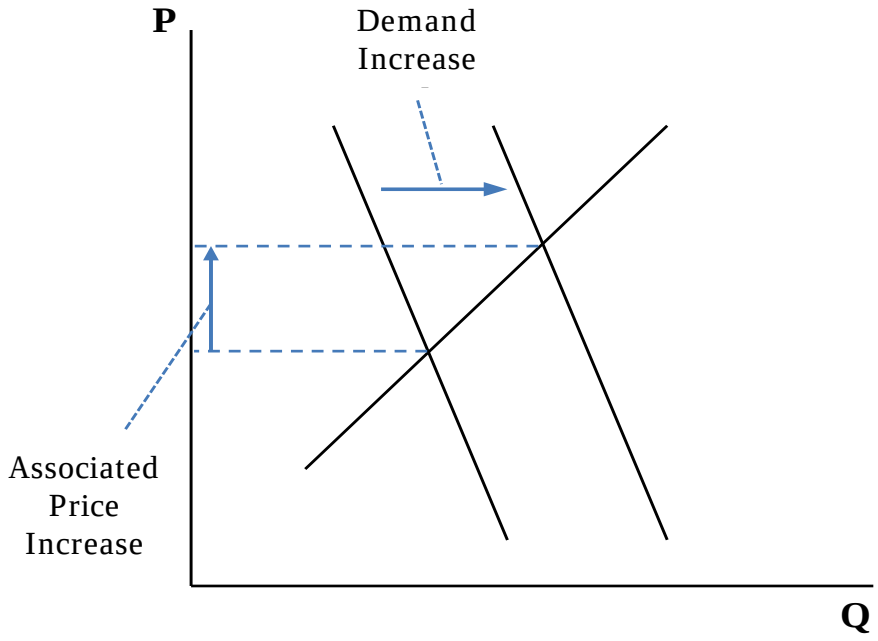
- What are the end-uses where demand could change?
  - Power generation
  - Industrial uses as an energy source and feedstock
  - Personal automotive transportation
  - Heavy vehicle and fleet transportation
  - Marine transportation – EPA forcing out heavy fuel oil and diesel
  - LNG and pipeline exports (foreign demand for US gas)
- Incremental demand responses could be large, but is this reasonable? (by 2025 →35 bcfd)
  - LNG exports (12 bcfd)
  - Power generation (10 bcfd)
  - Industrial uses (7 bcfd)
  - Light and heavy vehicle and fleet transportation (2 bcfd)
  - Marine transportation (2 bcfd)
  - Pipeline exports (2 bcfd)

Response depends on price, which depends on response: the riddle of endogeneity

- Price will only rise dramatically (and sustainably) when demand grows if US domestic supply is highly inelastic (in the long run). Short run price movements will depend on other issues, such as the realization of deliverability constraints.



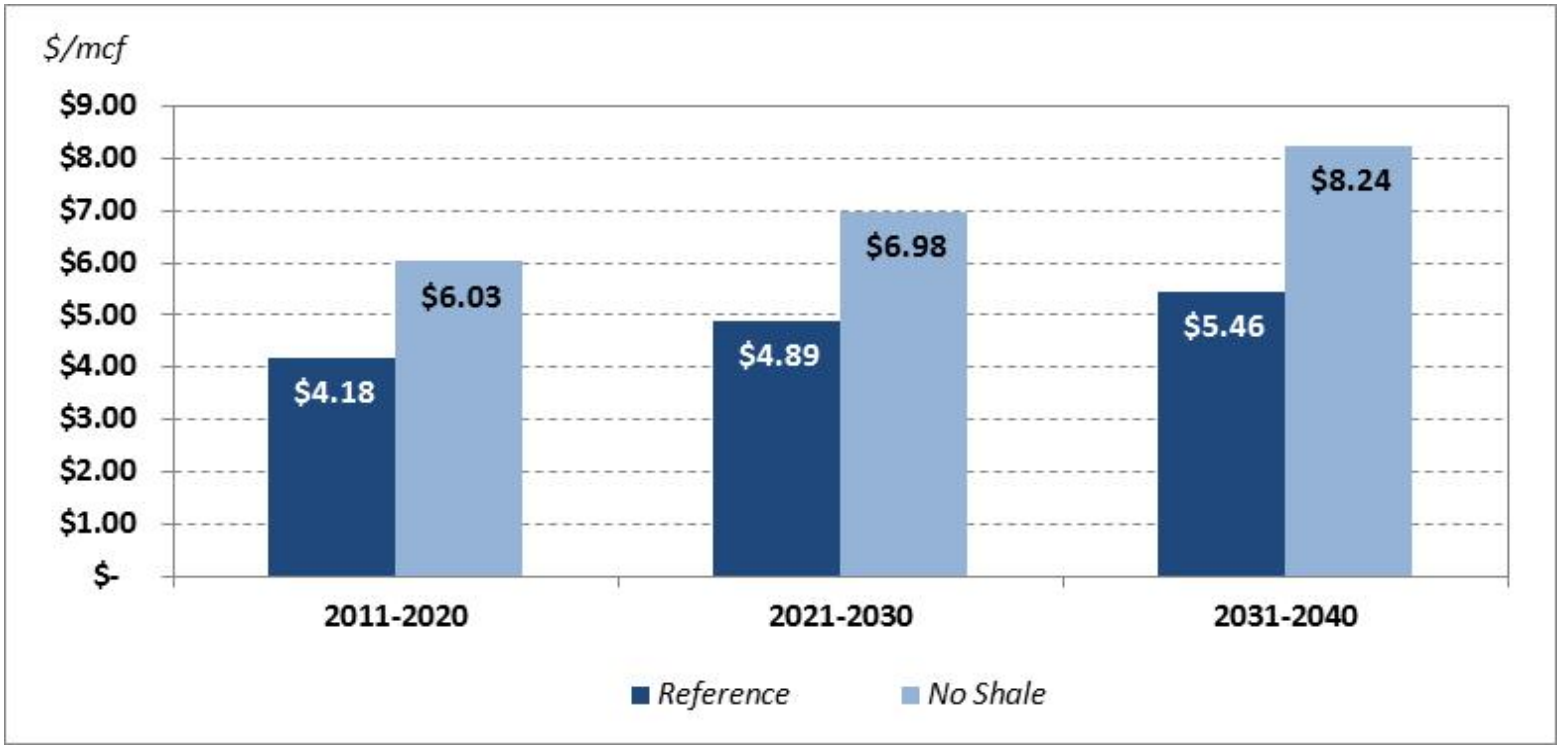
Case 1: Supply elastic



Case 2: Supply inelastic

CES Outlook: Shale and Henry Hub, 2011-2040

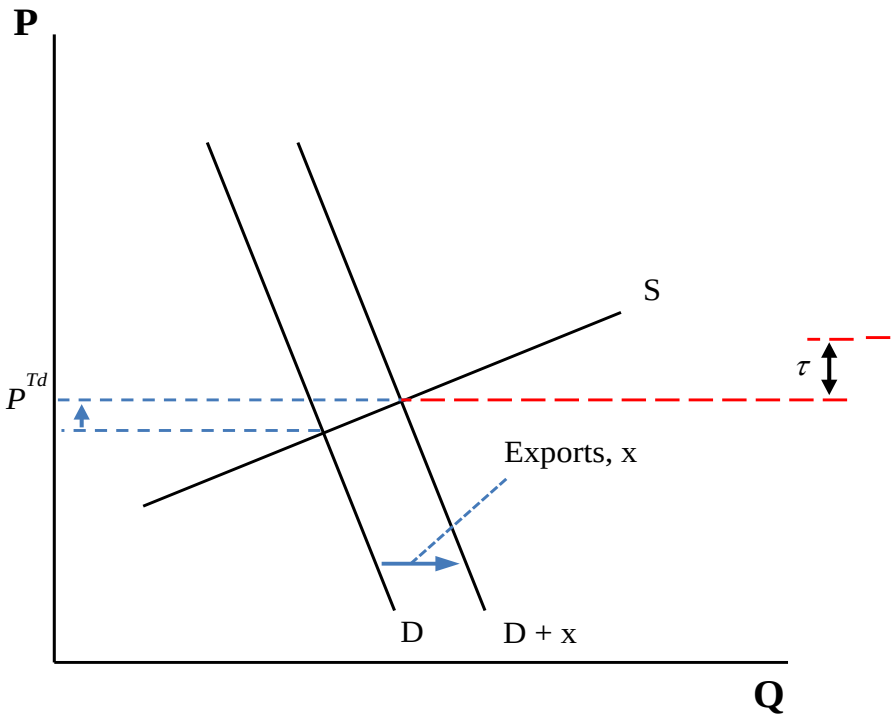
- The domestic supply curve is much more elastic as a result of shale gas developments. Domestic ***long run*** elasticity*
  - with shale = 1.52; without = 0.29.



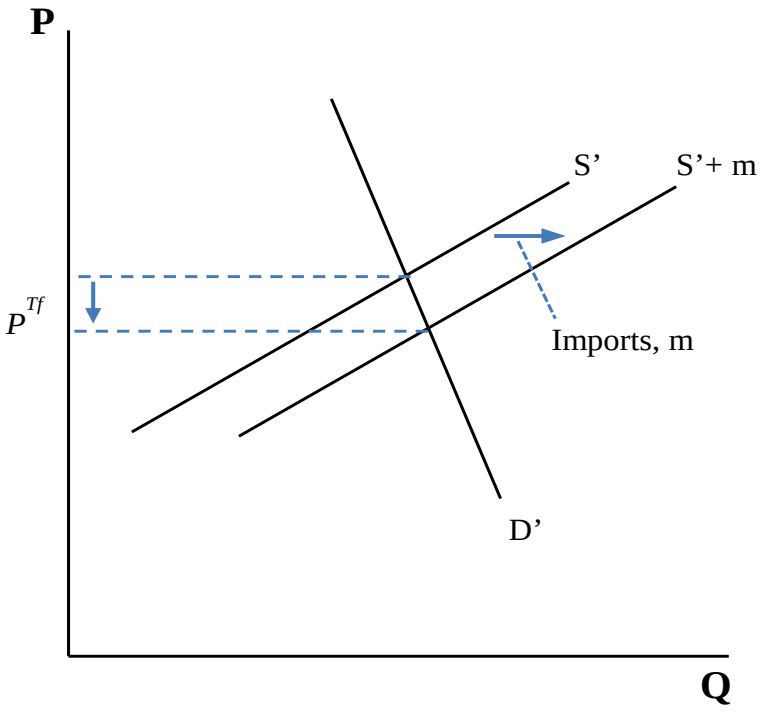
* - Results derived from the Rice World Gas Trade Model (RWGTM). The RWGTM was developed by Ken Medlock and Peter Hartley at Rice University using the MarketBuilder software provided by Deloitte MarketPoint .

How do exports fit in?
The foreign market response is critical

- With trade between two markets, price in each adjusts. The adjustment depends on the elasticities of supply and demand.



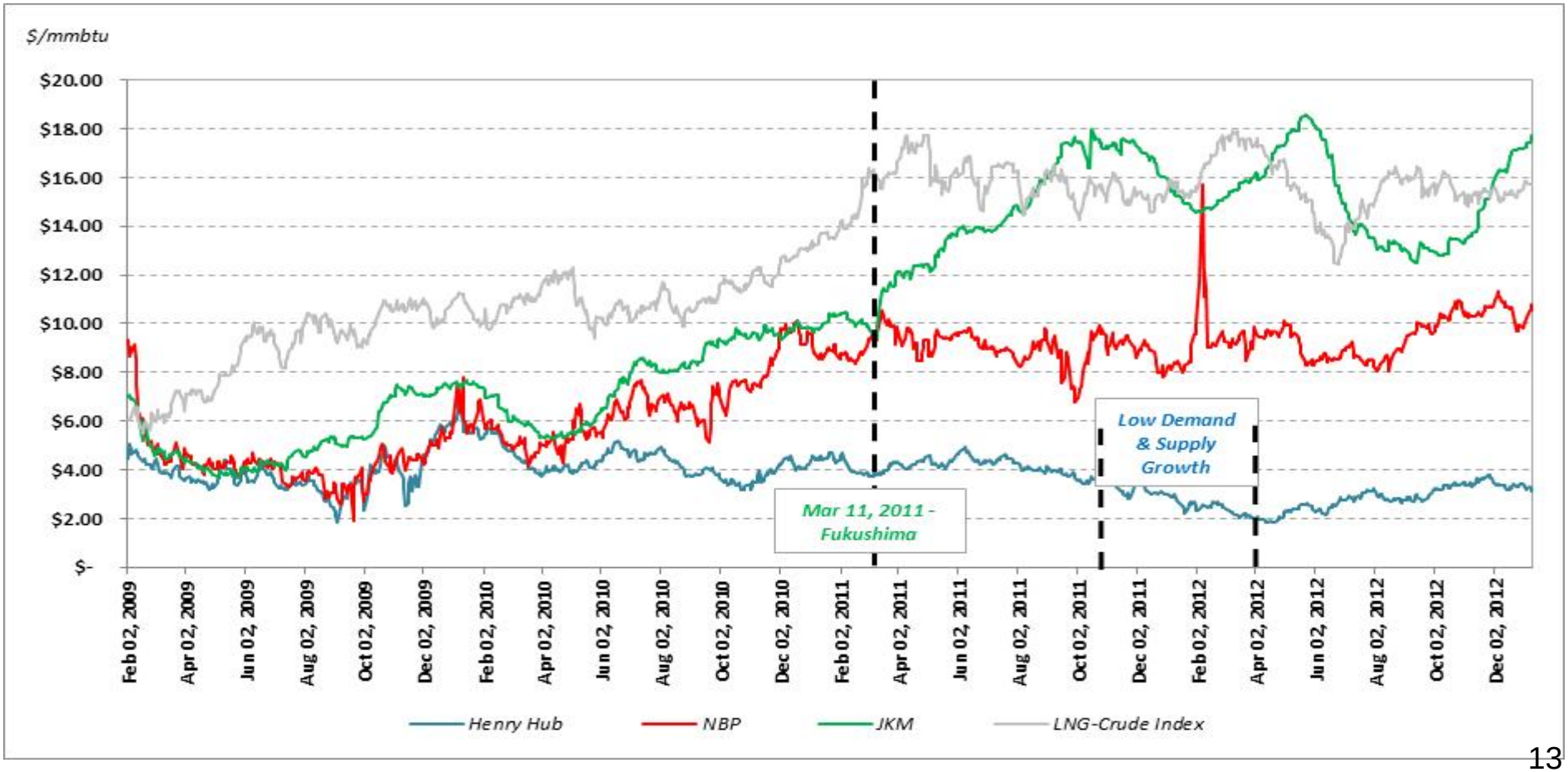
Domestic Market



Foreign Market

International Natural Gas Prices

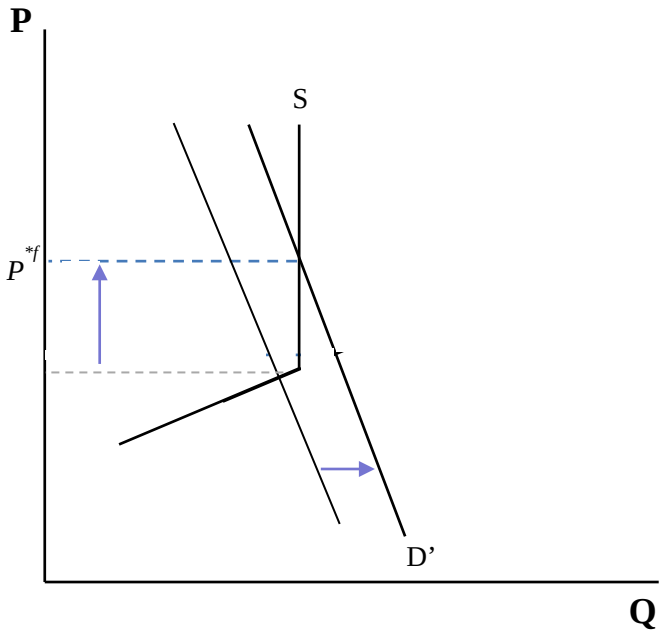
- Will the change in regional gas price relationships since March 2011 persist?
  - Unexpected demand shocks in Asia and the US have exacerbated spreads



Price data from Platts; LNG Oil-Index author's calculation

The Short Term

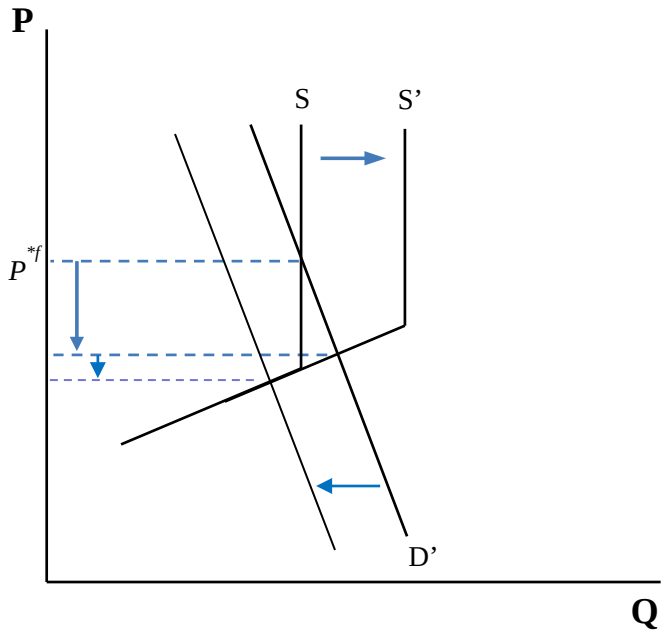
- A wide divergence in price is exactly what we should expect to see if the ability to deliver is constrained…
  - Increased Japanese demand for natural gas in the wake of Fukushima is an *unexpected* demand shock. These sorts of shocks stress delivery capability and create rents in the marketplace.



Moving past the short term

- Alleviating the deliverability constraint will have a large impact on international prices.
  - US exports could put downward pressure on international price.
  - This will be exacerbated by (a) demand reductions and (b) other supplies (for example, China shale, East Africa, Australia, Russia) .

The extent is highly uncertain, but the direction is not...



Feasibility of US LNG Exports

- Lots of weight given to current international spot price, but several factors are often ignored, such as
  - short term capacity constraints, which are important when considering where we are today,
  - domestic market interactions with markets abroad, and
  - a weak US dollar.
- US LNG exports could put significant downward pressure on international price.
  - In 2012, LNG trade was about 30 bcfd. Current filings exceed 30 bcfd.
- Prices will adjust, and greater liquidity will alter the market paradigm in a substantial way.

The Full U.S. Demand Response: Modeled in the RWGTM

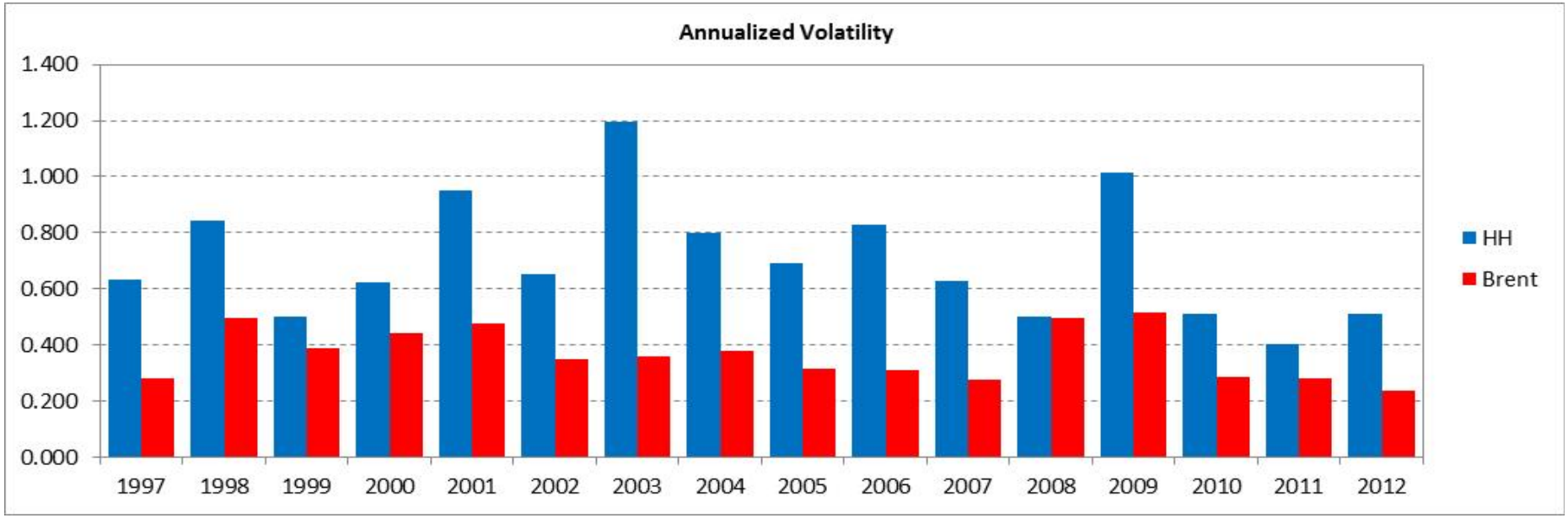
- Incremental demand responses (by 2025 → ??? bcfd)
  - LNG exports → < **4 bcfd** – *market*
  - Power generation → < **5 bcfd** – *policy and market*
  - Industrial uses → < **3 bcfd** – *market*
  - Personal auto transport → < **0.15 bcfd** – *market*
  - Heavy vehicle and fleet transport → **< 1 bcfd** – *market*
  - Marine transportation → < **1 bcfd** – *policy*
  - Pipeline exports → < **2 bcfd** – *market*
- **Scale of net demand increase is about 15 bcfd**
  - … or close to 25% of current demand.
  - Residential and commercial demand falls by over 1.5 bcfd

A comment on long term prices

While we should recognize that there will be demand-driven volatility, the extremes and durations are likely to be mitigated relative to history. The nature of production and becoming connected to the international market will each enhance fungibility. Anything that lowers the incentives to invest in the upstream will work against this. Indeed, we are where are today due to the unique regulatory frameworks that exist in the US gas market with regard to accessing resource development opportunities and transporting natural gas to end-users.

Effects on Price Volatility?

- Gas has traditionally been more volatile than oil and coal.



- Economic theory predicts this. The more fungible (or tradable) a commodity is, the lower its price volatility, all else equal.
- We see this in microcosms historically at traded hubs after pipeline expansions in North America.
- The demand for storage? Counterintuitively, it should go up.

More on the impacts of LNG Exports: Exchange Rates and Contracts – LNG prices in Asia will fall, and when it happens, it will happen fast!

The Effect of the Exchange Rate

- Another factor that is important to the **export** issue is the exchange rate. In fact, this matters for **US industrial** sector competitiveness as well.
  - Exchange rate impacts: $P_{US} - P_{UK} \cdot XR \cdot HR = arb\ value$

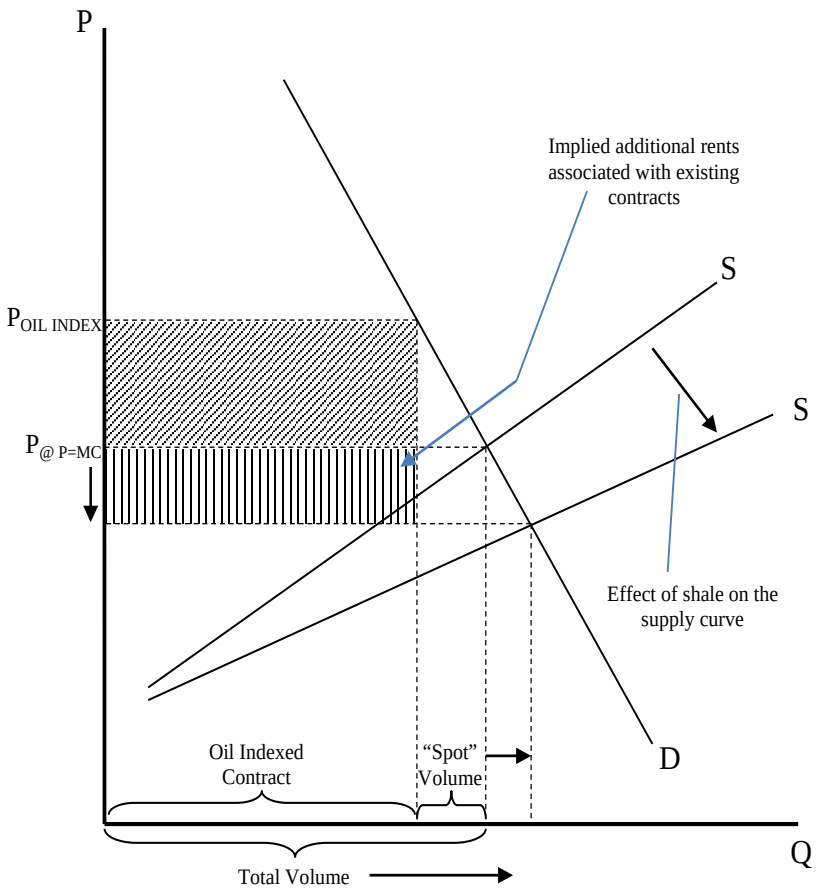
Trade-Weighted Value of US $, Major Currencies (Daily, Jan 1973 – Jan 2013)

Source: US Federal Reserve Bank

Contracts and Liquidity

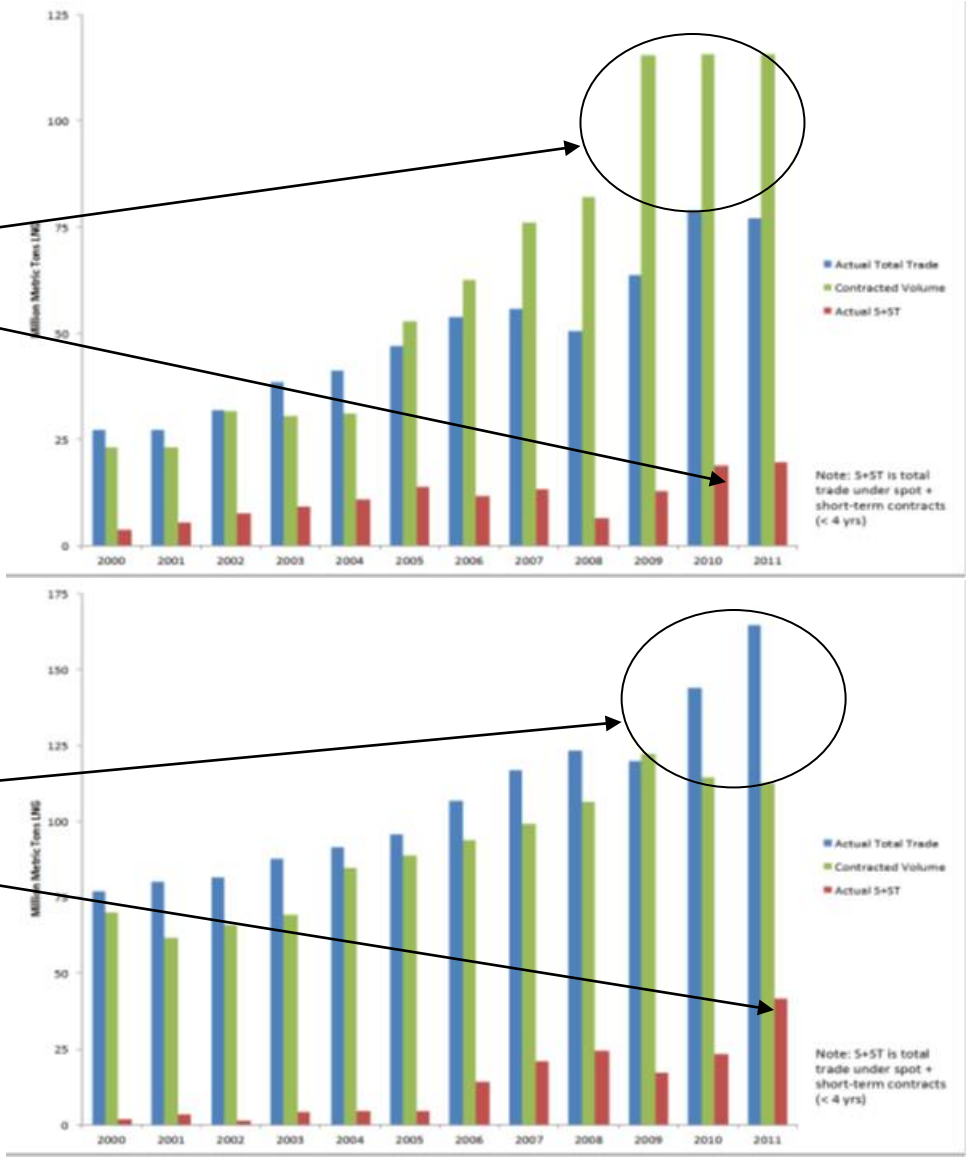
- Absent storage and physical liquidity, oil indexation provides an element of price certainty.
- Oil indexation is a form of price discrimination
  - (1) Firm must be able to distinguish consumers and prevent resale.
  - (2) Different consumers have different elasticity of demand.
- Increased ability to trade between suppliers and consumers (physical liquidity) violates condition (1).
  - This will happen in a liberalized market, or as LNG trade grows, or as hubs emerge in end-use markets.

The Supply Curve Effect of Shale and Implications for Price



Contracts and Flows

- Atlantic Basin LNG diverted…
  - short term volumes expand
- … Pacific Basin LNG expands.
  - short term volumes expand



Data Sourced from the International Group of Liquefied Natural Gas Importers (GIIGNL)

More on US LNG Exports

- Export capacity will be built on the expectation that rents from arbitrage will "pay" for the fixed cost.
  - But, some terminals will not earn the *ex-ante* required rate of return, contingent on the off-take agreement and who bears risk.
- Expect seasonal flows. If *seasonal* price differences among the regional markets are sufficient, US exports will be profitable during those periods. This serves to dampen volatility everywhere.
- **US LNG exports will link global markets to storage in the US. Thus, liquidity will spill over and contribute to very different market paradigm. This will be felt most heavily in Asia.**
- **The Asian gas market will become substantially deeper over the next decade.**

Viability of US LNG Exports

- Current arbitrage value is high, but there is risk
  - Price impact in foreign market could be significant
    - Relative elasticities matter. Price impact abroad increases as domestic supply becomes more elastic and/or foreign supply becomes less elastic.
  - Risk of foreign supply developments
    - For example, Asia can be served by pipeline supplies from Russia, Central Asia, and South Asia; LNG from Middle East, Africa, Australia, Asia-Pacific, North America; and local supplies.
  - Exchange rate risk is present
    - Recent paper by Hartley and Medlock (2012) indicates exchange rates are important in determining the crude oil-natural gas price differential when (i) there is limited capability for direct arbitrage and (ii) fuel-switching capabilities are limited. Thus, oil-indexed flows are potentially exposed.
    - Gas-indexed trades are also exposed. Foreign gas is traded in own currencies, so exchange rates effect the arbitrage opportunity.
  - Increase in supply elasticity challenges traditional pricing paradigms
- Of course, uncertainties exist on all fronts!

Viability of US LNG Exports (cont.)

- Export capacity will be built on the expectation that current rents from arbitrage will persist long enough to "pay" for the upfront fixed cost. Once the fixed cost is sunk, the operating decision no longer hinges on the payment to capital. It is possible that some terminals will not operate at full capacity and will not earn the *ex-ante* required rate of return, contingent on the off-take agreement.
- US LNG export capacity could be used for seasonal arbitrage. While the annual load factor would be lower in this circumstance, if seasonal price differences among the regional markets are sufficient, US exports would be profitable.
- LNG exports from the US will link global markets to storage opportunities in the US. The US has the most well-developed storage market in the world, which contributes to market liquidity. By providing a link for the rest of the world to US storage capacity, the liquidity benefits could spill over.

So what about the foreign opportunities for shale? Not so Fast. The US is Unique.

- Stable and conducive regulatory and institutional frameworks.
  - **Resource Access** – mineral rights ownership; acreage acquisition; resource assessments; environmental opposition; etc.
  - **Market Structure** – transportation regulation (unbundled access vs. incumbent monopolies) and bilateral take-or-pay obligations vs. marketable rights; existence of infrastructure; pricing paradigms; etc.
- Many other issues face shale development.
  - **Water** – use in production; water rights and management; flowback options (recycle and/or treatment and disposal) and native infrastructure; concerns about watershed protection (casing failures and fracture migration); etc.
  - **Other issues** – earthquakes related to injection of produced and treated water; long term effects of methane escape; concerns about contamination from produced water; ecological concerns over land use and reclamation; etc.
- **BUT, for other supplies impediments are different, and changing**
  - East Africa, Australia, Russia...

Questions/Comments