Irreversible Time Commitments for LNG Trade: Constraints on Spatial Market Integration

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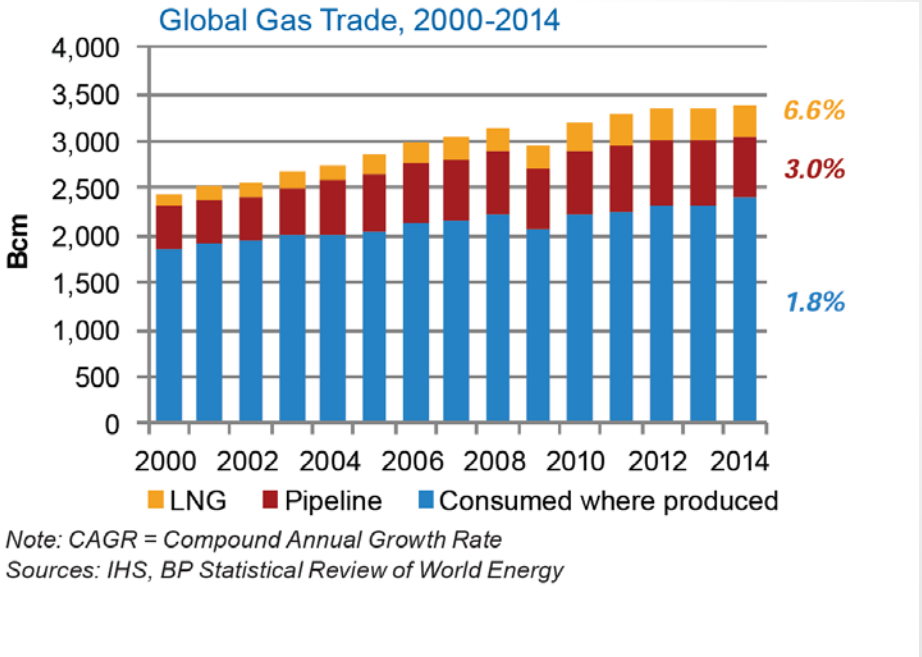
Introduction – LNG trade

- **LNG trade** – Small, but important for the value of natural gas resources
- Connects regional supplies to global markets
- A common global natural gas price possible?



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LNG trade and Market Integration

- Literature show some (but weak) evidence for LNG trade facilitating improved regional natural gas market integration (Neumann, 2012; Li et al., 2014; Dehnavi and Yegorov, 2012; Oglend et al., 2016)

- Barriers to LNG facilitated Market Integration
  - Regulatory restrictions, inflexible and slow regulatory process, domestic security concerns
  - Differences in how gas is transacted (Spot vs forward contracting based on indexed pricing).
  - Specific, lumpy and time-consuming investments in the LNG supply chain (liquefaction plants, LNG carriers, regasification plants). Gives inelastic supply of transportation services in the short run and cyclical expansion/contraction of capacity
  - Unsynchronized investments in the supply chain due to decentralized decisions
  - **Time commitments to LNG shipments due to transportation over long distances**

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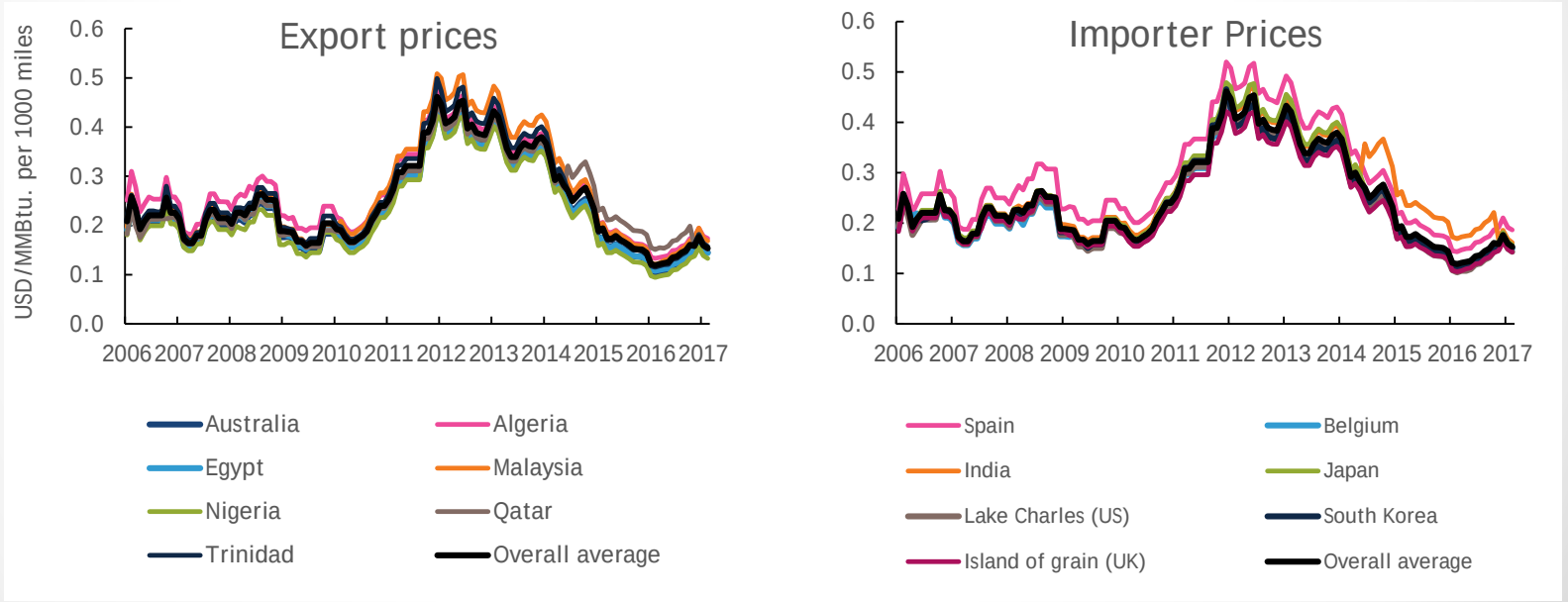
The cost of LNG trade – Freight rates

- Investment expansion cycle has been completed
- Freight markets are highly integrated across exporter and importer regions



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The cost of LNG trade – Freight rates

- The cyclicality and persistence of LNG freight rates reflects the technological demanding nature of LNG trade
  - Capacity is fixed in the short-run and so prices are sensitivey to demand changes
  - Coordinating capacity adjustments in the supply-chain is complicated
  - Investments are lumpy

- Not accounting for the endogeneity of trade costs will bias measures of LNG market efficiency and integration downwards (Dehnavi and Yegorov, 2012; Oglend et al., 2016)
  - Large regional price spreads does not translate to arbitrage opportunities

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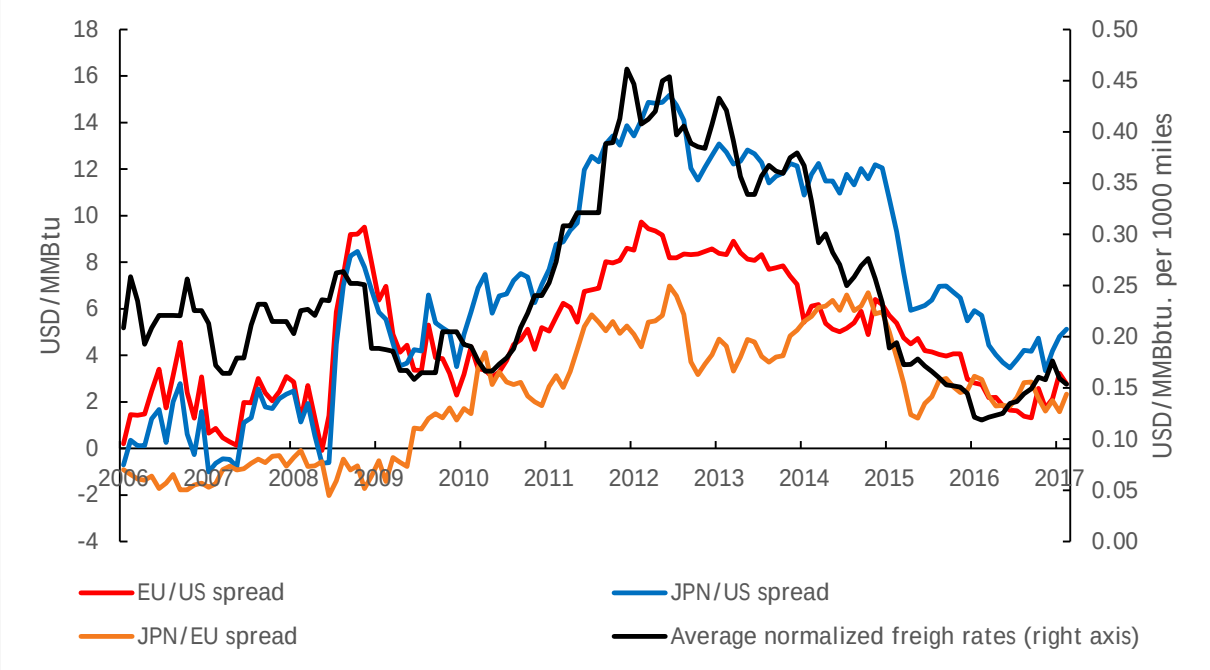
Freight rates and Regional price spreads



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Time Commitments in Trade

- LNG trade occurs over long distances
  - Main LNG exporting countries are Australia, Algeria, Egypt, Malaysia, Nigeria, Qatar and Trinidad
  - Main destination markets are Asia (Japan, South Korea), Europe (Belgium, Spain and the UK), India, and to a less degree now the US.

- **Irreversible time commitments to trade imposes an additional barrier to market integration**
  - Novel barrier to trade not analysed previously in the literature

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Time Commitments in Trade

- Irreversible time commitment generates an opportunity cost of trade that *augments* the direct accounting transportation cost

- Cost of LNG trade per MMBtu:

  $C = liq\_cost + regas\_cost + freight\_rate*distance + \omega(S)$
- S – Price spread – i.e. terms of trade condition
- $\omega(S)$ – opportunity cost due of trade commitment
- $\omega(S)$ - typically convex in S

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Measuring Market Integration, Example

Model for Price Spread Dynamics:

$$\Delta S_{t+1} = \alpha \left(S_t - \hat{C}(S_t) \right) + \varepsilon_{t+1},$$

Cost specifications:

1. $\hat{C}_1(S_t) = C$
2. $\hat{C}_2(S_t) = C + distance * freight\_rate_t,$
3. $\hat{C}_3(S_t) = C + distance * freight\_rate_t + \omega(S_t),$

- *Measure of strength of market integration:* $|\alpha|$

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Example: EU/US spread (2006-March 2017)

- Opportunity cost $\omega(S)$ is solved for numerically as part of the exporters optimal trade commitment decision
  - Assumes annual cost of capital of 15%
  - Cost of trade as in cost specification 3.
  - Assume time commitments of two months for trade decisions
  - Dynamics of spread as in above model for price spread dynamics

- This allows estimation of the degree of price convergence under all three hypothetical cost specifications
  - **Important:** *This does not identify $\omega(S)$, only a function consistent with $\omega(S)$. We therefore refer to the esimated $\omega(S)$ as the* ***implied opportunity cost of trade****.*

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Application: EU/US spread (2006-March 2017)

- Cost spec. 1: α_1 =-0.072 (S.E. = 0.030)
- Cost spec. 2, with freight cost: α_2 =-0.094 (S.E. = 0.029)
- Cost spec. 3, with freight cost and implied opportunity cost of trade: α_3 =-0.135 (S.E. = 0.045)

- Accounting for *freight cost variation* and additional *implied opportunity cost of trade* improves the measured price convergence
  - Suggests cost convexities are relevant barriers facing LNG trade in facilitating market integration

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Concluding Remarks

- LNG trade is technologically demanding
  - Remains an important barrier for LNG trade in ensuring regional market integration
  - Is partly reflected in the cyclicality and persistence of LNG freight rates
- Irreversible time commitments to trade adds an opportunity cost to the direct cost of trade
  - The asset is locked in during transit
  - Raises an additional barrier to LNG trade not previously discussed in the literature
- Cost convexities and endogeneity are empirically important to explain lack of regional price convergence

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