Market power across the Channel: Continental gas markets isolated?

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Motivation

- **<u>Post-liberalization:</u>** emergence of spatially localized spot markets interconnected throughout a network.

Are the arbitrages performed between these markets efficient?

Map 2: US natural gas spot prices at major trading hubs, 2006 ($/MBtu)

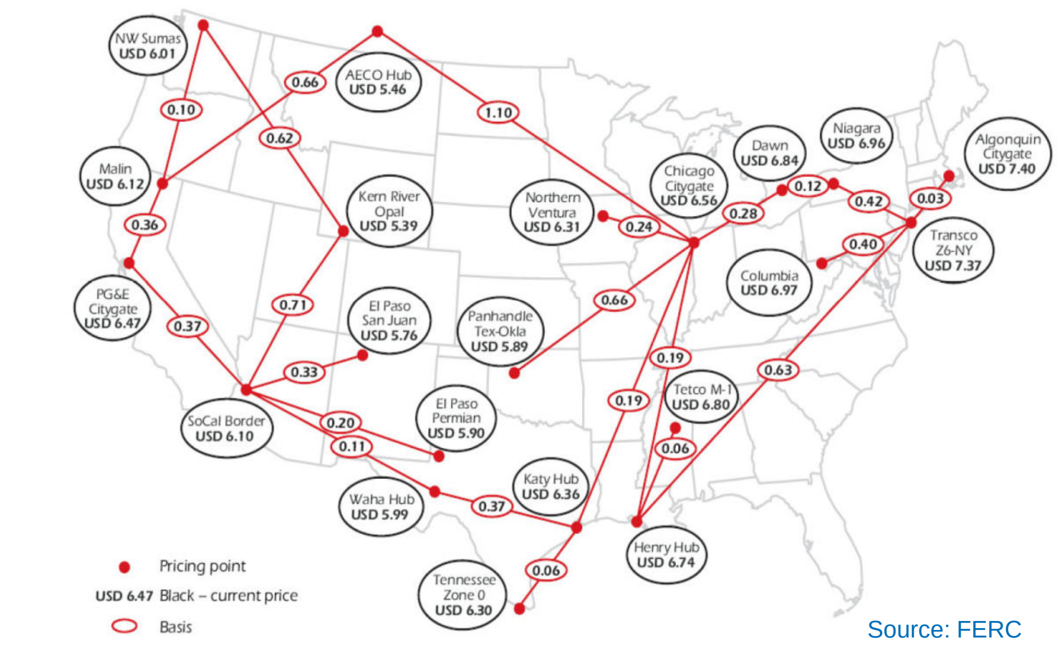
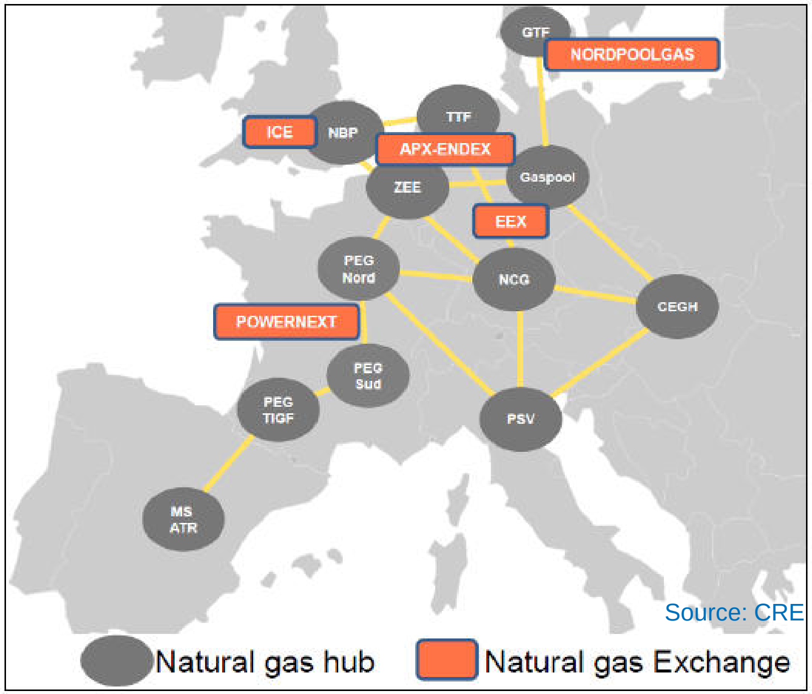


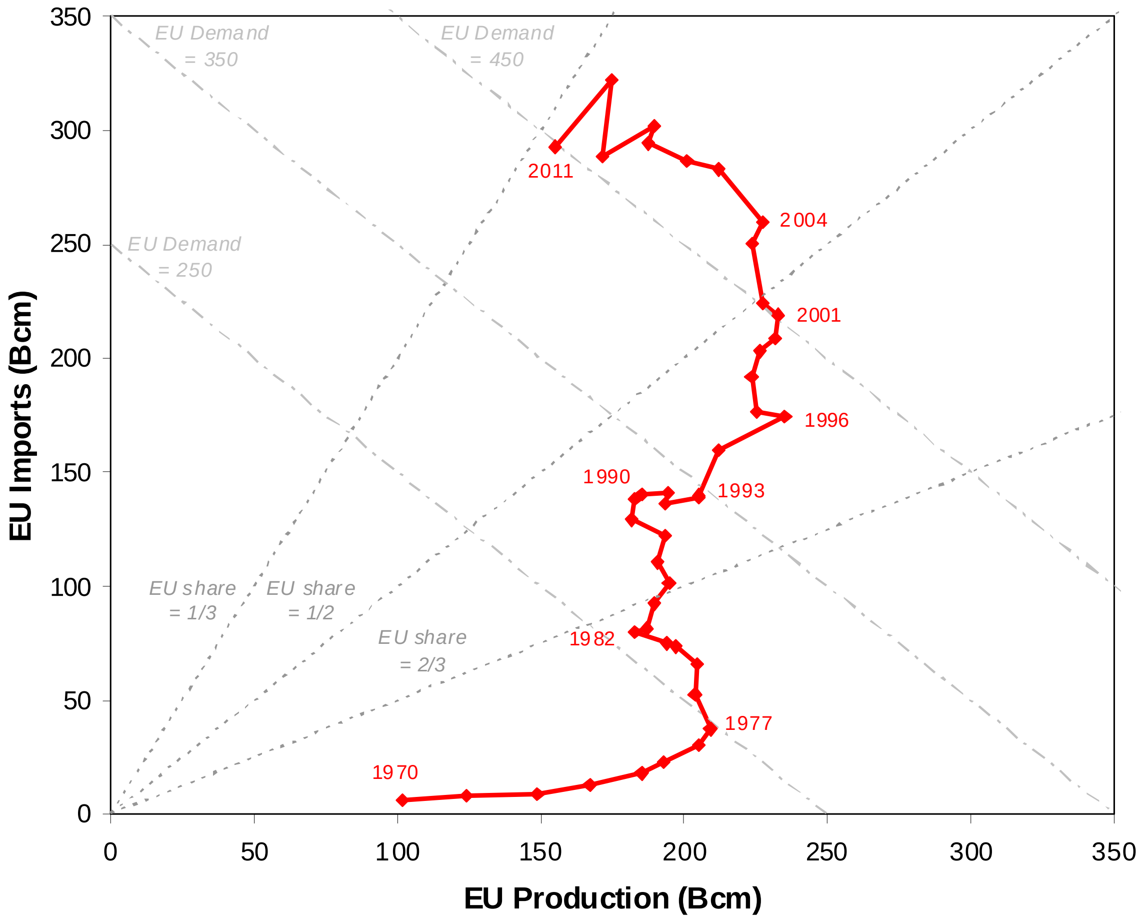
Figure 1: European gas hubs and gas exchanges



The boundaries and names shown and the designations used on maps included in this publication do not imply official

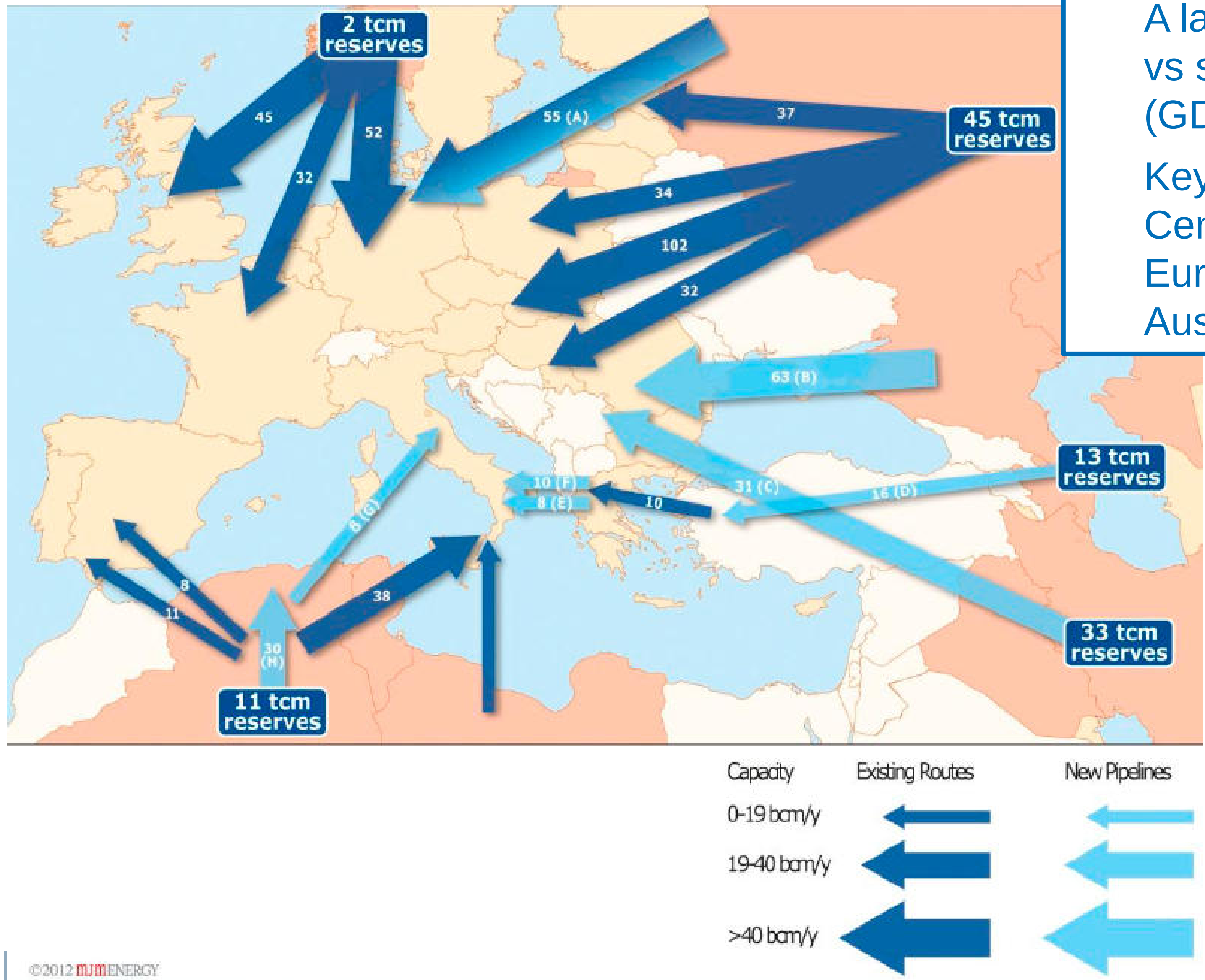
Background

■ **The resurfacing of supply security concerns in Europe**



Source: BP (2012)

Market power shifts outside the EU



- A large seller (Gazprom) vs several smaller buyers (GDF, ENI, RWE,...)
- Key (but not restricted to) Central and Eastern Europe (Bulgaria, Austria,...)

Market integration as a “solution”

- **Non-EU suppliers’ market power:**
  - **Traditionally mitigated by indexation of gas to oil prices in long-term contracts**
  - **But nowadays (since 2007-08) mostly indexed to wholesale gas prices**

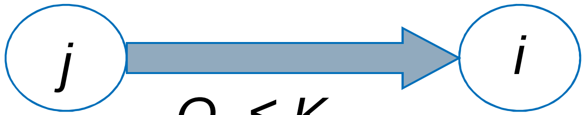
- **EU solution: “market integration” (Ofgem, 2012, EGIG 2011)**

- **To achieve market integration:**
  - **Gas interconnection capacity**
  - **Efficient spatial arbitrages**
  - **“Short-term spatial arbitrages to prevent *balkanization*” (Vazquez et al., 2012)**

- **RESEARCH QUESTION: How efficient are these spatial arbitrages?**

Our (methodological) contribution

- **Empirical methodology to assess spatial arbitrages:**
  - **Between two regional markets for wholesale natural gas**
  - **Linked by a capacity-constrained pipeline system**



$$Q_{ji} \leq K_{ji}$$

... designed to:

- **Detect if markets are "integrated,"**
  - **i.e., if all spatial arbitrage opportunities are being exploited, and**
- **Decompose price differences into factors such as transportation costs, bottlenecks, and oligopolistic behaviour of the arbitrageurs**

... incorporating:

- **Test for the presence of market power and**
- **Distinguish between physical and behavioural constraints to MC pricing**

Our application

- **Spatial arbitrages in the “Interconnector” pipeline:**
  - **Connecting UK’s NBP and Belgium’s Zeebrugge, Europe’s two oldest (and among the most competitive) spot gas markets**
  - **Most liquid exchange, with most experienced participants**
  - **Its design shaped the designs of the other Continental exchanges**

- **Preview of the findings:**
  - **All the arbitrage opportunities are being exploited**
  - **But, evidence of market power in the spatial arbitrages**

Some now usual definitions of an economic market

- **A. Cournot (1838)**
  - "Economists understand by the term of market, not any particular marketplace in which things are bought and sold, but the whole of any region in which buyers and sellers are in such free intercourse with one another that the prices of the same goods tend to equality easily and quickly ..."

- **A. Marshall (1920)**
  - "… the more nearly perfect a market is, the stronger is the tendency for the same price to be paid for the same thing at the same time in all parts of the market; but of course if the market is large, allowance must be made for the expense of delivering the goods to different purchasers; each of whom must be supposed to pay in addition to the market price a special charge on account of delivery."

Empirical studies: The traditional approach

- **Spatial integration between wholesale gas markets:**
  - **Rely on local price data**
  - **Assess the co-movements of prices at each market location**
    - *e.g. Correlation, Cointegration tests ; Granger causality tests; analyses based on the Kalman Filter approach to examine the degree of price convergence ; AR models of pairwise price differentials ; ECMs models.*
- **Law of one price (LOOP) enforced through spatial arbitrages if**
  - **High degrees of price series correlation and/or co-integration**
  - **Useful insights into how local price shocks are transmitted**
- **But of no help in assessing competitive nature of arbitrages**
  - **Fail to detect the presence of imperfect competition**
  - **Unable to account for transfer costs and trade flow considerations**
    - *A lack of theoretical connections with spatial economic models (Enke, 1951; Samuelson, 1952; Takayama and Judge, 1971)*

Our approach

- **Use agricultural economics' parity bounds model (PBM):**
  - **Arbitrageurs assumed to be profit-maximizing**
  - **Spreads examined with "switching regime" specification, estimating probability of observing each of a series of trade regimes**
- **Sexton et al. (1991), for example, considers three regimes:**
  - **(i) "arbitrage": price difference = unit transportation cost**
  - **(ii) "autarkic": local price difference < transportation cost**
  - **(iii) "barriers to trade": price difference> transportation cost**
- **Barrett and Li (2002), our point of departure,**
  - **Direction-specific approach making use of trade flow data**
  - **Distinguishes whether trade occurs in each of the three regimes**
- **Are arbitrage opportunities being exploited?**

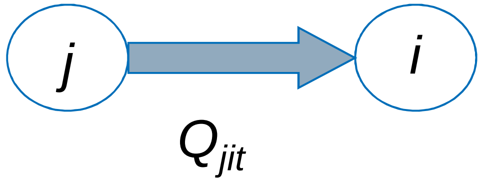
Natural gas adjustments to the PBM model

- **Account for the role of market power:**
  - **Existing models assume perfect competition**
  - **Our specification shall test for this assumption**
- **Isolate effect of pipeline capacity constraints**
  - **Role of transportation bottlenecks has so far been neglected**
  - **But binding capacity constraints likely to occur in gas**
- **Incorporate dynamic error specification:**
  - **Often posited to be serially independent with constant variance**
  - **Assumption too restricted when using daily data**

Methodology

Spatial equilibrium with a capacity-constrained infrastructure

Case A: Perfectly competitive spatial arbitrages



$$\underset{Q_{jit}}{Max} \quad \Pi^{C}_{jit}\left(Q_{jit}\right) = \left(P_{it} - P_{jt} - \tau_{jit}\right) Q_{jit}$$

$$\text{s.t.} \quad Q_{jit} \leq K_{jit}$$

$$Q_{jit} \geq 0$$

Marginal profit to spatial arbitrage

$$\text{KKT:} \quad 0 \leq Q_{jit} \perp P_{it} - P_{jt} - \tau_{jit} - \xi_{jit} \leq 0$$

$$0 \leq \xi_{jit} \perp Q_{jit} \leq K_{jit}$$

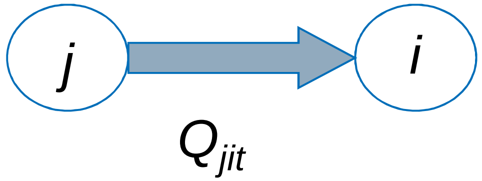
Marginal congestion cost

- **If marginal congestion cost is zero (ξ_{jit}=0):**
  Either, marginal profits to arbitrage are negative and $Q_{jit} = 0$
  Or marginal arbitrage profits are zero and $0 < Q_{jit} < K_{jit}$

- **If marginal congestion cost is positive (ξ_{jit}>0):**
  Or marginal arbitrage profits are positive and $Q_{jit} = K_{jit}$

Spatial equilibrium with a capacity-constrained infrastructure

- **Case B: Monopolistic spatial arbitrages**



$$\underset{Q_{jit}}{Max} \quad \Pi^{M}_{jit}\left(Q_{jit}\right) = \left[p_{it}\left(S_{it}\left(Q_{jit}\right) + Q_{jit}\right) - p_{jt}\left(S_{jt}\left(Q_{jit}\right) - Q_{jit}\right) - \tau_{jit} \right] Q_{jit}$$

$$\text{s.t.} \quad Q_{jit} \leq K_{jit}$$

$$Q_{jit} \geq 0$$

where : $p_{it}(q)$ is the linear inverse demand function $p_{it}(q) = a_{it} - b_i q$

the local inverse supply functions are linear $p_{it}(S_{it}) = c_{it} + d_i S_{it}$

$- \gamma Q_{jit}$

$$\text{KKT:} \quad 0 \leq Q_{jit} \perp P_{it} - P_{jt} - \tau_{jit} - \left(\frac{d_i b_i}{b_i + d_i} + \frac{d_j b_j}{b_j + d_j} \right) Q_{jit} - \xi_{jit} \leq 0$$

$$0 \leq \xi_{jit} \perp Q_{jit} \leq K_{jit}$$

Marginal arbitrage profits are positive if $Q_{jit} > 0$ (even if $\xi_{jit} > 0$)

Empirical specification (1/3): An extension to Barrett & Li (2002)

A taxonomy of 7 regimes:

		Trade $0 < Q_{jit} \leq K_{jit}$	**No trade** $Q_{jit} = 0$
Observable marginal profits to spatial arbitrages	**= 0**	**Regime I**	**Regime II**
	> 0	**Regime III_a** iff $Q_{jit} < K_{jit}$ **Regime III_b** iff $Q_{jit} = K_{jit}$	**Regime IV**
	< 0	**Regime V**	**Regime VI**

The ambition is to estimate λ_r the probabilities to observe these regimes

Empirical specification (2/3)
A Parity Bounds Model

Assumptions and notations:

- **the marginal arbitrage cost is** $\tau_{jit} \equiv T_{jit} + \alpha_{ji} + Z_{jit}\beta_{ji} + \varepsilon_{jit}$

- **the observable portion of the marginal rent to arbitrage is:** $R_{jit} \equiv P_{it} - P_{jt} - T_{jit}$

Modeling the marginal profits to arbitrage

- **Regimes I & II** $R_{jit} - \left(\alpha_{ji} + Z_{jit}\beta_{ji}\right) - Q_{jit}\gamma = \varepsilon_{jit}$

- **Regimes III, III' & IV** $R_{jit} - \left(\alpha_{ji} + Z_{jit}\beta_{ji}\right) - Q_{jit}\gamma = \varepsilon_{jit} + \mu_{jit}$

- **Regimes V & VI** $R_{jit} - \left(\alpha_{ji} + Z_{jit}\beta_{ji}\right) - Q_{jit}\gamma = \varepsilon_{jit} - \upsilon_{jit}$

where

$$\varepsilon_{jit} \sim N\left(0, \sigma_\varepsilon^2\right) \qquad \mu_{jit} \sim N^+\left(0, \sigma_\mu^2\right) \qquad \upsilon_{jit} \sim N^+\left(0, \sigma_\upsilon^2\right)$$

Empirical specification (3/3):

- **The joint density function for the observation at time *t* is the mixture distribution:**

$$f_{jit}\left(\pi_{jit}\middle|(\lambda,\theta)\right) \equiv A_{jit}\left[\lambda_I f_{jit}^{I}\left(\pi_{jit}\middle|\theta\right)+\left(\left(1-B_{jit}\right)\lambda_{IIIa}+B_{jit}\lambda_{IIIb}\right)f_{jit}^{III}\left(\pi_{jit}\middle|\theta\right)+\lambda_V f_{jit}^{V}\left(\pi_{jit}\middle|\theta\right)\right]$$

$$+\left(1-A_{jit}\right)\left[\lambda_{II} f_{jit}^{II}\left(\pi_{jit}\middle|\theta\right)+\lambda_{IV} f_{jit}^{IV}\left(\pi_{jit}\middle|\theta\right)+\lambda_{VI} f_{jit}^{VI}\left(\pi_{jit}\middle|\theta\right)\right]$$

- **Estimation:**

Max (λ,θ) $\quad \sum_{t=1}^{N}\log\left(f_{jit}\left(\pi_{jit}\middle|(\lambda,\theta)\right)\right)$

s.t. $\quad \sum_r \lambda_r = 1$

$$\lambda_r \in [0,1], \quad \forall r$$

This is a nonconvex NLP

Empirical specification

Correcting for serial correlation (Kleit, 2001)

- **Regimes I & II:**

$$R_{jit} - \left(\alpha_{ji} + Z_{jit}\beta_{ji}\right) + Q_{jit}\gamma - \rho_{ji}\mathrm{E}\left(\varepsilon_{ji(t-1)} \middle| \eta_{ji(t-1)}\right) = \varepsilon_{jit}$$

- **Regimes III, III' & IV**

$$R_{jit} - \left(\alpha_{ji} + Z_{jit}\beta_{ji}\right) + Q_{jit}\gamma - \rho_{ji}\mathrm{E}\left(\varepsilon_{ji(t-1)} \middle| \eta_{ji(t-1)}\right) = \varepsilon_{jit} + \mu_{jit}$$

- **Regimes V & VI**

$$R_{jit} - \left(\alpha_{ji} + Z_{jit}\beta_{ji}\right) + Q_{jit}\gamma - \rho_{ji}\mathrm{E}\left(\varepsilon_{ji(t-1)} \middle| \eta_{ji(t-1)}\right) = \varepsilon_{jit} - \upsilon_{jit}$$

where $\mathrm{E}\left(\varepsilon_{ji(t-1)} \middle| \eta_{ji(t-1)}\right)$ **is computed using:**

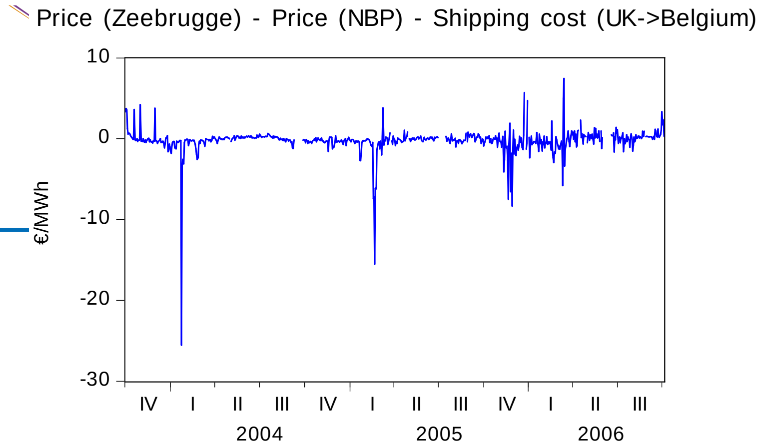
$$\mathrm{P}_{t-1}\left(r \middle| \eta_{ji(t-1)}, \theta_1\right) == \frac{\lambda_r f_r\left(\eta_{ji(t-1)} \middle| \theta_1\right)}{\sum_{k=I}^{VI} \lambda_k f_k\left(\eta_{ji(t-1)} \middle| \theta_1\right)}$$

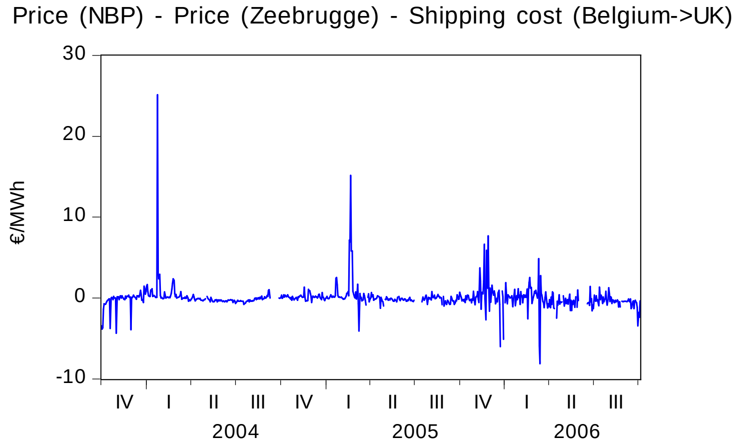
where λ_r is the probability to observe regime *r*

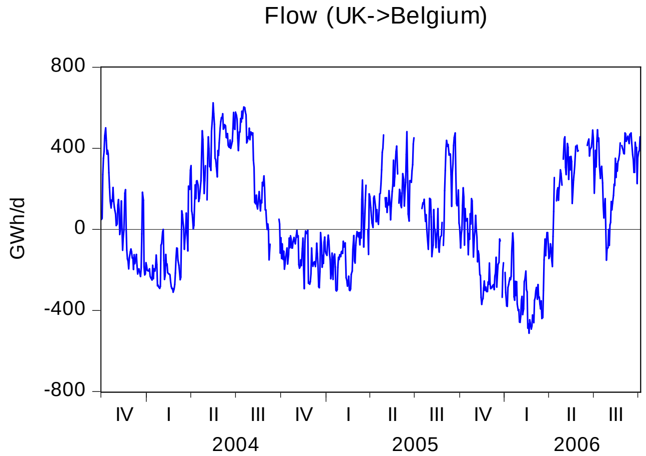
An application:
the case of the IUK pipeline

The case study

- **Period: Oct. 1, 2003, to Oct. 5, 2006.**
- **Data sources:**
  - prices: Platt's day-ahead natural gas prices (€/MWh).
  - flows and transportation costs: IUK







Estimation results (1/2)
On market integration...

	From UK to Belgium	From Belgium to UK
Probabilities (in %)		
λ_{I}	48.56***	41.60***
λ_{II}	41.16***	50.50***
λ_{III_a}	2.45***	1.69***
λ_{III_b}	0.00	0.92**
λ_{IV}	2.88***	0.49
λ_{V}	0.00	3.05***
λ_{VI}	4.96***	1.76
Probability of spatial market equilibrium conditions (in %) $\left(\lambda_{I}+\lambda_{II}+\lambda_{III_a}+\lambda_{VI}\right)$	94.68	94.77

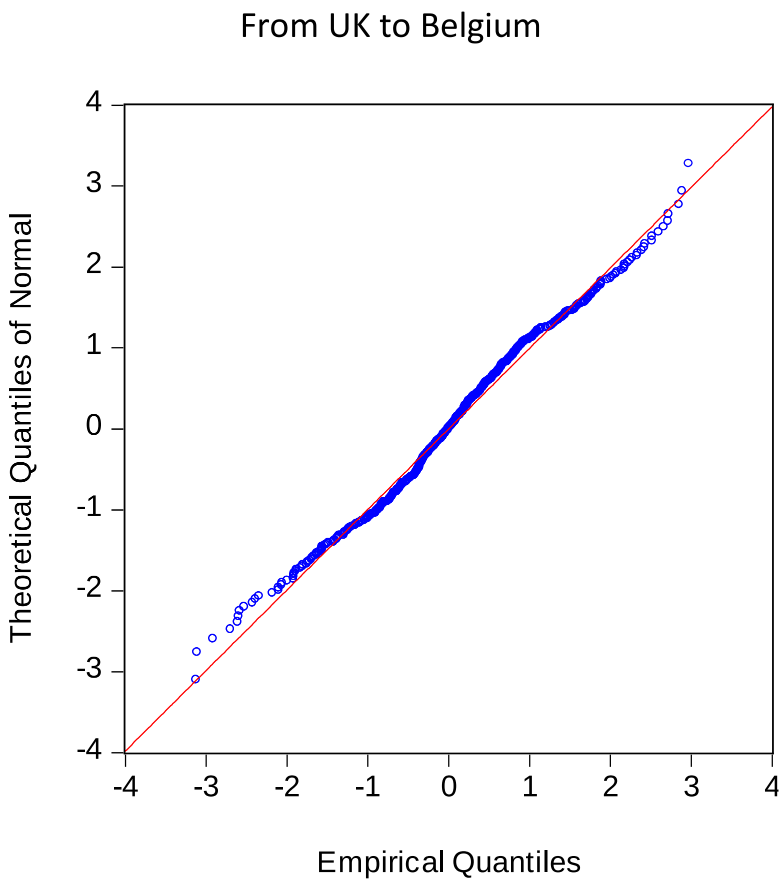
Estimation results (2/2)
Testing for perfect competition

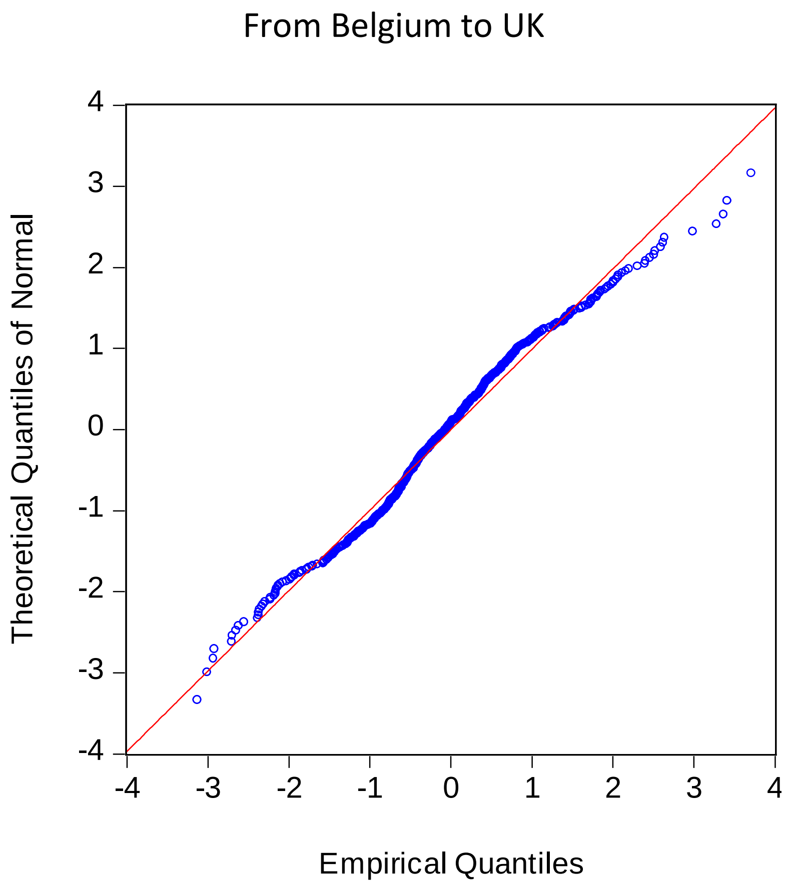
	From UK to Belgium	From Belgium to UK
Mean parameters		
α	-0.3164***	-0.0990***
β_{time}	0.2019	-0.7017***
$\beta_{D_{2000-2005}}$	-0.0401	0.2442***
$\beta_{D_{2005-2006}}$	-0.2391**	0.5304***
γ	0.0012***	0.0026***
ρ	0.3396***	0.4860***
Log likelihood	-982.6623	-991.7400
LR tests		
H_0: $\gamma = 0$	128.868 *(0.000)*	115.345 *(0.000)*
Observations	723	723

Model validation

- **For each observation, identify the regime with the highest probability.**
- **Then, select the observations explained by regimes I & II**

Figure 1. Q-Q plots of the standardized residual series (sample: $\hat{d}^{I}_{jit} + \hat{d}^{II}_{jit} = 1$)





Conclusion

- **This paper provides**
  - **an extension of the standard Parity Bound Model**
    - **to model the role of capacity constraints**
    - **a dynamic specification to account for serial correlation and a time-varying variance.**
  - **a novel test for the presence of perfect competition in spatial arbitrages.**
  - **An application to the IUK pipeline**
- **Our findings**
  - **document the efficiency of the spatial arbitrages observed between Belgium and the UK.**
    - **Spatial equilibrium conditions hold with a high probability**
  - **document the presence of market power**
    - **The usual assumption of competitive spatial arbitrages needs to be revised**

Thank you for your attention!

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