The Development of Gas Hubs in Europe

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The paper in a nutshell

• **Fact:** during the liberalization process several wholesale gas markets have developed in Europe, at different times and with different results.

• **Research questions:**
  - What determines the emergence of gas hubs?
  - Is there a detectable pattern of development that helps interpreting the different situations as part of a common process?

• **What this paper offers:**
  1. **Simple model** to frame the balancing issue in a liberalized market.
  2. Some **predictions** to analyse the different development of each hub.
  3. Comparison of the main predictions with the evolution of the gas hubs in the **UK, the Netherlands, Germany and Italy**.
Balancing in a liberalized market

- Upstream (shippers) and downstream (suppliers, retailers) activities run by contracts.
- The amount of gas to be delivered and injected into the gas system is set according to expectations on the demand of the buyers.
- Actual supply and demand, however, are hit by shocks that may make the contracted (injected) and actual (withdrawn) quantities different, creating physical and commercial imbalances.
Balancing in a liberalized market

• Individual shippers may compensate some shocks within their portfolios of contracts and (part of) their net imbalance by trading with other shippers with opposite positions.

• The residual individual imbalances not cleared this way add up to the aggregate imbalance of the system, that requires to adjust the net gas injections through physical flexibility tools (line pack, storage, production swing, interruptible demand) to preserve pressure and system integrity.

• The more fragmented the market, the smaller the size of portfolios, the larger the need to trade with other shippers to clear the individual positions.
A simple model

- Suppose that in the market there are $n$ customers with inelastic demand for $p \leq v$, where $\epsilon \sim \{ -\epsilon/n, \epsilon/n \}$ are i.i.d. shocks.

- Each supply contact by a shipper is set to deliver $d$ at a price $p \geq w$, hence ex-post excess demand or supply may occur.

- Each of the shippers $m \leq n$ manages a portfolio of contracts involving $n/m$ different customers.

- Some of the shocks (of opposite sign) may be adjusted within each portfolio, while others require to clear the portfolio imbalances through transactions with other operators.

- If eventually there is an aggregate imbalance, this can be adjusted only by dealing with upstream (production, storage) or downstream (interruptible demand) operators.
A simple model

<table>
<thead>
<tr>
<th>States of the world</th>
<th>1 operator</th>
<th>2 operators</th>
<th>4 operators</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) (-ε/4, -ε/4, -ε/4, -ε/4)</td>
<td>0</td>
<td>-ε</td>
<td>0, 0</td>
</tr>
<tr>
<td>(-ε/4, -ε/4, -ε/4, ε/4)</td>
<td>ε/2</td>
<td>-ε/2</td>
<td>0, ε/2</td>
</tr>
<tr>
<td>(-ε/4, ε/4, -ε/4, ε/4)</td>
<td>ε/2</td>
<td>-ε/2</td>
<td>0, ε/2</td>
</tr>
<tr>
<td>ii) (-ε/4, -ε/4, -ε/4, ε/4)</td>
<td>ε/2</td>
<td>0</td>
<td>0, -ε/2</td>
</tr>
<tr>
<td>(ε/4, -ε/4, -ε/4, -ε/4)</td>
<td>ε/2</td>
<td>0</td>
<td>-ε/2</td>
</tr>
<tr>
<td>iii) (-ε/4, ε/4, ε/4, -ε/4)</td>
<td>ε</td>
<td>0</td>
<td>0, ε/2</td>
</tr>
<tr>
<td>(ε/4, -ε/4, -ε/4, -ε/4)</td>
<td>ε/2</td>
<td>0</td>
<td>ε/2, -ε/2</td>
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<tr>
<td>(ε/4, -ε/4, ε/4, -ε/4)</td>
<td>ε/2</td>
<td>0</td>
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<tr>
<td>(ε/4, -ε/4, -ε/4, ε/4)</td>
<td>ε/2</td>
<td>0</td>
<td>ε/2, -ε/2</td>
</tr>
<tr>
<td>iv) (ε/4, -ε/4, ε/4, ε/4)</td>
<td>ε/2</td>
<td>ε/2</td>
<td>ε/2, 0</td>
</tr>
<tr>
<td>(ε/4, -ε/4, ε/4, ε/4)</td>
<td>ε/2</td>
<td>ε/2</td>
<td>ε/2, 0</td>
</tr>
<tr>
<td>v) (ε/4, ε/4, ε/4, ε/4)</td>
<td>0</td>
<td>-ε</td>
<td>0</td>
</tr>
</tbody>
</table>

I.A. Internal adjustment of shocks within each portfolio
N.I. Net imbalance of each portfolio after internal adjustments
A simple model

<table>
<thead>
<tr>
<th>Market structure</th>
<th>Wholesale trade</th>
<th>Within portfolio Adjustment</th>
<th>Aggregate Imbalance</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Monopoly: A(1,2,3,4)</td>
<td>0</td>
<td>5ε/16</td>
<td>6ε/16</td>
</tr>
<tr>
<td>b) symmetric duopoly A(1,2), B(3,4)</td>
<td>ε/16</td>
<td>4ε/16</td>
<td>6ε/16</td>
</tr>
<tr>
<td>c) asymmetric duopoly A(1,2,3), B(4)</td>
<td>2ε/16</td>
<td>3ε/16</td>
<td>6ε/16</td>
</tr>
<tr>
<td>d) asymmetric oligopoly A(1,2), B(3), C(4)</td>
<td>3ε/16</td>
<td>2ε/16</td>
<td>6ε/16</td>
</tr>
<tr>
<td>e) symmetric oligopoly A(1), B(2), C(3), D(4)</td>
<td>5ε/16</td>
<td>0</td>
<td>6ε/16</td>
</tr>
</tbody>
</table>

**Proposition 1:** When gas customers’ demand is hit by random shocks while supply contracts are set according to the expected demand, individual shippers may face ex-post individual imbalances, while the system as a whole may be unbalanced as well. These latter imbalances can be cleared only dealing with agents, and using tools, outside the network of pipelines (e.g. imports, storage). Shocks hitting individual customers’ demand can be cleared through compensations within each operator’s portfolio of contracts and through wholesale trade between shippers with opposite net positions. This latter tool involves larger volumes of trade the larger the number of shippers and the larger the number of shippers with small portfolios.
A simple model

**Proposition 2:** When the market structure of the shippers is not excessively asymmetric, the price that is set on the wholesale market is an unbiased signal of the state of the aggregate market for gas. When one shipper dominates the market, managing a large portfolio of contracts, it can manipulate the market price pushing it up when in a long position and down when being in a short position. In these cases, the wholesale price does not reflect the market fundamentals.
Predictions/Educated guesses

1. The first phase in the development of a wholesale gas market entails balancing as the primary objective of traders, while a more mature phase entails gas provision as a second sourcing in the wholesale market. Being linked to the physical delivery of gas, these phases tend to develop in each national gas system.

2. An entry-exit model, a market based balancing regimes and rules for fundamental transparency have proved to be a favorable market design for the development of a wholesale market for balancing needs.

3. The wider the virtual trading area within a national gas system, the more rapid and effective the development of wholesale gas markets.

4. Market liquidity increases more rapidly in countries endowed with significant local gas production.

5. Transactions of financial instruments to hedge gas price risk, the third phase of the development, concentrate in a small number of market venues.
# Predictions >> Indicators

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Indicators</th>
<th>Formulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>Self-sufficiency index</td>
<td>$\text{SSI} = \frac{\text{Production}}{\text{Total Consumption}}$</td>
</tr>
<tr>
<td>Balancing rules</td>
<td>Years since market-based balancing. Integrated market area within countries. No barriers to entry for operators (e.g. quality conversion) Transparency rules</td>
<td>Qualitative assessment.</td>
</tr>
<tr>
<td>Market integration</td>
<td>Price convergence.</td>
<td>Difference between price of country $i$ and price at reference hub.</td>
</tr>
</tbody>
</table>
| Liquidity             | Volumes of gas traded, Churn ratios, bid-ask spread                       | $\text{Gross Churn Ratio} = \frac{\text{traded gas}}{\text{internal consumption}}$  
|                       |                                                                           | $\text{Net Churn Ratio} = \frac{\text{traded gas}}{\text{physical deliveries}}$       |
Indicators: production

Self-sufficiency index
• All countries have adopted and entry-exit model and the rules for fundamental transparency (still, very different accounting criteria, non comparable data, changes in accounting rules)

• Balancing rules display some difference from country to country
  - UK and TTF: market-based
  - Germany: two balancing zones (previously 19!)
  - Italy: first attempt to promote a wholesale market for trading (unsuccessful), then a balancing platform introduced.
Indicators: traded volumes
Indicators: traded volumes

Reduction of market areas from 12 to 3
Indicators: traded volumes
Indicators: price convergence (1)

Auctions on European pipelines (e.g. TAG)
Indicators: liquidity
Indicators: liquidity

Relative Bid-Ask Quote - PSV

Relative Bid-Ask Quote - NCG

Relative Bid-Ask Quote - TTF

Relative Bid-Ask Quote - NBP
Indicators: liquidity

Number of active parties at TTF
Indicators: liquidity
Indicators: financial market
Conclusions

- Wholesale gas trading consequence of market liberalization.

- Natural endowment/importance of upstream long term contracts matter.

- Appropriate rules may help enhancing market liquidity:
  - Adoption of an entry/exit system;
  - Transparency;
  - Adoption of a market-based balancing system → e.g. UK, Netherlands;
  - Reduction of market areas → e.g. Germany;
  - Start with balancing platform → counterfactual: Italy;

- Wholesale gas trade in each national gas system, financial transaction in a single market venue: U.K.
Thank you.
Back-up slides
Data

- Data collected from a number of sources.
- Data on volumes:
  - Where available, data published by TSOs or hubs operators.
- Data on prices:
  - Bloomberg database;
  - ICE Endex;
  - EEX.
- Data on consumption, production, import, export:
  - IEA, Eurostat.
Indicators: liquidity
Indicators: liquidity

Relative Bid-Ask Quote - PSV
Indicators: liquidity

Relative Bid-Ask Quote - TTF

Relative Bid-Ask Quote - NBP
Indicators: liquidity

Relative Bid-Ask Quote - NCG
Regulation: UK

- First EU country to liberalize gas market.
- ‘90s: creation of Flexibility mechanism for balancing, heavily relying on the physical flexibility tools available.
- 1999: New Gas Trading Arrangements (NGTA): more reliance on market-based tools for balancing, in order to improve price signals and to reduce the cost of balancing.
- Operators have incentives to clear their positions, with the TSO (National Grid) balancing only residually the system at a price related to the System Average Price (SAP).
- The price set on the OCM is used as a reference for the SAP; subsequently, the System Marginal Buy Price (SMBP) and the System Marginal Sell Price (SMSP) are computed.
- The main market instrument to acquire the resources for balancing is the On-the-day Commodity Market (OCM).
Regulation: the Netherlands

- 2004: GTS (Gas Transport Services) introduced an entry-exit capacity system and the virtual trading point TTF.

- 2005: ownership unbundling of Gasunie into GasTerra, as trading company, and Gasunie as transportation company.


- 2011: Nieuw marktmodel introduced. TTF becomes the central trading point for all natural gas in the Dutch transmission system.
Regulation: Germany

• 2002: creation of the Bunde-Oude hub on the Dutch/German border.

• 2005: Energiewirtschaftsgesetz (EWG), entry-exit system; 19 entry-exit zones, called “Marktgebiete”.

• 2008: reduction of the zones to 12.

• 2010: Gas Network Access Ordinance (GasNZV) required TSOs to reduce the market areas for L-gas to one and for H-gas to two by 2011.

• 2013: Further steps into balancing market reform.
2006: creation of the PSV hub.

2010: creation of the P-GAS, in order to exchange quotas of imported gas.

2011: creation of the PB-GAS for balancing purposes (similar to old UK flexibility mechanism).

2014: enlargement of the flexibility tools allowed for balancing.