Natural Gas Storage:
Competitive Storage vs. Strategic Behavior

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DRAFT! PLEASE DO NOT CITE, COMMENTS WELCOME!

Enerday
April 13, 2007
Agenda

1. The Issue

2. (Natural Gas) Storage – Theory and Literature

3. Case Study: Competitive vs. Strategic Behavior

4. Conclusion
Continental Europe: Heterogeneous Regulation and Little Transparency in Natural Gas Storage Markets

- Article 19 of 2003/55/EC: Third party access (TPA) to facilitate downstream competition

→ 3 countries regulate (BG, IT, E), others mainly negotiated TPA

- Article 22: exemption under the condition that “the investment must enhance competition in gas supply and enhance security of supply”


→ Lack of compliance to guidelines

→ Poor transparency on capacity excluded from TPA

→ Limited development of secondary markets

⇒ In a liberalizing gas market, storage is an essential element to provide flexibility and promote competition
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Types of Natural Gas Storage
(seasonal storage vs. peak storage)

A – Salt Caverns    B – Aquifers    C – Depleted Reservoirs
## Natural Gas Storage

<table>
<thead>
<tr>
<th>Fee</th>
<th>Salt Cavern</th>
<th>Depleted Gas Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed Fees (based on MMBtu of capacity reserved):</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Demand Charge, $ MMBtu</td>
<td>1,00</td>
<td>0,40</td>
</tr>
<tr>
<td><strong>Variable Costs (based on volume of throughput):</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Injection Fee, $/MMBtu</td>
<td>0,02</td>
<td>0,02</td>
</tr>
<tr>
<td>Withdrawal Fee, $/MMBtu</td>
<td>0,02</td>
<td>0,02</td>
</tr>
<tr>
<td>Fuel Expense, %</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Injection Days To Fill</td>
<td>20</td>
<td>180</td>
</tr>
<tr>
<td>Withdrawal Days To Deplete</td>
<td>10</td>
<td>120</td>
</tr>
<tr>
<td>Typical Number of Cycles Per Year</td>
<td>4 to 5</td>
<td>1 to 1.5</td>
</tr>
</tbody>
</table>

→ **Salt Caverns exhibit more flexibility albeit at higher costs**

Source: Simmons (2005, 8)
Convenience Yield and Theory of Storage

- Difference of spot and forward prices of a commodity at a level given by storage and interest costs
- Formal derivation of optimal storage levels and the resulting impact on prices and quantities
- Variations in spot prices directly related to benefit of holding inventory and inversely related to the correlation between spot and forward prices
- “Store until the expected gain on the last unit put into store just matches the current loss from buying – or not selling it – now” (Williams and Wright, 1991, p.25)
- Arbitraging potential in functioning markets
- Production and storage performed by competitive profit-maximizers is favorable for consumers
- Natural gas storage is limited by technical factors influencing operability of facilities induced by geological characteristics, and strong seasonality
Empirical Evidence in Natural Gas Markets

Uria and Williams (2005)
→ Injection in Californian facilities increases slightly with a strengthening intertemporal spread on NYMEX

Serletis and Shahmoradi (2006)
→ High inventory: large inventory responses to shocks imply roughly equal changes in spot and futures prices;
→ Low inventory: smaller inventory responses to shocks imply larger changes in spot prices than in futures prices

Chaton, Creti, and Villeneuve (2006)
→ Modeling the impact of policies on prices and quantities consumed or stored (including demand and supply shocks), taking into account seasonality of natural gas markets
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## Depleted Gas Field – Storage in Europe

<table>
<thead>
<tr>
<th></th>
<th>Dötlingen</th>
<th>Rough</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Owner</strong></td>
<td>BEB</td>
<td>Centrica</td>
</tr>
<tr>
<td><strong>Max. working capacity in GWh</strong></td>
<td>8.847 (17.899)</td>
<td>17.735 (29.638)</td>
</tr>
<tr>
<td><strong>Max. injection rate in GWh/day</strong></td>
<td>109 (217)</td>
<td>678 (445)</td>
</tr>
<tr>
<td><strong>Max withdrawal in GWh/day</strong></td>
<td>135 (855)</td>
<td>496 (445)</td>
</tr>
<tr>
<td><strong>Available data</strong></td>
<td>Daily aggregated injections and withdrawals</td>
<td>Daily closing stock levels</td>
</tr>
</tbody>
</table>

Note: Numbers in brackets provide technical maxima
The Model

Determine optimal storage strategy \( X_t \) with \( t = (1, \ldots, T) \) (injection if \( X_t < 0 \) and withdrawal if \( X_t > 0 \) )

\[
\max_x (\Pi) = \max_x \left( \sum_{t=1}^{T} (X_t P_t) \right)
\]

s.t. \( WR_{\text{max}} \leq X_t \leq IR_{\text{max}}, \forall t \)

\( 0 \leq \sum_{t=0}^{k} X_t \leq \text{CAP}, \forall k \)

\( X_0 = S_0 \quad \sum_{t=0}^{T} X_t = S_T \)

\( WR_{\text{max}} \): maximum withdrawal rate

\( IR_{\text{max}} \): maximum injection rate

\( \text{CAP} \): maximum storage capacity

\( S_0 \): initial storage level

\( S_T \): final observed storage level
Results (1): With observed restrictions

Rough (UK)

Dötlingen (GER)

Real Profit: 157,680
Max Profit: 272,759

Real Profit: 592,686
Max Profit: 1,519,544

Real Profit: 786,259
Estimated Profit: 1,155,198
Results (2): With given technical restrictions

Rough (UK)

Dötlingen (GER)

Real Profit: 592,686
Estimated Profit: 1,360,104

Real Profit: 157,680
Estimated Profit: 347,008
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Conclusions

- Natural gas storage in Europe in need for harmonization and transparency

- Arbitraging potential should favor the emergence of commercial storage operators

- Storage facilities are used differently in European countries

- Observed storage usage for Rough (UK) and Dötlingen (GER) largely deviates from ex-post optimal strategy

- Storage activities are not purely carried out on a merchant basis
Selected References


