Pipeline Power

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Motivation

The EU’s gas dependency (as to 2008):

- on Russia: 40% of imports, 25% of consumption,
- on transit countries, Ukraine and Belarus 75% and 25% of imports from Russian, respectively.

New pipeline links *Nord Stream & South Stream*:

- diversify transit routes for Russian gas, but
- increase dependency on Russia and may
- reduce viability of investments in alternative sources (*Nabucco*)
The Pipeline Network
The Puzzle: Three huge projects but neither adequate supply nor demand

Nord Stream: 58 bcm/a, South Stream: 60 bcm/a, Nabucco: 30 bcm/a

In 2008 Europe’s

- consumption: 489.7 bcm
- production: 184.2 bcm
- net imports: 305.5 bcm \((BP\ (2009),\ Statistical\ Review\ of\ World\ Energy)\)

Nord Stream and South Stream will increase transport capacity for Russian gas from app. 186 bcm/a to 304 bcm/a (63%).

All three pipelines together will increase the European pipeline import capacity by 150 bcm/a (47%).
The Strategic Role of Pipelines

The pipelines have a potential to change the balance of power in the network.

Using a quantitative model, solved with the Shapley Value we show:

**Nord Stream:** weakens transit countries. The gains in bargaining power for Russia and Germany clearly justify the cost of investment.

**South Stream:** with Nord Stream already in place, the additional leverage is small.

**Nabucco:** weakens Russia and strengthens Turkey. The gains for the EU are negligible.
Literature

Non-cooperative approach


- computational advantages, but
- counterfactual assumptions from standard Cournot and Bertrand set up instead of price-quantity contracts,
- ad hoc assumptions on the nature of strategic interaction at the various stages (production, transmission, distribution), the sequencing of actions and the ability to commit.
Cooperative approach

Hubert & Ikonnikova (2011a)
- efficient use of the existing network,
- derive power structure endogenously from the actor’s role in gas production, transport and consumption,
- narrow regional scope.

Hubert & Orlova (2012)
Mergers and the liberalizations of access rights within the EU.
The Network

Set of nodes $R$:

- $R_P$: Production
- $R_T$: Transit connections
- $R_C$: Customer

A link $l = \{i, j\}$, $i \neq j \in R$ connects two nodes and has a capacity limit $k_{ij}$ and specific transportation costs $T_{ij}(x)$.

$x_{ij}$ denotes gas flows from $i$ to $j$. 
Value Function

The value (or characteristic) function $v : 2^{|N|} \rightarrow R_+$ gives the maximal payoff, which a subset of players $S \subseteq N$ can achieve.

The value function captures the essential economics features, such as the geography of the network, different cost of alternative pipelines, demand for gas in the different regions, production cost, ownership and access rights, etc.

For any coalition $S \subseteq N$ we have to determine to which pipeline links $L(S)$ the coalition $S$ has access to.
Value Function

\( p_j \): inverse demand at node \( j \), \( T_{ij} \) transport cost / production cost.

\[
v(S) = \max_{\{x_{ij} \mid \{i, j\} \in L(S)\}} \left\{ \sum_{\{i, j\} \in L(S), j \in R_C} \int_0^{x_{ij}} p_j(z)dz - \sum_{\{i, j\} \in L(S)} T_{ij}(x_{ij}) \right\}
\]

subject to

the node-balancing constraints \( \sum_i x_{it} = \sum_j x_{tj}, \ \forall \ t \in R_T \)

the capacity constraints of the network \( |x_{ij}| \leq k_{ij}, \ \forall \ \{i, j\} \)

and non-negativity constraints \( x_{ij} \geq 0, \ \forall \ i \in R_P \ or \ j \in R_C \).
Bargaining Power: Shapley Value

The Shapley Value assigns a share of the surplus from cooperation to each player.

\( \phi_i, i \in N, \) which is player \( i \)'s weighted contribution to possible coalitions:

\[
\phi_i(v) = \sum_{S: i \not\in S} P(S) [v(S \cup i) - v(S)]
\]

where \( P(S) = |S|!(|N| - |S| - 1)!/|N|! \) is the weight of coalition \( S \).
Pipeline Power

1. Calculate the value function and Shapley Value for the network without the pipeline $\phi_i(v^o)$.

2. Calculate the value function and Shapley Value for the network with the pipeline in place $\phi_i(v^1)$.

3. The difference $\phi_i(v^1) - \phi_i(v^o)$ yields the gross impact of the pipeline on the surplus of player $i$, which is then compared to the investment cost of the pipeline.
Institutional Framework

Access rights

- Within the EU: Open third party access (TPA) to the international high pressure transport pipelines.
- Outside the EU: Every country has unrestricted control over its pipelines and gas fields.

Short horizon

A stationary environment with constant demand, technology, production cost, etc. All pipelines can be made bi-directional, but capacities cannot be increased.
Calibration

Data for 2009 from IEA (2010a) on consumption and production in the regions and flows between the regions.

Constant production cost up to the production levels achieved in 2009.

Linear demand functions with the same intercept for all regions.

Slope parameters estimated as to replicate the consumption in 2009, given assumption on production cost.
Only Strategic Benefits of Investments

Given the demand and the cost of producing gas, the pipeline network as existing in 2009 has sufficient capacity (no congestion).

None of the expensive pipeline projects considered in this paper can be justified in narrow economic terms.

The investments change the power structure, hence, redistribute surplus. They do not create surplus.

A project is 'strategically viable' for a group of players, if their gains in bargaining power exceed the investment cost.
Critical Assumptions

The main differences between the power of the regions rely on:

- Relation of total consumption to own production and not on demand functions on which information is poor.
- Production capacity and pipeline connections to the markets and not on differences in wellhead production cost which are difficult to estimate.

‘Strategic viability’ depends on surplus (intercept of demand) and annualized capacity cost (interest rate).

We report low surplus / high interest variant.
Results - Nord Stream

Very large gains for Russia and Germany, substantial gains for France, Austria, Italy.

Large losses for Ukraine and Belarus.

Norway and Netherlands suffer due to supply competition in the European markets.

Gains of Russia and Germany alone justify investment cost in all scenarios.
Results - South Stream

South Stream and Nord Stream play a similar role:

- bypass the transit countries,
- allow Russia to compete more effectively with Norway and Netherlands,
- protect Russia’s strong position in the Southeast.

However, in the presence of Nord Stream’s large capacities, South Stream provides little *additional* leverage, and is not viable in most scenarios.
Results - Nabucco

Increased supply competition imposes a substantial loss on Russia, but the lion’s share of the benefits accrues to Turkey and Iraq.

The impact on EU-members as a group is very small.

Nabucco appears oversized. Gains of Turkey and the European members of the consortium do not cover the project’s cost.

The Eastern section connecting Iraq and Turkey is highly profitable for the two.

South Stream has almost no impact on the strategic viability of Nabucco.
Robustness

The relation of demand intercept and production cost determines the overall surplus from the gas trade.

With respect to an aggregate increase of demand in relation to production cost:

- the relative shares of different players tend to be rather robust,
- the absolute values of their shares will increase, and as a result more pipeline projects will become strategically viable for given investment cost

Exclusive pipeline access within the EU: Conclusions regarding the strategic viability of the projects remain valid.
Shapley Value - Example 1

\[ N = \{ a, b, c \} \]
\[ v(a) = 0, \quad v(b) = 0, \quad v(c) = 0 \]
\[ v(a, b) = 0, \quad v(a, c) = 0, \quad v(b, c) = 0 \]
\[ v(a, b, c) = 1 \]

Then, \( \phi_a(v) = \phi_b(v) = \phi_c(v) = 1/3 \)
Shapley Value - Example 2

\[ N = \{a, b, c\} \]
\[ v(a) = 0, \ v(b) = 0, \ v(c) = 0 \]
\[ v(a, b) = 1, \ v(a, c) = 0, \ v(b, c) = 0 \]
\[ v(a, b, c) = 1 \]

Then, \( \phi_a(v) = \phi_b(v) = 1/2, \ \phi_c(v) = 0 \)
Nord Stream’s Impact on Bargaining Power

<table>
<thead>
<tr>
<th>Country</th>
<th>Shapley Value Without Nord Stream</th>
<th>Shapley Value With Nord Stream</th>
<th>Difference</th>
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<tr>
<td>Russia</td>
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<td>13.3</td>
<td>3.3</td>
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<tr>
<td>Ukraine</td>
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<td>1.4</td>
<td>-2.9</td>
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<tr>
<td>Belarus</td>
<td>1.3</td>
<td>0.4</td>
<td>-0.9</td>
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<tr>
<td>Norway</td>
<td>11.3</td>
<td>9.1</td>
<td>-2.3</td>
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<tr>
<td>Netherlands</td>
<td>8.4</td>
<td>7.2</td>
<td>-1.2</td>
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<tr>
<td>Center</td>
<td>20.5</td>
<td>22.1</td>
<td>1.6</td>
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<tr>
<td>Center-East</td>
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<td>13.3</td>
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<tr>
<td>Italy</td>
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<td>4.0</td>
<td>0.3</td>
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<tr>
<td>Poland</td>
<td>2.1</td>
<td>2.2</td>
<td>0.2</td>
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<tr>
<td>France</td>
<td>8.7</td>
<td>9.4</td>
<td>0.7</td>
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South Stream’s Impact on Bargaining Power

<table>
<thead>
<tr>
<th>Shapley value [%]</th>
<th>Impact of pipeline sections (difference to column 3 table 1)</th>
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<tbody>
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<td></td>
<td>OS</td>
</tr>
<tr>
<td>Russia</td>
<td>14.2</td>
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<tr>
<td>Ukraine</td>
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<td>Belarus</td>
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<td>Norway</td>
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<td>Netherlands</td>
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<tr>
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<td>Center-East</td>
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<td>Italy</td>
<td>4.2</td>
</tr>
<tr>
<td>France</td>
<td>9.6</td>
</tr>
<tr>
<td>Balkan</td>
<td>1.1</td>
</tr>
<tr>
<td>Turkey</td>
<td>8.4</td>
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Table 3: Nabucco’s Impact on Bargaining Power

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<tr>
<th></th>
<th>without South Stream</th>
<th>with South Stream</th>
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<tr>
<td></td>
<td>Impact of pipeline sections</td>
<td>Impact of pipeline sections</td>
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<td></td>
<td>Shapley value [%]</td>
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<td>(difference to column 2 table 2)</td>
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<td>TC+ES</td>
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<td>Russia</td>
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<td>Ukraine</td>
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*a* difference to column 3 table 1