Pipeline Power

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Presentation for the 5th FIW-Research Conference
13 April 2012

Motivation

The EU's natural gas dependency on:

- Russia (40% of imports, 25% of consumption)
- The transit countries, Belarus and Ukraine (75% of Russian imports)

New pipeline links (Nord Stream & South Stream) with Russia:

- Diversify transit routes for Russian gas
- Increase dependency on Russia
- Reduce viability of investments in alternative sources (Nabucco)

Motivation

In 2008 Europe's

- Consumption: 489.7 bcm
- Production: 184.2 bcm
- Net imports: 305.5 bcm *(Source: 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%).

Neither supply nor demand is there. The focus is on the strategic role of the pipelines and the balance of power in the network.

Literature

Non-cooperative approach

Grais & Zheng (1996), Boots et al. (2004), von Hirschhausen et al. (2005) and Holz et al. (2008)

- Computational advantages
- 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, the sequencing of actions and the ability to commit

Literature

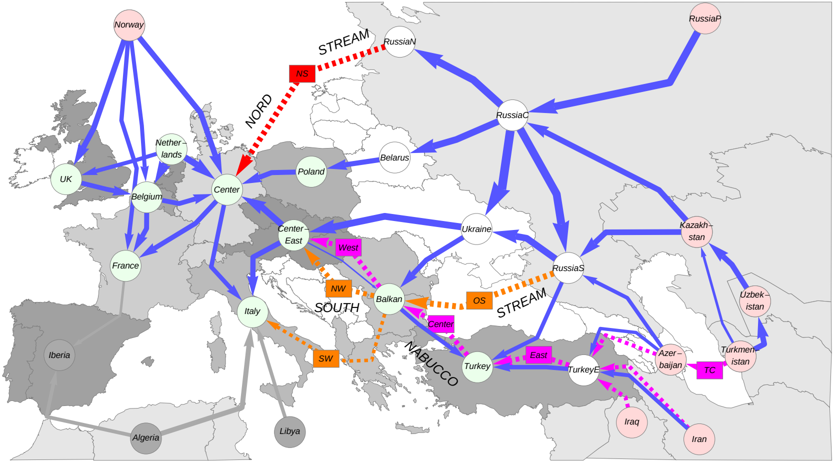
Cooperative approach

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

Model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Libya

Model

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.

Model

The value (or characteristic) function $v : 2^{|N|} \to R_+$ 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 pipelines $L(S) \subseteq L$ the coalition S has access.

Model

$$v(S) = \max_{\{x_{ij} | \{i,j\} \in L(S)\}} \left\{ \sum_{\{i,j\} \in L(S),\, j \in R_C} \int_0^{x_{ij}} p_j(z) dz - \sum_{\{i,j\} \in L(S)} T_{ij}(x_{ij}) \right\} \quad (1)$$

subject to

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

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

and non-negativity constraints $x_{ij} \geq 0,\ \forall\, i \in R_P$ or $j \in R_C$.

Model

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

$\phi_i(v^1) - \phi_i(v^o)$: the gross impact of the pipeline on the surplus of player i, which is then compared to the investment cost of the pipeline

Model

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

The pipeline system as existing in 2009 is sufficient. None of the expensive pipeline projects considered in this paper can be justified in narrow economic terms.

Calibration

The main differences between the power of the regions rely on solid information rather than assumptions:

- 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

Results - Nord Stream

Nord Stream's total strategic value for the initiators of the consortium, Wintershall and EON Ruhrgas of Germany and Gazprom of Russia (in our model Center and Russia) clearly exceeds the project's cost.

Transport competition mitigates the power of Ukraine and Belarus.

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

It is in the interest of the EU to support the project.

Results - South Stream

Both South Stream and Nord Stream have almost identical effects on the power structure since both projects

- bypass the transit countries
- allow Russia to compete more effectively with Norway and Netherlands
- protects Russia's strong position in the Southeast

In the presence of Nord Stream's large capacities, South Stream provides much less additional leverage. The gains for the consortium are not large enough to compensate for the project's high cost.

Results - Nabucco

The whole Nabucco project just breaks even.

The lion's share of the benefits accrues to Turkey and Iraq while the impact on the European regions is very small.

Supply competition harms Russia.

However, starting with the eastern parts, the incremental gains of bargaining power do not cover the incremental cost of the central and the western sections.

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 TPA within the EU: Conclusions regarding the strategic viability of the projects remain valid.

Thank you for your attention!

Questions?

Shapley Value

ϕ_i, $i \in N$, which is player i's weighted contribution to possible coalitions:

$$\phi_i(v) = \sum_{S: i \notin S} P(S)\left[v(S \cup i) - v(S)\right] \tag{2}$$

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

The Shapley value assigns a share of the surplus from cooperation to each player, which will be also referred to as his 'power'.

Shapley Value - Example 1

$N = \{a, b, c\}$

$v(a) = 0; v(b) = 0; v(c) = 0$

$v(a, b) = 0; v(a, c) = 0; v(b, c) = 0$

$v(a, b, c) = 1$

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, $\phi_a(v) = \phi_b(v) = 1/2; \phi_c(v) = 0$