Pipeline Power

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Abstract

We use cooperative game theory to analyze the strategic impact of three controversial pipeline projects. Two of them, Nord Stream and South Stream, allow Russian gas to bypass transit countries, Ukraine and Belarus. Nord Stream's strategic value turns out to be huge, justifying the high investment cost for Germany and Russia. The additional leverage obtained through South Stream, in contrast, appears small. The third project, Nabucco, aims at diversifying Europe's gas imports by accessing producers in Middle East and Central Asia. The project has a large potential to curtail Russia's power, but the benefits accrue mainly to Turkey, while the gains for the EU are negligible.

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JEL class.: L5, L9, O22

1 Introduction

Gas from the Russian Federation accounts for a quarter of the consumption in the European Union and for more than 40% of its imports. In 2010 essentially all of these imports depended on transit through either Belarus or Ukraine, both being major importers of Russian gas themselves. On both routes conflicts over transit fees and gas prices led to several interruptions of supply, the most serious one in January 2009 when transport through Ukraine was shut down for three weeks with dire consequences for heating and power supply in the Balkan.[1] European policy makers are struggling to find a coherent response to these challenges. On the one hand, new pipeline links with Russia are needed to diversify transit routes for Russian gas. On the other hand, such pipelines have the potential to further increase the dependency on Russian gas and reduce the viability of investments securing supplies from alternative sources.

In this paper we analyze three controversial pipeline projects, which have the potential to thoroughly transform the Eurasian supply system for natural gas. In the North, the offshore twin-pipeline *Nord Stream* establishes a direct link between Russia and Germany through the Baltic Sea. In spite of strong opposition from Poland and some Baltic states, it received EU support as a strategic infrastructure project. The first pipeline was inaugurated in late 2011 and the second is scheduled for completion in 2013. Further to the South, Italy and Russia discuss another offshore pipeline, *South Stream*, through the Black Sea. If realized, it would provide a direct connection between Russia and Bulgaria, from where gas should flow to Central Europe, Italy and Turkey. By bypassing the transit countries, Belarus and Ukraine, both projects diversify transit routes for Russian gas. However, critics argue that they will also increase Europe's dependency on Russian exports and safeguard Russia's dominance in European markets by preempting investments into alternative gas supplies. The third project, *Nabucco*, reflects these concerns. Nabucco opens a southern corridor through Turkey connecting Europe to new suppliers in the Middle East and the Caspian region. It also offers a new option to producers in Central Asia, which currently ship gas through Russia. South Stream and Nabucco are still at the planning stage and often portrayed as competing projects. The EU made Nabucco a major strategic project under its Trans-European Energy Networks (TEN-E), and the European Bank for Reconstruction and Development, the European Investment Bank, and IFC (a member of the World Bank Group) ten-

[1] For a comprehensive account of major conflicts over transit through Belarus and Ukraine see Bruce (2005) and Pirani et al. (2009), respectively.

tatively earmarked 4 billion € for funding. EU support for South Stream, in contrast, has been lukewarm, due to concerns that it might pre-empt Nabucco by draining it of potential gas supplies in Central Asia.[2]

The size of these projects appears out of range with both production possibilities and market demand. With 55 bcm/aand 63 bcm/a, respectively, Nord Stream and South Stream will increase transport capacities for Russian gas by 63% from app. 186 bcm/a to almost 304 bcm/a. If compared to the actual gas deliveries, which peaked in 2008, the increase is almost 80% (BP (2011)). Given growing domestic consumption and slow progress in developing new fields in Western Siberia, Russia will not be able to produce enough gas to make use of the additional offshore transport capacity any time soon (Stern (2005)). Taken together all three pipelines would increase the European import capacity by 150 bcm/a or 47%. While declining production in the EU makes an increase of imports a likely scenario, pipeline gas faces stiff competition from liquefied natural gas (LNG), which experienced a sharp drop in prices due to decreasing cost and competing supplies of non-conventional shale gas. Hence, we consider it as very unlikely that demand could take up so much additional gas in the foreseeable future.[3]

In this paper the focus is on the *strategic* role of the pipelines. Even if not needed for transporting *additional* gas, pipelines may have a substantial impact on the balance of power in the network. To assess the pipelines' impact on bargaining power, we develop a disaggregated quantitative model of the Eurasian gas network. The interdependencies among the players are represented by a game in characteristic function form, which is solved using the Shapley value. The power index thus obtained reflects the production possibilities, market size and the architecture of the transport network. When the latter is changed trough a new pipeline, we obtain a different game entailing gains for some and losses for other players. If the gains of the beneficiaries are larger than the cost of the pipeline, the project is a viable strategic option, even if the impact on total consumption and production is negligible. This does not necessarily imply that the pipeline will be built. Those players who are set to loose power might dissuade those who will gain from carrying out

[2]For the position of the EU see EU (2006), EU (2007), and EurActiv (2011).

[3]It is misleading to relate the projects to import needs projected for 2030 or later. While a pipeline will easily last 40 years, the decision to invest at a given time should be based on a much shorter forecasting range. Once the 'go ahead' is given, it will take 3-7 years before the pipeline is ready to deliver gas. Hence, if demand forecasted for a decade ahead is too low or too uncertain to justify the project, the investment should be *delayed*. For the option like nature of sunk investment under uncertainty see Dixit & Pindyck (1994).

the project. However, the pipeline option is at least a credible threat which can be used to extract concessions.

Our analysis shows that Nord Stream's strategic value is huge, justifying the high investment cost for Germany and Russia. It severely curtails the power of transit countries, Belarus and Ukraine, and the EU's main producer, Netherlands. In principle, South Stream fulfills a similar strategic role. However, with Nord Stream already in place, the additional leverage obtained through South Stream is too small to make the project viable for its main beneficiaries; Russia, Germany and some central European countries. Nabucco has a large potential to curtail Russia's power, but the benefits accrue mainly to Turkey, which will diversify its gas imports and become a major potential hub. The gains for the EU, in contrast, are negligible. With financial support from Turkey and Iraq the project is strategically viable but our results cast doubts on the prospects of raising the necessary funds within the EU. Somewhat surprisingly, South Stream has little effect on Nabucco's viability. The EU Commission's concern (or Russian hopes) that South Steam might pre-empt the investment in a southern corridor through Turkey appears unfounded.

The paper can be related to various strands of literature. Grais & Zheng (1996), Boots et al. (2004), von Hirschhausen et al. (2005) and Holz et al. (2008) use a non-cooperative approach to model strategic interaction in quantitative models of the Eurasian gas system. While this approach has computational advantages when solving large disaggregated models, we do see several conceptional shortcomings. First, the literature ignores that most pipeline gas is delivered under negotiated, comprehensive price-quantity-contracts. Instead it adopts counterfactual assumptions from the standard Cournot or Bertrand set up. In combination with market power, these restrictions on the strategy space lead to inefficiencies, which can be avoided by the contracts, which exists in the real world.[4] Second, the power distribution is largely determined by ad hoc assumptions on the nature of strategic interaction at the various stages (production, transport, distribution) and on the sequencing of actions, hence, the ability to commit, and not derived from the underlying economic environment. To avoid these problems, Hubert & Ikonnikova (2011a) propose a cooperative model. They assume that players make efficient use of the existing network and derive the power structure endogenously from the actor's role in gas production, transport and consumption. Their regional scope

[4] The European pipeline system was developed under long–term agreements with so called 'take–or–pay' provisions. Contracts stipulate prices *and* quantities to ensure the efficient usage of the capacities and to avoid double marginalization (see Energy Charter Secretariat (2007) for details). Contracts with transit countries also cover tariffs *and* quantities.

however is very narrow. Here we extend their model to include several competing producers and transit countries such as Turkey. We also allow importers in the EU to act strategically. With these modifications we can assess the pipelines' impact on all major market participants. In a closely related paper Hubert & Orlova (2012) use the same quantitative model of the gas industry to analyze mergers and the liberalization of access rights within the EU.

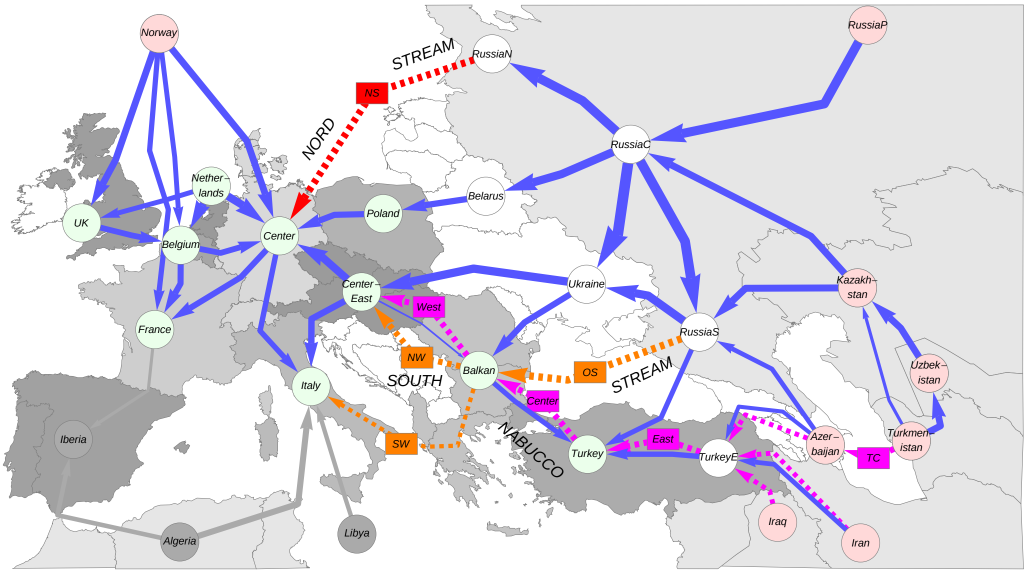
On a more abstract level, the Eurasian pipeline network can be seen as just one example of a network, which enables the parties to trade. Its architecture determines not only the actual trade flows but also the power of the parties, i.e. how they will share the gains from trade. Hence, the actors will try to shape the network to their own advantage. That the formation or severance of trade links can be used to enhance the power of a nation has been recognized long ago (Hirschman (1969)). More recent theoretical research developed formal models of strategic network formation (e.g. Jackson & Wolinski (1996), for a review see Jackson (2008)). In this paper we measure the impact of particular link on the power structure and relate it to its cost, but we do not try to predict the equilibrium network structure (for a first attempt along these lines see Hubert & Ikonnikova (2011b)).

2 The Model

The Eurasian gas network consists of a set of nodes R, which may be production sites R_P , customers R_C or transit-connections R_T, and a set of directed links L representing pipelines (see figure 1 for a simplified illustration). A link $l = \{i, j\},\ i \neq j \in R$ connects two nodes. Gas flows are denoted x_{ij} where negative values indicate a flow from j to i. For those links, which connect a producer to the network or the network to a customer, flows have to be positive ($x_{ij} \geq 0,\ \forall\, i \in R_P$ or $j \in R_C$). For each link $\{i, j\}$ we have a capacity limit k_{ij} and link specific transportation costs $T_{ij}(x)$, which includes production costs in case of $i \in R_P$. For capacities which already exist, transportation cost consist only of operation costs, because investment cost are sunk. When we allow for investments to increase k_{ij}, the capital costs for new capacities are added to the transportation costs. Each customer is connected through a single dedicated link to the network. So consumption at node $j \in R_C$ is equal to x_{ij} and the inverse demand is $p_j(x_{ij})$.

The set of strategic players is denoted N. The interdependencies among the players can be represented by a game in value function form (N, v), where the value (or characteristic) function $v : 2^{|N|} \rightarrow R_+$ gives the maximal payoff, which a subset

Figure 1: The Network



Red nodes represent producers and transit nodes are white. Blue points represent regions where we have a major transit node, which is linked to local production and local customers (the nodes are not shown separately). Solid arrows represent the main pipelines as existing in 2010. Grey nodes and pipelines are taken into account but not considered as strategic instruments. Dashed arrows are pipelines under construction or planning.

of players $S \subseteq N$ can achieve. The legal and regulatory framework determines the access rights of the various players. So for any coalition $S \subseteq N$ we have to determine to which pipelines $L(S) \subseteq L$ the coalition S has access. Access to the link $\{i, j\},\ i \in R_P$ is equivalent of having access to production at p. Access to $\{i, j\},\ j \in R_C$ yields access to customer j. The value function is obtained by maximizing the joint surplus of the players in S using the gas-flows in the pipelines:

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

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 $|x_{ij}| \le k_{ij},\ \forall \{i, j\} \in L(S)$ and non-negativity constraints $x_{ij} \ge 0,\ \forall i \in R_P$ or $j \in R_C$. The value function captures the essential economic features, such as the geography of the network, different cost of alternative pipelines, demand for gas in the different regions, production cost, etc. It also reflects institutional features, such as ownership titles and access rights.

Finally, we calculate the Shapley value, $\phi_i,\ i \in N$, which is player i's weighted contribution to possible coalitions:

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

Table 1: Consumers

Regions	Consumption[a] [bcm]	Production[a] [bcm]	Import[a] Dependency[c] [%]	Import Dep.[b] on Russia [%]
Center[d]	107.3	21.4	80.1	43.6
Center-East[e]	37.2	4.9	86.8	82.
Italy	83	8.3	90.	18.9
France	49.8	0.7	98.6	17
Poland	17.2	6.1	64.5	89.5
Netherlands	54.9	88.5	−61.2	−11.1[f]
Balkan[g]	21.3	11.1	47.9	77.7
Belgium	20.3	0.	100.	0.
Turkey	38.1	0.7	98.2	46.2
UK	90.5	62.1	31.4	0

[a]Data are from IEA (2010).

[b]Imports from Russia/net imports, BP (2011)

[c]Net imports/consumption

[d]Germany, Denmark, Switzerland and Luxembourg

[e]Austria, Hungary, Czech Republic and Slovakia

[f]In 2010 Netherlands imported 4.03 bcm from Russia and 16.97 bcm in total, although she is a net exporter. (BP (2011)).

[g]Romania, Bulgaria and Greece

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'. Suppose we change a network generating the value function v^o by adding a pipeline to obtain a new network generating v^1. The gross impact of the pipeline on the surplus of player i is then given by $\phi_i(v^1) - \phi_i(v^o)$. This difference in payoff is then compared to the investment cost of the pipeline.

To obtain a detailed representation of the various customers, owners of pipelines, gas producers, etc. we would like to consider a large set of players. Unfortunately, computational complexity increases fast in the number of players, as we have to solve $2^{|N|} - 1$ optimization problems to calculate the value function. It is for computational reasons that we restrict the geographical scope by aggregating customers into large markets and leaving out producers which appear to be of minor strategic relevance.

As to producers, we focus on Russia, the supplier for Nord Stream and South Stream, its main competitor Norway, and those countries in the Middle East and Central Asia which have a potential to serve Nabucco (Iraq, Iran, Azerbaijan, and Turkmenistan). Transit countries are Belarus, Ukraine and Georgia. Turkey is a major consumer and a potential transit country for Middle Eastern and Caspian gas. We aggregate customers and producers within the EU into eight regional players. Each controls local production, access to local customers, and possibly transit through the region. France, UK, Italy, Poland, Netherlands, and Belgium correspond their respective countries. In each of these countries a national champion dominates imports and local supply (GDF, ENI, PNGiG, Gasunie, Botas). We collect Austria, Czech Republic, Slovakia and Hungary in one region called “Center-East”. South Stream and Nabucco will end in Center-East, from where gas will be distributed to other European consumers. The countries in the region exhibit similar consumption and import dependency patterns. With very little alternative supplies the region depends with almost 90 % of its consumption on imports from Russia. While the pipeline networks are largely privatized, some owned by Western importers. The Austrian OMV can be seen as the dominant private supplier in the region. Germany, Switzerland, Denmark and Luxembourg are bundled to “Center”. In terms of consumption the region is clearly dominated by Germany, which is also home of large gas suppliers, E.ON-Ruhrgas and Wintershall. The region covers more than three quarters of gas consumption by imports, but its imports are well diversified between Russia (43.6%), Norway (38%) and Netherlands (31.1%).[5] Finally, we collect Romania, Bulgaria and Greece in a region called “Balkan”. The region has only weak links to other European regions and its imports depend largely on Russian gas.

We aggregate all pipelines and interconnection points between any two players into one link. The arrows in figure 1 indicate direction of net flows between regions according to IEA (2010a). Nord Stream, South Stream and Nabucco are presented in dashed arrows. The arrows display direction of flow after the completion of the project, namely from East to West. As to access rights, we assume that outside EU every country has unrestricted control over its pipelines and gas fields. For the regions within the EU, in contrast, we assume that common market rules ensure open third party access to the international high pressure transport pipelines. Hence, regions within the EU cannot derive bargaining power from blocking gas transit. Since this is an idealization of the current state of regulation, we discuss the robustness of our results in Section 4. EU regions control local production and access to the local customers. Most of them are mainly customers, who use Russian and Norwegian gas to complement their own production and other imports, which are taken as given. The only exception is Netherlands, which produces in excess of own consumption and is the only net exporter in the EU.

[5] Imports from the supplier/Net imports, BP (2011).

We assume a stationary environment with constant demand, technology, production cost, etc. The value of a coalition, nevertheless, depends on the temporal scope of the model. In the very short run, the pipeline network is essentially static. The longer one projects into the future, however, the more options to invest in pipes, compressors etc. can be exploited, hence the more flexible the transport system becomes. Here, we adopt a rather short horizon assuming that all pipelines can be made bi-directional, but capacities cannot be increased.

The details of the numerical calibration are given in a technical appendix, which is available on request. Here we outline only the main principles. We calibrate the model using data for 2009 from IEA (2010a) on consumption and production in the regions and flows between the regions from November 2009 to October 2010 taken from IEA (2010b). We assume production cost, which are constant up to production levels achieved in 2009 and linear demand functions with the same intercept for all regions. The slope parameters are then estimated as to replicate the consumption in 2009, given our assumption on production cost. The most important implication of our calibration of demand in relation to cost is that the pipeline system as existing in 2009 is sufficient. Given the willingness to pay and the cost of producing gas, it is able to deliver the efficient amount of gas into the different consumption nodes. Thus, none of the expensive pipeline projects considered in this paper can be justified in narrow economic terms.

This approach also ensures that the main difference between the regions is the relation of total consumption to own production on which we have solid information and not our assumption on demand functions on which information is poor. The main difference between producers is production capacity and pipeline connections to the markets, for which data are good, and not differences in wellhead production cost, which are difficult to estimate.

Perhaps the most critical part of the calibration is the relation of demand intercept and production cost which determines the overall surplus from gas trade. The relative shares of different players tend to be rather robust with respect to an aggregate increase of demand in relation to production cost. However, the absolute values of their shares will increase, and as a result more pipeline projects will become strategically viable for given investment cost. We use a discount rate of 15% to annualize investment cost to account for depreciation and the real option nature of the investment.

3 Results for Pipelines

We assess the impact of a new pipeline by comparing the Shapley value (SV) for two games, one without and another with the pipeline in place. Given our calibration of demand, the pipelines do not create value. They can only change the power structure. To assess the strategic viability of the pipeline, we relate the cost of the pipeline to the gains of those players, whose power is increased.

Since a player's Shapley Value is the weighted sum of his contributions to the values of possible coalitions of other players, any change can be traced back to changes of these contributions. The value of a coalition depends on its access to pipelines, markets and gas fields. Hence, a player can increase the coalition value by providing additional markets, additional supply or by improving connections through transit. In any case, the value of his contribution will depend on how well his resources complement what is already there. Adding a market to other markets with no access to production helps little compared to making the same market available to several producers, which are short of customers. Generally speaking, a pipeline may benefit a player by improving his access to complementary inputs and hurt him by improving his competitors access to such resources. The trade-off between access and competition is complicated by the fact that some countries play multiple roles. While in our model Russia is a pure producer, and Belarus and Ukraine are pure transit regions; Balkan is all, a gas producer, a customer and a transit region for Russian gas. Moreover, the role of a player depends on the coalition against which he is evaluated. For example, Turkey is an importer when all players are in the coalition. However, it becomes a transit country for Russian gas in a smaller coalition, for which neither transit through Belarus nor Ukraine is available. Multiple and changing roles make it sometimes difficult to predict what the overall impact of a new pipeline on a player will be.

3.1 Nord Stream

Nord Stream bypasses the transit countries in the Northern corridor and connects Russia via a twin offshore pipeline through the Baltic Sea to Germany. The project was initiated by Russian Gasprom and German EON-Ruhrgas and Wintershall in 2005. Later French GDF Suez and Dutch Gasunie joined the consortium. The first pipeline was put into service in late 2011. The pipeline is expected to be fully operational with 55 bcm/a by 2013. Published figures on investment cost have been revised several times. We estimate total cost including complementary pipelines in

Table 2: Nord Stream's Impact on Bargaining Power

	Shapleyvalue [bn €/a]		
	without Nord Stream	with Nord Stream	difference
Russia	4.6	6.1	1.5
Ukraine	2.	0.6	−1.3
Belarus	0.6	0.2	−0.4
Norway	5.2	4.2	−1.
Netherlands	3.9	3.3	−0.6
UK	1.	0.9	0.
Center	9.4	10.1	0.7
Center-East	5.7	6.1	0.4
Italy	1.7	1.9	0.2
Poland	0.9	1.	0.1
France	4.	4.3	0.3
Belgium	1.7	1.9	0.1
Balkan	0.4	0.4	0.
Turkey	3.8	3.8	0.
Iran	0.6	0.6	0.
Azerbaijan	0.2	0.2	0.
Georgia	0.2	0.2	0.
project cost[a]			1.5

[a]Investment cost annualized with an interest of 15%.

Russia and Germany at 10 billion €.

Table 2 exhibits Nord Stream's effect on the players' relative power. For each player we report the Shapley value with and without the pipeline as well as the difference between the two measuring the project's impact on the players' surplus. As we measure all figures in bn €/a we can compare the impact with annualized investment cost of 1.5 bn €/a.

The benchmark case without Nord Stream is presented in the first column. The sum of all figures gives the total surplus of the grand coalition, when all players cooperate regarding the production and transport of pipeline gas. The shares of suppliers reflect their production capacities as well as their dependency on the transit countries to access to consumer markets. Although Russia exports more gas than Norway to the European markets, Norway's surplus (5.2 bn €/a) is larger than Russia's (4.6 bn €/a), since Norway has direct access to the European pipeline network, while Russia depends on transit countries, Ukraine and Belarus, to ship gas to the European markets. Different transport capacities in Ukraine and Belarus are reflected in their shares of profit, 2 bn €/a and 0.6 bn €/a, respectively. The largest European producer, Netherlands obtains 3.9 bn €/a. The other European regions are net importers, hence their benefits tend to increase with the size of their markets and their dependence on pipeline gas. The figures reflect the gains from trading gas, not the gains from consuming gas. A country whose own production or LNG imports are large enough to cover demand will gain little from participating in the gas trade even if its gas market is large. The EU as a whole obtains 28.7 bn €/a, with Center, Center-East and France having the largest shares. Turkey benefits from its consumption of pipeline gas as well as its potential transit position between Balkan and the suppliers; Russia, Iran and Azerbaijan.

The last column in Table 2 presents Nord Stream's impact on the players' surplus as the differences. Russia gains 1.5 bn €/a, which is 32.6% of its share of profits in the benchmark case. Increased transport competition mitigates the power of Ukraine and Belarus, which loose 1.3 bn €/a and 0.4 bn €/a, respectively. The transit countries together lose 65.4% of their relative power in the benchmark case, since their monopoly in transportation of Russian supplies to Europe is broken. Due to intensified supply competition in the European markets, Norway and Netherlands suffer losses of 1 bn €/a and 0.6 bn €/a, respectively. The European players together benefit from increased transport and supply competition gaining 1.2 bn €/a. In the EU, Center has the largest increase with 0.7 bn €/a.

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), is 2.2 bn €/a, which clearly exceeds the project's cost of 1.5 bn €/a. It is worth stressing that the project appears profitable only because it increases the bargaining power of the consortium vis-a-vis other players. Given our calibration of demand, the pipeline is not needed to transport additional gas. Our results also suggest that it is in the interest of the EU to support the project since the gains of the EU and Russia (2.7 bn €/a) is larger than the annualized cost of the project.

After the project was kicked off Gasunie of Netherlands and GDF Suez of France joined the consortium each with a share of 9%. In view of our results the participation of Gasunie is surprising, since Netherlands supplies 15% of the EU's consumption and is set to loose (-0.6 bn €/a) from intensified supply competition. Our interpretation is the following. Gasunie joined in anticipation of its changing role in the system. Due to rapidly declining reserves Netherlands will become a net importer around 2025. The country also intents to become a gas hub in Northwestern Europe transiting Russian gas from Germany to UK (Netherlands Ministry of Economic Affairs, Agriculture and Innovation (2010)).

3.2 South Stream

South Stream can be seen as the Black Sea twin of the Baltic Sea crossing Nord Stream. Russia pushes the project to obtain direct access to its customers in the Southeast, bypassing Ukraine. It consists of three sections: offshore, northwestern and southwestern.

OS: The offshore section runs through Turkey's economic zone in Black Sea and connects Russia directly with Bulgaria with a capacity of 63 bcm/a. The consortium for the offshore section is composed by Gazprom of Russia, Eni of Italy and EDF of France. Onshore the pipeline splits in two routes.

NW: The northwestern route runs from Bulgaria to Baumgarten in Austria via Serbia and Hungary with a capacity of 30 bcm/a.

SW: The southwestern route connects Bulgaria to Italy via Greece and a short offshore pipeline through Adriatic Sea. It has a capacity of 10 bcm/a. Each section of northwestern and southwestern routes in the participating countries will be undertaken by a joint-venture between Gazprom and national gas company of the corresponding country.

The offshore and the onshore pipeline sections are expected to cost 10 billion € and 5.5 billion €, respectively. Thus, South Stream has total investment cost of 15.5 billion € (South Stream (2010)). According to press releases, the first line of the project with a capacity of 16 bcm/a should be operational at the end of 2015. The project will be in service with full capacity at the end of 2018.

Table 3: South Stream's Impact on Bargaining Power

	without Nord Stream				*with Nord Stream*			
	Shapley value	Impact of pipeline sections[a] (*difference to column 2 table 2*)			Shapley value	Impact of pipeline sections (*difference to column 3 table 2*)		
		OS	OS+NW	OS+NW+SW		OS	OS+NW	OS+NW+SW
Russia	6.	0.2	1.3	1.4	6.5	0.2	0.4	0.4
Ukraine	0.7	−0.2	−1.1	−1.3	0.2	−0.2	−0.4	−0.4
Belarus	0.3	0.	−0.3	−0.3	0.1	0.	−0.1	−0.1
Norway	4.4	0.	−0.7	−0.8	3.9	0.	−0.2	−0.3
Netherlands	3.4	0.	−0.4	−0.5	3.2	0.	−0.1	−0.1
UK	0.9	0.	0.	0.	1.	0.	0.	0.
Center	10.	0.	0.5	0.6	10.4	0.	0.2	0.2
Center-East	6.	0.	0.3	0.3	6.2	0.	0.1	0.1
Italy	1.8	0.	0.1	0.1	1.9	0.	0.	0.1
Poland	1.	0.	0.1	0.1	1.	0.	0.	0.
France	4.3	0.	0.2	0.3	4.4	0.	0.1	0.1
Belgium	1.9	0.	0.1	0.1	1.9	0.	0.	0.
Balkan	0.5	0.1	0.1	0.1	0.5	0.1	0.1	0.1
Turkey	3.9	0.	0.	0.	3.9	0.	0.	0.
Iran	0.6	−0.1	−0.1	−0.1	0.6	−0.1	−0.1	−0.1
Azerbaijan	0.2	0.	0.	0.	0.2	0.	0.	0.
Georgia	0.1	0.	0.	0.	0.1	0.	0.	0.
Turkmenistan	0.	0.	0.	0.	0.	0.	0.	0.
project cost[b]		1.3	1.8	2.3		1.3	1.8	2.3

[a] OS: offshore section with 63 bcm/a and investment cost of 8.6 billion €.
NW: Northwestern section with 30 bcm/a and investment cost of 3.5 billion €.
SW: Southwestern section with 10 bcm/a and investment cost of 1.5 billion €.

[b] Investment cost annualized with an interest of 15%.

Russia enjoys a very strong bargaining position in Southeastern Europe. Competing producers such as Norway or Netherlands cannot reach this region, since the transport capacities between Balkan and Central Europe are very small (1.7 bcm/a).[6] The northwestern section improves the connection between Center and Balkan; thus, it has a potential to increase competition for Russian gas in Balkan and Turkey. However, Gazprom can prevent its competitors from using the pipeline. As a co-owner, it can seek exemption from the Third Party Access (TPA) rules for new investment.[7]

Nord Stream will be fully operational, before the construction of South Stream is expected to start. So, the impact of South Stream has to be assessed for a network which already includes Nord Stream (the right panel of Table 3). Nevertheless, it is instructive to study the counterfactual case first, which is presented in the left panel of Table 3. The comparison of left panel's last column in Table 3 and the last column in Table 2 shows that South Stream and Nord Stream alter the power structure in a similar way. It does not matter much whether Russian gas is injected in Center or in Balkan if third party access to the existing European network is free, while at the same time new investment in the Northwestern section enjoys regulatory holiday, so that Russia's dominance in Southeastern Europe remains protected.[8] The differences in the figures are in the range of 0.1 bn €/a. As in the case of Nord Stream, Russia enjoys the biggest increase in bargaining power, worth 1.4 bn €/a, while competing suppliers and transit countries loose.

As an alternative to Nord Stream, the more expensive South Stream is viable for the members of the consortium (Russia, Italy, France, Center-East and Balkan), if the offshore section is combined with the northwestern section, but the incremental gains of southwestern section are not worth the additional cost. The whole project is barely viable under our parameter assumptions. The consortiums jointly gains 2.2 bn €/a, while project cost are 2.3 bn €/a.

[6]In January 2009, the gas dispute between Russia and Ukraine hit Balkan countries severely, since the bottleneck between Balkan and Central Europe hinders imports from other major suppliers in Northwestern Europe and North Africa via Central Europe.

[7]To incentivize new investment in infrastructure projects, the EU allows for so called regulatory holiday under EU (2009). Nabucco, which is considered below, has a section which is similar to the northwestern section of South Stream. There we are going to analyze the case of open third party access.

[8]We also considered the case that South Stream's Northwestern section is not exempted from free third party rules. In this case, the strategic gains from bypassing Ukraine are compensated by the strategic loss of increased competition from Dutch and Norwegian gas. Thus Russia would loose interest in the project.

Now we turn to the realistic scenario, in which Nord Stream is already in operation (the right panel of Table 3). We start with the impact of the offshore section alone (the column headed 'OS'). The leverage gained is very small, since the gas could only be transported to Balkan, a small market, and Turkey, which is already accessible through Blue Stream. The offshore section is of little strategic use without substantial onshore investments. If these complementary sections are added the picture, we obtain a scaled down version of the counterfactual case. Russia gains 0.4 bn €/a, while Ukraine and Belarus suffer from transit competition and Netherlands and Norway from intensified supply competition. As a group the consortium gain 1.0 bn €/a, which is less than the half of the project cost. With Nord Stream in place, South Stream is no longer strategically viable.

It is also worth noting that the southwestern section has very little impact on the power structure. With Nord Stream in place, there is already a large amount of spare capacity to transport Russian gas to Central Europe and Italy.[9] Adding a 10 bcm/a link through the Adriatic Sea makes hardly a difference.

In summary, considered as an alternative, both South Stream and Nord Stream have almost identical effects on the power structure, since both projects bypass the transit countries and allow Russia to compete more effectively with Norway and Netherlands, without loosing its strong position in the Southeast. However, 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.

3.3 Nabucco

Plans for a new 'southern corridor' have been discussed for almost two decades. In the late nineties the US government pushed for a 'Trans-Caspian Pipeline' from Central Asia through the Caspian Sea, Azerbaijan and Georgia into Turkey and further on to Southern Europe. The strategic aim was twofold: to reduce Turkey's and Europe's dependency on Russian gas and to decrease Russia's leverage in the newly independent former Soviet republics. However, US energy companies dragged their feet over uncertain economic prospects. These worsened when Russia started to contract large volumes of gas from Turkmenistan in 2002 at much higher prices than before. With the US' support withering the Europeans took over

[9]The northwestern and offshore sections of South Stream and Nord Stream together increase pipeline capacity between Russia and Europe (except Balkan) from 140 bcm/a to 225 bcm/a, while in 2008 the demand for Russian gas in the area was 108.3 bcm (BP (2009)).

the initiative. A consortium lead by OMV of Austria and Botas of Turkey (later joined by German RWE) coined the new name 'Nabucco'.[10] The focus of the new project has shifted, in the East from Central Asia towards suppliers in the Middle East and in the West towards extending the pipeline into the heart of Europe. The project has been postponed several times and is currently scheduled to become operational in 2017.

For the assessment of the pipeline's impact it is useful to divide Nabucco into four sections: Trans-Caspian, the eastern section, the central section and the western section.

TC: Trans-Caspian, for the purpose of this paper, is narrowly defined as the off-shore pipeline between Turkmenistan and Azerbaijan. With 30 bcm/a capacity it is estimated to cost 2.3 billion €. RWE of Germany and OMV of Austria, both also members of Nabucco's overall consortium, have the initiative.

ES: The Eastern section consists of several pipelines connecting Turkey with potential suppliers, Azerbaijan, Iran and Iraq. We include Iran even though at present this appears to be very unlikely for political reasons. The country has the second largest gas reserves in the world and Turkey already imports gas from Iran. Even though none of the parties involved in the project will openly admit, Iran is an important potential supplier for Nabucco. For the calculation we assume that the existing capacity of each feeder pipeline between Turkey and the suppliers is increased by 15 bcm/a, and the section from Turkey's East to the West is enlarged by 30 bcm/a. We estimate the cost at 7.2 billion €, which includes in some cases the cost of developing fields.

CS: The central section connects western Turkey with Balkan. It is important to note that existing pipelines with a capacity of app. 16 bcm/a are currently used to pump Russian gas into the opposite direction, from Balkan into Turkey. Nabucco will reverse the direction of the flow through the central section and expand its capacity by 30 bcm/a to an estimated total of 46 bcm/a. We estimate the cost of the central section at 1.9 billion €.

WS: The western section connects Balkan to Center with a planned capacity of 30 bcm/a and an estimated cost of 3.5 billion €. At present, Southeastern Europe is isolated from Central Europe since existing transport capacities between these regions are small (1.7 bcm/a). As a result, Russia faces no

[10] The consortium also includes companies from transit countries: Bulgargaz of Bulgaria, Transgaz of Romania, and MOL of Hungary.

> competition from Norway and Netherlands in the Southeast. The Nabucco consortium rallied political support in the EU arguing that it would help to integrate the region to other European markets by eliminating the bottleneck. The pipeline is designed for bidirectional use and shall be open for gas transport for all interested parties. So, we assume that every player has access to Nabucco's western section, whereas we assumed exclusive access for South Stream's northwestern section.

Nabucco's expected total cost is 12.6 billion €. Since none of the potential suppliers are member of either Nabucco's or Trans Caspian's consortium, producers will not contribute to investment cost.[11] It is worth emphasizing, that Nabucco's commercial prospects are built on reversing flows in the present network. Currently, gas flows in small quantities from Center to Balkan and in substantial quantities from Balkan to Turkey. These flows have to be reversed before anybody will pay transport fees to Nabucco's owners. Considering the pipeline in isolation, it is easy to underestimate how much additional gas in Turkey is needed to justify its capacity. Let's consider the central section of Nabucco. First, some 10 bcm/a are needed to substitute for the current flow from Balkan to Turkey. Second, existing capacities can be made bidirectional at modest cost to pump some 16 bcm/a from Turkey to Balkan without new pipelines. Third, 30 bcm/a are needed to fill the additional pipeline capacities. In total it would require app. 55 bcm/a additional gas in Turkey to make fully use of the new pipeline. As with Nord Stream and South Stream, many observers raised serious doubts as to whether such quantities can be provided anytime soon.

In Table 4 we report selected results for the strategic impact of Nabucco. We focus on a scenario where Nord Stream is already completed and then Nabucco is added to the system (left panel). The first column shows the absolute Shapley values for the completion of all sections. It should be compared to column 2 in Table 2. The difference between the two i.e. the impact of the whole project is shown in column 4. It is instructive to consider the effect of the different sections separately. First, we consider only the sections in the east (TC and ES), which connect Turkey to the producers in the Middle East and Central Asia (second column). As increased supply competition harms other producers, in particular Russia, it benefits Turkey and to a much lesser extend Balkan. The effects of additional producers in the East on other EU regions are negligible, which is not surprising in view of the bottleneck

[11] In principle, the suppliers can compensate the members of the consortium for investment cost by providing cheap gas under long term contracts. It is not clear, however, whether countries like Azerbaijan and Iraq, not to speak of Iran, can credibly make such long term commitments.

Table 4: Nabucco's Impact on Bargaining Power

	without South Stream				*with South Stream*	
	Shapley value	Impact of pipeline sections[a] *(difference to column 3 table 2)*			Shapley value	Impact[b]
		TC+ES	WS	TC+ES+ CS+WS		TC+ES+ CS+WS
Russia	4.7	−0.8	−0.3	−1.4	5.	−1.5
Ukraine	0.4	−0.1	−0.1	−0.2	0.1	−0.1
Belarus	0.2	0.	0.	0.	0.1	0.
Norway	4.	−0.1	0.3	−0.1	3.8	−0.1
Netherlands	3.2	0.	0.2	−0.1	3.1	0.
UK	0.9	0.	0.	0.	0.9	0.
Center	10.2	0.	−0.1	0.1	10.5	0.1
Center-East	6.2	0.	−0.1	0.1	6.3	0.1
Italy	1.9	0.	0.	0.	1.9	0.
Poland	1.	0.	0.	0.	1.1	0.
France	4.4	0.	−0.1	0.	4.5	0.
Belgium	1.9	0.	0.	0.	1.9	0.
Balkan	0.6	0.1	0.1	0.1	0.6	0.1
Turkey	5.1	0.7	0.5	1.3	5.1	1.2
Iraq	0.3	0.4	0.	0.3	0.3	0.3
Iran	0.6	−0.1	−0.2	−0.1	0.5	0.
Azerbaijan	0.2	0.	−0.1	0.	0.1	0.
Georgia	0.1	0.	−0.1	0.	0.1	0.
Turkmenistan	0.1	0.	0.	0.1	0.1	0.1
project cost[c]		0.9	0.5	1.7		1.7

[a] TC: Trans Caspian with 30 bcm/a and investment cost of 2.3 bn €.
ES (eastern section). Pipelines between east Turkey and Azerbaijan, Iran and Iraq, each increased by 15 bcm/a. East to West Turkey enlarged by 30 bcm/a. Total investment cost 7.2 billion €.
CS (central section) with 30 bcm/a and investment cost of 1.9 billion €.
WS (western section) with 30 bcm/a and investment cost of 3.5 billion €.

[b] difference to column 6 table 3

[c] Investment cost annualized with an interest of 15%.

between Balkan and the rest. Iraq, which previously had no connection, gains substantially, but other producers and transit countries in the region have little to gain and might even loose. The benefits of Turkey and Iraq clearly outweigh the cost of the pipelines in the East. As gain depends only on the branch leading into Iraq, we expect investments here even when the rest of Nabucco fails to materialize.

Next, we consider only the western section (WS) connecting Balkan and Turkey (column three). This pipeline with a capacity of 30 bcm/a will not be used. Nevertheless, the option to move gas from Northwest to Southeast intensifies competition for customers in the Southeast which benefits Turkey and Balkan as well as producers in Northwest at the cost of Russia and producers in the Middle East and Caspian region. Some regions in the EU, such as Center, Center-East and France are slightly harmed from increased demand competition, since Norway and Netherlands will gain better access to other markets. Again the effect on the EU as a group is negligible. With a total gain of 1.0 bn €/a compared to cost of 0.5 bn €/a the section is a viable option for producers in Northwest together with Turkey and Balkan.

Now, we consider the project as a whole (column 4, left panel). Bringing in new suppliers in the East and connecting them with the center of Europe's network weaken the bargaining power of all old suppliers, but in particular Russia (-1.4 bn €/a). The lion's share of the benefits accrues to Turkey (+1.3 bn €/a) and Iraq (+0.3 bn €/a) while the impact on the European regions is again very small. Comparing the gains of the winners to the investment cost, the whole project just breaks even. 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. Nabucco does surprisingly little to improve the power of Turkmenistan. We attribute this to the fact, that the cost of the Trans-Caspian section is high and the new supply route has three transit countries of which Azerbaijan is also a competing producer. In view of these results, it is difficult to make much sense out of the EU's support of the project. Nabucco appears oversized given the limited supplies of gas in the east, and the main beneficiaries are Turkey and possibly producers in the east.[12]

Finally, we return to the perception that South Stream and Nabucco are competing projects and the concern that the former might preempt investment into the latter.

[12]Recent developments lend credibility to this sceptical assessment. While support for Nabucco is crumbling Botas of Turkey and Socar of Azerbaijan agreed on a Trans-Anatolian pipeline from Shah Deniz gas field to Turkey's West, which corresponds to the eastern and central sections of Nabucco but has half of its capacity, 16 bcm/a (Businessweek (2011)). In the West, BP considers a South-East Europe pipeline, with 10 bcm/a a scaled down version Nabucco's Western section (FT (2011)).

In the right panel of Table 4 we show the strategic impact of Nabucco in a situation, where South Stream and Nord Stream will be fully operational. Comparing the second column of the right and the fourth column of the left panel, we find very little difference. Hence, South Stream has almost no impact on the strategic viability of Nabucco.

4 Concluding Remarks

In this paper we analyze the strategic impact of three controversial pipeline projects, Nord Stream, South Stream and Nabucco, which have the potential to thoroughly transform the Eurasian supply system for natural gas. The interdependencies among the players are represented by a game in characteristic function form. We use the Shapley value of the game to measure the bargaining power of the players. A disaggregated quantitative model of the Eurasian gas network is used to calibrate the model. Each pipeline changes the architecture of the network, hence, the value function for the game. We identify the strategic impact by comparing the power index for the various players and relate it to the cost of the project.

If considered as an alternative, both South Stream and Nord Stream have almost identical effects on the power structure in the Eurasian transport network for natural gas. The pipelines bypass the transit countries Belarus and Ukraine and allow Russia to compete more effectively with Norway and Netherlands. For the initiators of Nord Stream, Russia and Germany, the gains in bargaining power clearly justify the cost of investment. The main beneficiaries of South Stream are Russia, Germany and some Central European countries. Due to its much higher cost, it is difficult for the project to brake even. However, once Nord Stream's large capacities become operational, South Stream's additional leverage is much reduced and the project turns strategically unviable.

Nabucco opens a southern corridor through Turkey connecting Europe to new suppliers in the Middle East and the Caspian region. It also offers a new option to the producers in Central Asia, which currently ship gas through Russia. The EU made Nabucco a major strategic project under its Trans-European Energy Networks (TEN-E) and substantial public funds have been earmarked for the project. The project has large potential to decrease Russia's power, but the benefits accrue mainly to Turkey, which will diversify its gas imports and become a major potential hub. The gains for the EU, in contrast, are negligible. The gains for Turkey and Iraq are very large and clearly justify investments in the eastern sections of the project. The incremental cost of the sections in the center and towards the west are too large to justify the strategic gains.

We will now briefly discuss, how robust these results are. First, we reconsider our assumption of free third party access within the European Union. When the European Commission started its policies to ensure a common market for natural gas in the late nineties, the situation was very different. Most countries had a 'national champion' who monopolized the high pressure transportation grid, hence long distance transport, and one might argue that it is still a long way to overcome this fragmentation of the market. With exclusive access, a region in the EU can derive power by blocking gas shipments through its trunk pipe network. As a result each coalition has access only to the pipeline network of its members. Therefore, European consumers, which neighbor a producer or a transit country, gain transit power, while importers without Non-European borders suffer. While the impact of pipelines on bargaining power change slightly, our conclusions regarding the strategic viability of the various projects remain valid. There is one minor exception for Nabucco: The incremental gain through the central and western sections justifies investment in these sections. If designed for free third party access, this sections of Nabucco have an stronger impact if the market is fragmented.

We also consider an increase of demand accompanied by a decrease in European production capacities. In accordance with predictions for 2030, we increase each consumer's demand by 20%. By that time Netherlands' production is expected to decrease by 30 bcm/a, making the region a net importer. By keeping LNG imports constant, we rule out that the growth of demand can be satisfied by alternative sources of gas. Regarding the production capacity of Russia, we study two cases: In the first, Russia's production capacity remains unchanged. In the second it is increased by 30 bcm/a to compensates for the decrease in Netherlands' production.

Overall, these scenarios create environments, which are very favorable for pipeline investments. Nevertheless, with Nord Stream in place the narrowly defined economic benefits of additional pipelines are still a tiny fraction of project cost in all scenarios.[13] The strategic effect, however, is amplified. Even with Nord Stream providing already a massive direct link, South Stream's additional leverage for Russia and European customers yields gains which clearly outweigh the projects cost. Only the Southwestern section through the Adriatic Sea remains an unattractive

[13] The increase in total surplus is 0.04 (0.03) bn €/a for South Stream and 0.16 (0.18) bn €/a for Nabucco if Russia can (cannot) increase production, while project cost are 2.3 and 1.7, respectively.

proposition. The increase in demand also enhances the strategic attractiveness of Nabucco. The value of the central and western section is raised enough to justify the investment cost. While the main benefits still accrue to Turkey and eastern producers, European importers would also improve their leverage. These results do not depend much on whether Russia can raise production capacities over present day levels or not.

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