Competition or Countervailing Power for the European Gas Market

Franz Hubert
Humboldt–Universität zu Berlin
hubert@wiwi.hu-berlin.de

Ekaterina Orlova
Humboldt–Universität zu Berlin
orlovaek@hu-berlin.de

first draft: February 2012
this version: January 2014

Abstract

Heading towards a common market for natural gas, the EU Commission is trying to liberalize pipeline access, break up vertically integrated structures and foster competition between the regions. However, critics argue that strong national players are needed to counter the power of a small number of external gas suppliers, such as Russia, Norway and Algeria, on which the EU depends to satisfy more than half of its consumption. We model the European gas supply system as a cooperative game and use the Shapley value as a power index for the players. In accordance with the buyer power argument, we find that the liberalization of access to the high pressure pipeline system within the EU, on balance, *strengthens* the power of external suppliers and weakens the regions within EU. Though, there is considerable variety on both sides of the market.

Keywords: Bargaining Power, Network Access, Natural Gas
JEL class.: L1, L95

This paper is part of larger collaborative research project on the Eurasian gas network to which Onur Cobanli made essential contributions. The authors are thankful for helpful comments from seminar participants at meetings of EARIE, EcoMod and Verein für Socialpolitik.

1 Introduction

When the European Union formally established the common market in 1993, its gas sector was a fragmented industry, where state owned or heavily regulated “national champions”, such as Gaz de France, Italian ENI, or German Ruhrgas, dominated local production and distribution as well as imports and long distance transport. As in telecommunications and electric power, the Commission initiated a policy to achieve integration and foster competition by opening access to bottleneck facilities such as transport pipelines and distribution networks.[1] However, critics of the Commission point to a fundamental flaw in its approach. In marked contrast to electric power, which is almost entirely produced within the Union, two third of its gas consumption is imported from a small number of producers beyond EU jurisdiction, whose stakes in transportation and distribution within the EU are negligible.[2] Gas importers, and often their governments, argue that strong national or even European players are needed to create “countervailing power” against gas exporting countries. In the words of France’s former President Nicolas Sarkozy: “Without Gaz de France, who would stand up to Gazprom?” (quoted in Mortished (2007)). According to critics, by weakening the national champions, the Commission risks strengthening already powerful outside producers such as Russia, Algeria, and Norway, which together account for 85% of imports.

These opposing views on priorities in the gas sector also clashed in several merger cases. When German energy companies E.ON and Ruhrgas applied for merger in 2001, Bundeskartellamt, the German authority for merger control, declined approval arguing that it would give the company a dominant position in import, transport and distribution. While the German Monopoly Commission and the European Commission supported Bundeskartellamt’s pro competitive stance, the German Government overruled the verdict. It claimed that the concentration is justified by an overriding public interest, namely it would help to improve the security of supply

[1]The process started with Directive 98/30/EC (EU (1998)), later amended by the Directive 2003/55/EC (EU (2003)) concerning common rules for the internal market in natural gas and the Council Directive 2004/67/EC of 26 April 2004 concerning measures to safeguard security of natural gas supply (EU (2004)). Frustrated with slow progress the Commission introduced stricter rules for unbundling gas transport (see Directive 2009/73/EC (EU (2009))).

[2]It is, in fact, surprising how little attention the Commission initially payed to Europe’s import dependency in the gas sector. For example, in its explanatory memorandum on proposed amendments to the Directive 2003/55/EC, the Commission consistently speaks of an “electricity and gas market” both in the analytical statements as well as in its recommendations. The whole document fails to acknowledge any structural differences between the two sectors.

of natural gas in Germany.[3] While the Commission could not block the German deal, it successfully prevented Italian ENI in cooperation with Portuguese power company EDP from taking over Portuguese gas operator GDP in 2004.

Concerns over producer power grew stronger in the years before the financial crisis. The foundation of the Gas Exporting Countries Forum 2001 in Teheran fueled worries that a gas cartel similar to the OPEC might be in the making. Later, rapidly increasing gas prices put 'energy security' on the top of the European agenda. Although most observers discount the chances for a strong gas cartel, the Commission began to move towards a centralization of the EU's foreign energy relations. As a first step it obliged members to provide information about intergovernmental agreements with third countries that influence gas supplies in order to be able to assess "the security of supply at Union level". The aim is to enhance coherence of the external energy policy eventually making it possible for EU to "speak with one voice".[4]

In this paper we analyze a disaggregated model of the European gas supply system as a cooperative game and use the Shapley value as a power index for the players. Our focus is on the distribution of power between regions within EU and outside producers and how it is affected by institutional change. The starting point is a patchwork of local monopolies, each controlling access to production, distribution, and the trunk pipes in its respective region. First, we analyze the liberalization of access to the long distance transport system within the EU. This reform strips the local champions of the power derived from monopolizing transit and creates an integrated wholesale market. However, it falls short of creating a fully competitive market. National champions retain control of local production and local distribution, hence access to customers. Second, we look at mergers between two or more local champions, both in a fragmented and an integrated market. We also analyze the potential of centralized bargaining with outside suppliers through political coordination at the EU level.

We find that the liberalization of access to the high pressure pipeline system within the EU, on balance, *strengthens* the power of external suppliers and transit countries for Russian gas and weakens the regions within EU. There is, however, considerable variety on both sides of the market, which might explain some of the

[3]See Bundeskartellamt (2002) and Bundesminister für Wirtschaft und Technologie (2002).

[4]On the gas cartel see Hallouche (2006), Finon (2007), and Gabriel et al. (2012). The groundwork for the Commission's policy has been laid out in a series declarations EU (2010), Commission (2011a), Commission (2011b).

difficulties of implementing the reforms in the European Union. Surprisingly, while the integration of the wholesale market tends to strengthen outside producers, it reduces their possible gains from establishing a producer cartel.

Our results regarding mergers depend much on the market structure. In a fragmented wholesale market, pairwise mergers of 'national champions' tend to be profitable for the parties, but the impact on outside producers is rather mixed. Among pairwise mergers of EU regions, excluding Netherlands, which is the main producer within EU, we find almost as many cases where the bargaining power of outside producers as a group is enhanced, as cases where it is diminished. Hence, a fragmented market provides only little evidence in support of the view that it takes large European players to counter the power of outside producers. Once market integration is achieved, a number of pairwise mergers turn unprofitable, often because they increase the bargaining power of Russia and transit countries for Russian gas. Again excluding Netherlands, only few mergers involving the UK curb the power of all outside producers. Under both market structures, however, there are large gains to be obtained by full centralization at the EU level.

The concept of 'countervailing power' has been controversial ever since it was coined by Galbraith (1952). The theoretical literature has proposed several models of bargaining in vertical structures which relate buyer size to market power, but it did not develop a canonical setting for the analysis of two sided market power.[5] By modeling the inter-dependencies among the players as a cooperative game we avoid assumptions on details of the negotiation process altogether. We assume that players can make efficient use of the network and by using the Shapley value we derive the power structure endogenously from the agents' role in gas production, transport and consumption. In this way we separate the issue of power from the issue of efficiency. The institutional changes have no effect on the efficiency of the industry, they affect only the power structure.

The cooperative approach separates the paper from most of the applied studies on the European gas market, e.g. Grais and Zheng (1996), Boots et al. (2004), Von Hirschhausen et al. (2005), Egging and Gabriel (2006), and Holz et al. (2008). Notwithstanding a number of differences they all analyze the gas industry as a succession of activities (production, transport, distribution), where the interaction among players of the same level of activity is modeled as a non-cooperative game either in linear prices or quantities. In addition, it is often assumed that the different

[5] See among others Horn and Wolinsky (1988), Von Ungern-Sternberg (1996), Snyder (1998), Chae and Heidhues (2004), Inderst and Wey (2003).

levels decide in a given order, which essentially implies that those who move first (producers) have the ability to commit, whereas those who move later (transiters, importers) cannot commit (Grais and Zheng (1996), Boots et al. (2004)). While this approach has computational advantages when solving large disaggregated models, we do see two important conceptual shortcomings. First, the distribution of power between producers, importers and customers is largely determined by ad hoc assumptions on the type of interaction at the different levels and on the sequencing of actions, hence, the ability to commit. Second, the literature ignores that most pipeline gas is delivered under negotiated, comprehensive price-quantity-contracts. These contracts with so called 'take–or–pay' provisions stipulate prices *and* quantities to ensure the efficient usage of the capacities (see Energy Charter Secretariat (2007) for details). Contracts with transit countries also cover tariffs *and* quantities. Instead, the literature adopts counter-factual assumptions from the standard Cournot or Bertrand set up. In combination with market power, these restrictions on the strategy space lead to inefficiencies (double marginalization), which can be avoided by the contracts, which exist in the real world.

The paper is closely related to Hubert and Ikonnikova (2011). Their focus however is on the impact of pipelines and their regional scope is too narrow to allow for an analysis of changes in market structure. Here we extend their model to include several competing producers and transit countries such as Turkey. We also allow importers in the European Union to act strategically. With these modifications we can assess the reform's impact on all major market participants. Finally, the paper shares the quantitative model of the gas industry and the calibration with Hubert and Cobanli (2014) who analyze the impact of strategic pipeline investments on the power structure.

2 The Approach

In this section we briefly describe the representation of the physical network, the cooperative game, the solution concepts and the model calibration. More details are given in the technical appendix at `http://www.ms-hns.de/research_gas` and at `http://www.ms-hns.de/paper_gas_countervailing`. While addressing a different topic, this paper uses the same approach as Hubert and Orlova (2014), Hubert and Cobanli (2014), and Cobanli (2014). Hence, there is considerable overlap with the corresponding sections in these papers, and the reader may skip it if familiar with any of the other papers.

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. A link $l = \{i, j\},\ i \neq j \in R$ connects two nodes. Gas flows are denoted f_{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 ($f_{ij} \geq 0,\ \forall\, i \in R_P$ or $j \in R_C$). For each link $\{i, j\}$ we have a capacity limit k_{ij} and link specific transportation cost $T_{ij}(x)$, which includes production cost in case of $i \in R_P$. For capacities which already exist, transportation costs consist only of operation costs, because investment costs 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 f_{ij} and the inverse demand is $p_j(f_{ij})$.

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 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:

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

subject to the node-balancing constraints $\sum_i f_{it} = \sum_j f_{tj},\ \forall\, t \in R_T(S)$, the capacity constraints of the network $|f_{ij}| \leq k_{ij},\ \forall\, \{i, j\} \in L(S)$ and non-negativity constraints $f_{ij} \geq 0,\ \forall\, i \in R_P$ 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:

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

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'. Usually we express the power in relative terms as a share of the total surplus.

Suppose we start with an institutional setting generating the value function v^o. By changing access rights we obtain a new game characterized by v^1. The impact of the change on a player i is then given by $\phi_i(v^1) - \phi_i(v^o)$.

When deriving the value function, we have to make two major assumptions on the scope of the game. The first refers to the temporal scope and the second refers to the geographical scope including the level of regional disaggregation.

Specification & Calibration

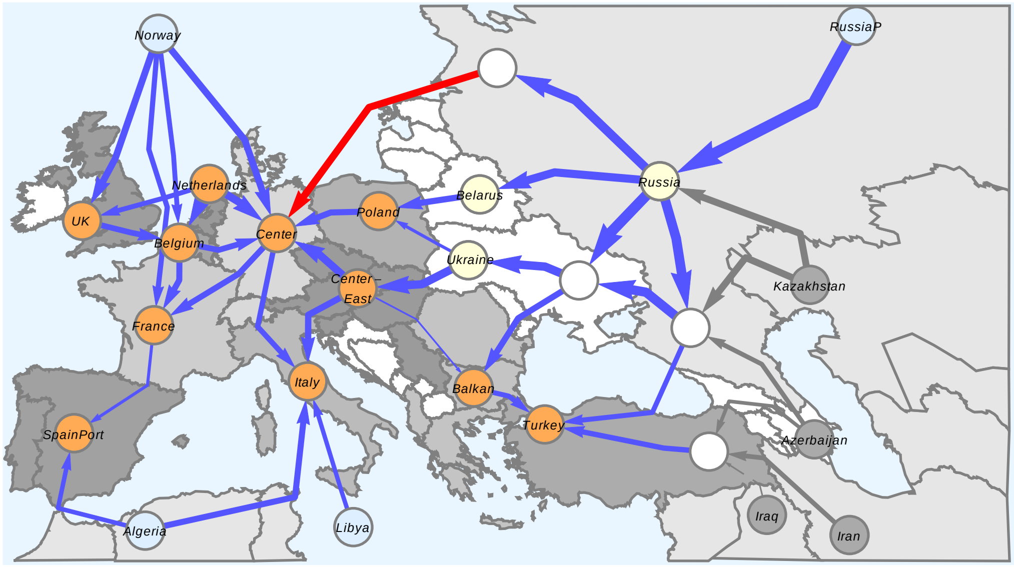
Temporal scope / network flexibility. We assume a stationary environment with constant demand, technology and production cost etc. The value of a coalition, nevertheless, depends on the temporal scope of the model (Hubert and Ikonnikova (2011)). In the short run, there are less instruments available to increase the surplus than in the long run. It is instructive to look at three different scenarios:

Very short term: It covers a time span lasting up to several weeks. The Ukrainian transit crisis in January 2009 may be taken as practical illustration for this case. The events showed the immediate impact of the withdrawal of one player, Ukraine, on gas flows and consumption, given the very high demand in the winter season, peaking load on major transport links and maximal withdrawal from storage facilities. The 'very short term' is like an emergency scenario, in which only gas flows can be redirected.

Short term: Here we consider a span of one year up to perhaps three years. Such a period allows to ignore the seasonal pattern of demand and the possibility of gas storage.[6] It is also long enough to convert existing pipeline to bidirectional usage but too short to build new pipelines or develop new fields. We refer to this variant as the 'status-quo' variant, because pipeline capacities are static. It can also be interpreted as a 'shortsighted' assessment of power, because the effects of adjustments which take longer than two or three years to be achieved are simply ignored.

[6] In Europe storage facilities help to smooth seasonal patterns of consumption, but at present they are too low to act as a strategic reserve for longer periods.

Figure 1: The Network



Blue nodes represent producers, major transit nodes are white. Russia, Belarus and Ukraine are marked with yellow color as we introduce domestic consumption for these countries. Orange 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 2005. Grey nodes and pipelines are taken into account but not considered as strategic instruments. The red pipeline is Nord Stream, which started the operation recently.

Long term: Here we envisage a scenario in which transport capacities can be increased. As a result the network is considered to be flexible. As these investments will take at least a couple of years to become effective, we consider a period starting some three years ahead from the date for which we assess the power structure. We refer to this variant as flexible network, because a coalition can use (almost) all investment possibilities to enhance its value. It can be also considered as a 'farsighted' assessment of power because it ignores the period which is needed to bring new capacities on stream.

We assume that decision makers, when assessing bargaining power, look beyond the very short term emergency, but we are somewhat agnostic as to whether they tend more to the 'shortsighted' or to the 'farsighted' view. It is worth remembering that many gas contracts are long-term covering periods from 5 to 20 years, so we would expect that the conditions agreed on, reflect long term considerations. On the other hand, the further one projects into the future, the more uncertain the prospects become, so that the clearer short term options may exert a stronger influence on relative power. In any case, we will report results for both cases and take these as limits for the range in which we would expect the true values to be.[7]

Geographical scope. To obtain a detailed representation of the various customers, owners of pipelines and 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 (for a stylized picture of the network see figure 1).

As to outside producers we focus on Russia, Norway, Algeria and Libya which together cover about 85% of the gas imports into the European Union.[8] Main transit countries for Russian gas are Belarus and Ukraine. We introduce domestic consumption for Russia, Belarus and Ukraine. Turkey is a major gas consumer and a possible transit country for Russian gas. We aggregate customers and producers within the European Union into ten regional players. Each controls local production, access to local customers, and possibly transit through the region. France, Italy, Poland, Netherlands, UK and Belgium correspond to the 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, Hungary, Serbia and Slovenia in one region called “Center-East”. South Stream and Nabucco would end in Center-East, from where gas would 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 80 % of its imports on 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 pipeline imports are well diversified between Russia (35%), Norway

[7] As pointed out in Hubert and Ikonnikova (2011), due to the linearity of the Shapley Value, the ‘shortsighted’ and the ‘farsighted’ assessment can be combined easily to obtain a more balanced result. Let v^s denote the value function and ϕ^s be the power index for the ‘shortsighted’ game and v^f and ϕ^f characterize the ‘farsighted’ variant, then the Shapley value of the weighted game is given as weighted average of the two Shapley values $\bar{\phi} = \delta\phi^s + (1 - \delta)\phi^f$.

[8] Figures are calculated for the year 2009 from BP (2010).

(34%) and Netherlands (26%). Spain and Portugal are aggregated into “SpainPort”. Finally, we collect Romania, Bulgaria and Greece in a region called “Balkan”. The region has only weak links to other European regions and imports mainly Russian gas. We aggregate all pipelines and interconnection points between any two players into one link. As to access rights, we assume that outside EU every country has unrestricted control over its pipelines and gas fields.

Cost and demand. The details of the numerical calibration are given in a technical appendix. Here we outline only the main principles. We assume piece-wise linear production cost for each producer and linear demand functions with the same intercept for all regions. The model is calibrated using data on consumption in the regions and flows between the regions from 2009. Production cost have a common base, to which we make minor regional adjustments to replicate flows in 2009. The slope parameters of demand are estimated as to replicate the consumption in 2009. 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 supplying gas the network is able to deliver the efficient amount of gas into the different consumption nodes. Nevertheless, the options to change the network will affect bargaining power, because they allow coalitions, which do not have access to the full network, to adjust it to their needs.

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.

3 Results

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.

When we assess the impact of a change in the rules for pipelines access, we compare the power index for two games. Generally speaking, a player benefits from getting better access to complementary inputs himself, but at the same time suffers from competitors also gaining better access. More specifically, a producer may gain from better access to markets, but he may suffer from his rivals improved access to the same markets, i.e. increased supply competition. A customer may gain from better access to suppliers, but he may suffer from other customers improved access to the same producers, i.e. increased demand competition. Finally, a transit country may gain from better access to markets and suppliers, but it may be harmed by other transit routes gaining access to the same markets and suppliers, i.e. increased transit competition. The change of own access will feature prominently in those coalitions, which do not include major rivals, whereas the effect on competition will be stronger in coalitions which include many potential rivals.

The trade-off between access and competition is complicated by the fact that some countries play multiple roles. For example, Center-East is a major gas customer, a transit region for Russian gas flowing westwards, and a transit region for North-Western gas flowing eastwards. Moreover, the role of a player depends on the coalition against which he is evaluated. For example, Italy and Turkey are importers when all players are in the coalition. However, Turkey becomes a transit country for Russian gas in a smaller coalition, for which neither gas from North Sea nor transit through Belarus and Ukraine is available. Similarly, Italy becomes a transit country for North-African gas, if other producers drop out. If we consider coalitions consisting only of countries, which are customers in the grand coalition, those with higher own production relative to demand should start exporting. Multiple and changing roles make it sometimes difficult to predict, what the overall impact of a measure on a player will be.

Fragmented Market

Our benchmark structure reflects the situation in Europe before the onset of reforms. We consider a fragmented market composed of regional monopolies, each controlling local production and both the high pressure transport network, hence, long distance gas transit, as well as the low pressure distribution network, hence, access to the customers in its region. While each customer can access producers only through the ‘regional champion’, we can accommodate various institutional arrangements at the local level. The champion may be a private profit maximizing firm efficiently exploiting local customers or an efficient public utility acting in the best interest of its constituency. In other words, we focus on how the surplus is shared between regions but we are agnostic about rent sharing within a region.

For this institutional set up we consider two network scenarios. The first reflects major pipeline as operational around the year 2005. The second takes into account the new offshore pipeline Nord Stream. For each network scenario we look at the shortsighted and the farsighted assessment of bargaining power, leaving us with four variants of the benchmark structure. In table 1 we report the Shapley values for the different variants. To simplify the interpretation, we consider only the surplus from cooperation regarding pipeline gas. So we deduct the payoff, which players can obtain on their own (e.g. from consuming own production or LNG import). All figures are given as percent of the total surplus. Figures in the first column report the shortsighted power assessment for the old pipeline network. Altogether, the group of outside producers, transit countries for Russian gas and the major EU supplier, the Netherlands, obtains a share of 46 per cent. The Russian supply chain receives more than half of this share or roughly a quarter of the total surplus. Belarus and Ukraine gain not only from transit, but also from consuming Russian gas. Other powerful producers are Algeria, Norway and Netherlands with shares of 4.7, 9.7 and 5.0, respectively. Their shares reflect their production capabilities but also their strategic location vis-a-vis major customers. Turkey and the EU countries (except Netherlands) benefit mainly through imports and transit of gas. Typically, their shares increase in the size of their own market, decrease in the amount of gas obtained through alternative means such as own production and LNG imports, and increase in their importance as a transit region. With a share of 17.9 Center, which includes Germany, Switzerland and Denmark, benefits most from cooperation. It is a large market with little own supply or LNG imports and a strategic location for potential gas transits. Balkan (0.7), in contrast, collects a number of countries with little consumption, considerable own production and few transit options.

In the farsighted assessment (second column), we employ a longer perspective and allow for investment in additional pipeline capacity. It is worth remembering that due to our calibration the grand coalition of all players would decide against such investments. Nevertheless, the investment options have a substantial impact on the power index. Russia increases its share by 24 percent up to 16.4, while the transit countries Ukraine and Belarus see their shares cut by 25 and 11 percent,

Table 1: Fragmented Market: Exclusive Access to Trunk Pipes

	Shapley Values in percentage of the total surplus			
	without Nord Stream		with Nord Stream	
	shortsighted	farsighted	shortsighted	farsighted
Russia	13.2	16.4	16.0	16.9
Belarus	4.5	4.0	4.1	3.9
Ukraine	7.7	5.8	6.2	5.4
Algeria	4.7	4.0	4.4	3.9
Libya	1.5	1.2	1.4	1.2
Norway	9.7	7.4	7.7	7.0
Turkey	1.8	1.7	1.8	1.7
Netherlands	5.0	3.9	4.1	3.8
Balkan[a]	0.7	1.1	0.6	1.1
Belgium	3.9	3.8	3.9	3.8
Center-East[b]	7.0	6.7	6.7	6.6
France	5.3	5.8	5.6	5.9
Center[c]	17.9	20.5	20.7	21.0
Italy	12.3	13.2	12.7	13.2
Poland	1.9	1.7	1.6	1.6
Spain/Portugal	0.9	1.1	0.9	1.1
UK	1.9	1.8	1.8	1.8
sum EU	56.9	59.5	58.5	59.9

[a] Romania, Bulgaria and Greece

[b] Austria, Czech Republic, Slovakia, Hungary, Slovenia and Serbia

[c] Germany, Switzerland, Denmark and Luxembourg

respectively. Russia's main competitors Algeria, Norway and Netherlands all loose about a fifth of their shares. Center and Italy gain while Center-East looses bargaining power. To a large extent these effects are driven by the option to invest in Nord Stream.[9] There are two exceptions, Balkan and Italy, which mainly gain from the option to strengthen pipeline links to the Center-East and Center. The figures in columns 3 and 4 assess power for the time after the completion of Nord Stream. Comparing columns 3 and 1, we see that the completion of Nord Stream with a capacity of 55 bcm/a has a strong impact on the shortsighted power index. In fact the shortsighted power index when having Nord Stream in place, hence investment cost sunk, is similar to the farsighted index (column 2) when Nord Stream is only an expensive option (again Balkan and Italy are the exception). Accounting for additional investment options in other links has only little effect on the power index. After the completion of Nord Stream, the differences between a shortsighted and a farsighted evaluation (column 3 and 4) become small.

Integrated Market

Starting from a fragmented market, an integrated market is achieved by liberalizing access to the high pressure pipelines within EU. While regional champions still control local production and access to low pressure distribution, hence local customers, they cannot block long distance transit. As a result, competition between the regions as well as among producers is enhanced. A priory, the effect is ambiguous. On the one hand producers gain through improved access to customers. For example, in a fragmented market, Russia needs the cooperation of Center and Poland or Center-East to deliver gas along the eastern corridor to reach customers in France. With liberalized access, Russia is entitled to use the transit pipelines and needs only the distribution network in France to access the customers in this region. Russia as a producer and France as a customer gain by saving transit rents at the cost of Center, Center-East and Poland. By the same argument, however, competition between producers is intensified. In a fragmented market, producers enjoy market power vis-a-vis captured customers, i.e. those regions which need cooperation of other European countries to access alternative suppliers. After liberalization of pipeline access, any two producers connected to the European transit grid will compete for any European customer.

In table 2 we present the impact of integration measured as the change in percent-

[9] A similar result has been obtained in Hubert and Ikonnikova (2011) for the North-Western region of the network.

Table 2: Impact of Wholesale Market Integration

	Change in percentage points compared to table 1			
	without Nord Stream		with Nord Stream	
	shortsighted / farsighted		shortsighted / farsighted	
Russia	−2.7	−3.7	−2.9	−3.7
Belarus	1.5	1.3	1.2	1.3
Ukraine	0.3	0.1	−0.1	0.0
Algeria	0.4	0.7	0.0	0.6
Libya	0.2	0.2	0.1	0.2
Norway	1.8	2.1	2.0	2.1
Turkey	0.2	0.4	0.2	0.4
Netherlands	0.2	0.4	0.4	0.4
Balkan[a]	0.0	−0.3	0.0	−0.2
Belgium	−1.0	−0.7	−0.8	−0.7
Center-East[b]	1.0	2.0	1.9	2.2
France	0.7	0.7	0.9	0.8
Center[c]	−3.0	−4.3	−4.7	−4.6
Italy	1.1	1.4	1.7	1.5
Poland	−0.4	0.0	0.0	0.1
Spain/Portugal	0.0	−0.1	0.0	−0.1
UK	−0.2	−0.3	−0.1	−0.2
sum EU	−1.7	−1.2	−0.6	−0.9

[a] Romania, Bulgaria and Greece

[b] Austria, Czech Republic, Slovakia, Hungary, Slovenia and Serbia

[c] Germany, Switzerland, Denmark and Luxembourg

age point compared to the benchmark cases in table 1. Perhaps the most important result is that the members of the Union as a group lose from liberalizing gas traffic among themselves. Their share decreases by 1.7 percentage points of the surplus in a shortsighted assessment of power before Nord Stream is available (column 1 of table 2). The losses become smaller in a farsighted evaluation of power (-1.2) or when Nord Stream is online (-0.6 and -0.9 for short and farsighted variant, respectively). These results cast into doubt that it is in the general interest of EU to liberalize access to the transmission networks. In other words, the results support the view that strong regional monopolies may be needed to counter the power of large producers. However, there are marked differences in the way the redistribution of bargaining power affects the various regions within EU as well as the various producers outside.

EU Countries. Center, here a union of Germany, Denmark and Switzerland, depends little on transit within EU. The region is directly connected to Netherlands and

Norway and has already two competing supply routes, Ukraine/Center-East and Belarus/Poland, for Russian gas, to which the completion of Nord Stream added a direct link. Hence, as a customer Center has little to gain from liberalization. At first glance Center's role as a transit country may appear to be modest. With 4.3 bcm/a and 9.1 bcm/a gas flows through Center to France and to Italy, respectively, are not particular large. However, the region is Europe's most important *potential* gas hub. Whenever one of the major producers is taken out of the picture, Center becomes a central transit region. Suppose Russian gas flows through Ukraine are interrupted. Norwegian and Dutch gas would have to flow through Center to reach Center-East and Italy. Similarly, if Norway's gas is to be substituted by supplies from Russia and Netherlands, these would have to travel through Center to reach the customers. Due to its strategic location Center enjoys substantial bargaining power as a potential transit region, which is lost when pipeline access is liberalized. As a result Center carries a loss of 3.0 percentage points, which further increases in the farsighted assessment or with the completion of Nord Stream. Belgium is another EU member, which will loose from liberalization for similar reasons.

Center-East $(+1.0)$ and Italy $(+1.1)$ in contrast, are regions set to gain from liberalized pipeline access. They highly depend on pipeline gas, but being directly connected only to one producer have little leverage over suppliers. As a result their bargaining position is strengthened through improved access to alternative suppliers. Somewhat surprisingly, even for Center-East, the important transit country for Russian gas, improved supply competition matters more than the loss of transit power. Center-East features higher gas transits than Center, but at the same time is more easily substituted for, in particular after Nord Stream becomes available.[10]

The pattern differs for Poland. Though Poland, as Center-East region, is the captured customer of Russia, it suffers a small loss of power (-0.4). On the one hand, Poland has much smaller market than Center-East. On the other hand, Poland is an important transit region for the Western part of the network and for Belarus with minor own production. For Poland the loss of transit power matters more than the improved supply competition. However, after Nord Stream becomes available,

[10] The liberalization's impact on the Shapley values given in table 2 already nets out gains in the contribution to some coalitions and losses in the contribution to others. If we look at these two components separately, we find that Center's gain from increased supply competition $(+1.3)$ constitute roughly a half of those for Italy $(+2.8)$ and Center-East $(+2.7)$, which have much smaller markets. Loss from curbing transit power and increased demand competition, in contrast, is - 4.4 percentage points for Center, much larger than Center-East's (-1.7).

Poland is more easily substituted for and the negative effect is offset.[11]

Outside Producers and Transit Regions. Russia faces important transit constraints outside EU, but with respect to EU itself it can deliver gas through a number of geographically diversified entry points such as Balkan, Center-East, Poland and Center (with Nord Stream). It also has direct access to Turkey. As a result, Russia gains little in terms of market access but will loose in terms of increased supply competition for regions such as Poland and Center-East. Norway starts from the opposite position. With its main connections all located in the North West, it has less diversified access to Europe. Moreover, it does not benefit from ‘captured customers’, as Russia does. Norway faces direct competition from Netherlands, which neighbors its direct customers. To reach other important markets, such as Italy, France and potentially Center-East and Poland, it depends on transit through Center and Belgium. As a result Norway gains from the integration through improved market access.

Liberalizing pipeline access within the EU increases the power of Belarus and has an ambiguous effect on Ukraine. On the one hand, both transit countries for Russian gas have domestic consumption and, hence, gain through improved access to alternative sources of gas. On the other hand, in the integrated market it becomes cheaper to circumvent each of the countries, but, as long as Nord Stream is not available, it requires the other country to do so. For example Russian gas can bypass Ukraine by flowing through Belarus, Poland, Center and back to Center-East and Italy. Avoiding transit rents for Poland and Center enhances the position of Belarus and weakens the position of Ukraine. As a result, when Nord Stream is not taken into account, Belarus and Ukraine gain 1.5 and 0.3 percentage points, respectively. With Nord Stream the positive effect of the improved access to markets is weakened for both countries, so that benefits of Belarus decrease ($+1.2$), while Ukraine is exposed to the slight loss of power (-0.1).

Integration and the Risk of Producer Cartels

Several initiatives of gas producing countries to establish a cartel similar to the OPEC have failed to produce tangible results. At first glance this may look surprising as it requires only a small number of major exporters to Europe to coordinate.

[11] Poland, having much smaller market than Center-East, gains only $+0.4$ percentage points from the improved supply competition. At the same time Poland suffers (-0.8) from a loss of transit power and increased demand competition.

Table 3: Pipeline Access and Producer Cartel

	Fragmented Market[a] shortsighted	Fragmented Market[a] farsighted	Integrated Market shortsighted	Integrated Market farsighted
	No cartel [absolute shares]			
Russia	16.0	16.9	13.1	13.2
Algeria	4.4	3.9	4.4	4.5
Norway	7.7	7.0	9.7	9.1
sum others	13.4	12.3	14.9	14.1
sum EU	58.5	59.9	57.9	59.0
	Impact of cartel: *Russia*, *Algeria* [differences]			
Russia+Algeria	1.5	1.7	0.7	0.6
Norway	0.1	0.2	1.0	1.3
sum others	−0.4	−0.3	−0.7	−0.5
sum EU	−1.2	−1.6	−0.9	−1.4
	Impact of cartel: *Russia*, *Algeria*, *Norway* [differences]			
Russia+Algeria+Norway	6.5	7.0	6.1	6.4
sum others	−1.1	−0.6	−2.2	−1.6
sum EU	−5.4	−6.5	−3.9	−4.8

[a]All variants are with Nord Stream being in place.

One reason may be that competition between producers is weak in a fragmented market and so may be the incentives to form a cartel to reduce competition. If competition is increased through liberalized access to the transport system, the gains from cartelization may increase as well. However, our calculations show that liberalizing access to the EU transit system appears to decrease the risk of a producer cartel.

The upper panels of table 3 summarize previous results. The left panel gives figures for the case of exclusive access to pipelines obtained from the right panels of table 1. The right panel reports the shares for liberalized access. It can be obtained by adding the right panels of table 1 and 2. In the middle and lower panels we report the gains and losses from establishing cartels among gas producers. As expected cartels are profitable. If Russia and Algeria form a cartel against a fragmented market they gain 1.5 and 1.7 percentage points in the shortsighted and farsighted assessment of power, respectively. If all major exporters join the cartel, the gains increase to 6.5 and 7.0 points, respectively.

Cartels remain profitable in an integrated market, but the gains from cartelization become smaller. In a fragmented market, there are important instances of bilateral competition for customers, which create strong incentives for cartelization. For example Italy is a major customer for Russian and Algerian gas. In a fragmented market other potential suppliers, such as Netherlands and Norway, are kept at bay by the need to ensure transit. Hence Russia and Algeria gain a lot by eliminating their mutual competition. In an integrated market Italy's access to alternative sources of gas is improved. Hence, the rent for which Russia and Algeria compete is diminished and so are the gains from cartelization. At the same time the spill-over to competing producers becomes larger.

Mergers and Centralization

In the previous section we argued that liberalizing access to the long distance network hurts the regions within EU as a group. Forcing regional champions to open their trunk pipes to competitors, or even spinning them off into a separate business, works against the fragmentation of the market by loosening up the vertical integration of the industry. Now we will turn to the question, how horizontal concentration affects the power structure. Such concentration can be result of private mergers of 'regional champions' like the E.ON - Ruhrgas merger mentioned in the introduction. It can also be achieved through public intervention such as the attempts of the European Commission to coordinate the EU's foreign gas relations.

Following Segal (2003) we model a merger as a change by which one party, the 'proxy player', acquires the exclusive right to use the resources of the other parties, which thereby become 'dummy players'. This change of access rights defines a new game. For the merging parties, the impact is measured by the difference between the share of the proxy player and the sum of the individual pre-merger shares. For all other players it is simply the difference between their shares in the two games. We have to distinguish two cases depending on whether we start in a fragmented market with exclusive access to trunk pipelines or in an integrated market where access is liberalized. In a fragmented market, the parties merge local production, access to local customers, and their transport network. Once the market is integrated, the merger embraces only local production and customer access. A centralized external policy of the European Union can be analyzed in the same manner. All members transfer their decision rights as far as relations with outsiders are concerned to a central player. With respect to the outside world, political centralization yields the same result as if the national champions would merge into a single 'European super champion'.

Recall that a merger does not change the total surplus, which depends only on the cost of producing and transporting gas and the benefits from consuming it. Hence, it benefits the merging parties only if surplus is redistributed at the cost of non-merging players (outsiders). Under which circumstances can this be expected? As is shown in Segal (2003) the answer to this question turns out be complicated. It does not depend on whether the resources of the merging parties are complements or substitutes as such. Instead, a merger between two players i and j harms an outside player k, hence benefits i and j, if their complementarity is decreased (their substitutability is increased) by k.[12]

Table 4 presents the impact of selected mergers and centralization on the power structure. For simplicity we report only the shortsighted scenario with Nord Stream being operational. Left and right panels refer to the fragmented market and the integrated market, respectively. The figures indicate by how many percentage points the players' share will change in comparison to the relevant benchmark case. In the first column of the left panel we report the impact of a merger between Center and Center-East, two important transit regions in a fragmented market. Such a merger would make it easier for Russian gas to bypass Ukraine but also for Norwegian gas to reach Russia's captured customers. As a result, Ukraine looses 0.8 points, Norway gains 0.4 points, while the impact on Russia is negligible. Within EU, Netherlands gains for similar reasons as Norway but Italy suffers. Center and Center-East provide alternative import routes for Italy so they gain by avoiding transit competition. The merging parties gain 0.4 points and the EU in total would gain, because the bargaining power of outsiders is weakened. In an integrated market, however, the same merger has very different effects (left column in the right panel). It is no longer profitable for the merging parties (-0.3), nor it is for the EU (-0.3). Russia and transit countries gain, while Algeria suffers a small loss.

For a merger between Center and Italy we observe a similar pattern. In a fragmented market the EU gains at the cost of outsiders, although in this case the African producers Libya and Algeria loose while Russia and Norway gain. Inside EU the merging parties and Netherlands gain while Center-East suffers. Italy depends more on Center-East for importing Russian gas than Center, which has alternative routes (e.g. Nord Stream). So the merger diminishes the transit power of Center-East. In an integrated market, the merger becomes unprofitable for the

[12]Two players i and j are complements (substitutes) with respect to a group S of players, if i's contribution to value of S is larger (smaller) if S includes player j. k decreases the complementarity (increases the substitutability) of i and j, if this difference becomes smaller (or larger in absolute terms if it is negative), if S also includes k. In a complex network like ours, such a criterion will never be fulfilled for all possible S and all possible outsiders k, but the network structure determines what will be more prominent on average.

Table 4: Impact of Mergers and Centralized Bargaining

	fragmented Market[a]				integrated market[b]			
	Center is merged with							
	Center East	Italy	Nether-lands	all EU	Center-East	Italy	Nether-lands	all EU
Russia	0.0	0.4	−1.9	−1.3	0.2	0.3	−0.6	−0.5
Belarus	0.0	0.0	0.0	0.3	0.1	0.1	−0.1	0.1
Ukraine	−0.8	−0.1	−0.2	−0.9	0.2	0.3	−0.3	0.5
Algeria	0.0	−0.6	−0.2	−1.4	−0.1	−0.1	−0.1	−0.9
Libya	0.0	−0.2	−0.1	−0.5	0.0	0.0	0.0	−0.3
Norway	0.4	0.4	−0.6	−0.3	0.0	−0.1	−0.5	−1.7
Turkey	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Netherlands	0.4	0.3	-	-	−0.1	−0.1	-	-
Balkan[c]	0.0	0.0	0.0	-	0.0	0.0	0.0	-
Belgium	0.1	0.0	−0.8	-	0.0	0.0	0.0	-
Center-East[d]	-	−0.4	0.4	-	-	0.0	−0.1	-
France	0.0	−0.1	−0.1	-	0.0	0.0	−0.1	-
Center[e]	0.4	0.3	3.2	4.2	−0.3	−0.5	2.1	2.7
Italy	−0.4	-	0.3	-	0.0	-	−0.1	-
Poland	−0.1	0.0	0.1	-	0.0	0.0	0.0	-
Spain/Portugal	0.0	0.0	0.0	-	0.0	0.0	0.0	-
UK	0.1	0.0	0.0	-	0.0	0.0	−0.1	-
sum EU	0.4	0.2	3.0	4.2	−0.3	−0.4	1.7	2.7

[a]Shortsighted assessment with Nord Stream being operational. Difference to table 1, column 3.

[b]Shortsighted assessment with Nord Stream being operational. Difference to the sum of column 3 of table 1 and column 3 of 2.

[c] Romania, Bulgaria and Greece

[d] Austria, Czech Republic, Slovakia, Hungary, Slovenia and Serbia

[e] Germany, Switzerland, Denmark and Luxembourg

parties (-0.5) and the EU (-0.4), while Russia and transit regions gain in a similar fashion as if Center and Center-East would merge.

The third example of a pairwise merger is between Center and Netherlands. It would pool a major producer with a large market and important transit region. In a fragmented market this merger would be highly profitable both for the merging players (+3.2) as well as for EU as a group (+3.0). Within EU the power of Center-East and Italy increases by 0.4 and 0.3 percentage points, respectively. Both regions increase complementarity of merging Center region and Netherlands. In the fragmented market Center is a transit region for Italy and Center-East for gas from the Northwest, including Netherlands. Therefore, both customers increase complementarity of Center as transit region and Netherlands as a producer. Belgium in contrast is hurt (-0.8) because it competes with Center for Dutch gas. All outside producers are hurt by the merger, with Russia and Norway bearing the brunt of the losses. As in the other cases, liberalization of pipeline access tends to decrease the profits of a merger, but the effect is not strong enough to turn it into a loss. In an integrated market, the merging parties gain 2.1 points. The gain for EU (loss to outside suppliers) is 1.7 points.

If thought to an end, a sequence of pairwise mergers would lead to full centralization, which is also the aim of the EU's attempts to speak 'with a common voice' in all external energy relations. The last columns of the two panels show the impact of such a scenario. Bargaining as a group the EU would gain 4.2 percentage points in a fragmented market and 2.7 points when internal markets are already integrated.

In summary, we find that in a fragmented market pairwise mergers of 'national champions' tend to be profitable for the parties. There is however much heterogeneity in the impact on others. As a rule some outside producers gain while others loose and the same holds true for other regions in the Union. So we see little evidence for the view, that it takes large European players to counter the power of outside producers. Once market integration is achieved, the attractiveness of mergers is much decreased and the results become more homogeneous. Bilateral mergers within EU have small effects on their fellow EU regions, Norway and Algeria, but they tend to increase the power of the Russian supply chain.

The reason for this pattern is to be found in the architecture of the network. Overall, the transport system is designed to ship gas from different points at the periphery Northwest (Netherlands and Norway), East (Russia) and South (Algeria, Libya) to the various centers of consumption in Europe. In a fragmented market each European region enjoys exclusive control of sections of the network of trunk pipelines.

As these pipeline sections tend to be complementary, customers depend on each other to access suppliers. Since outside producers are located at different points, it depends on the particular merger, whether an outside producer increases or decreases the complementary. Take Center and Italy as an example. With respect to Norwegian or Dutch gas Center and Italy are complementary. Italy depends on transit through Center. Algeria reduces this complementarity by providing an independent source of gas for Italy, so it is hurt by the merger. If we consider Russia instead of Algeria, supply in the North becomes very large, hence, Italy's market becomes more valuable for Center. So Russia increases the complementarity and, therefore, benefits from the merger. The first pattern is slightly more prevalent and tends to dominate other effects. As a result bilateral mergers of customer/transit regions tend to harm the group of outside producers and transit countries. However, the opposite case is also common and often the merging parties gain more at the cost of other regions within the EU.

In an integrated market each region enjoys access to the whole network. A merger joins access to customers and local production. The European regions are similar in the sense that they depend on imports, so they are competitors i.e. substitutable with respect to an outside producer.[13] In the previous example, with open access to trunk pipes Center and Italy become substitutable with respect to Norwegian gas. Russia, as additional producer, will reduce the competition between consuming regions and, hence decrease substitutability. Therefore, a merger tends to strengthen the bargaining power of Russia and the transit countries for Russian gas.

4 Concluding Remarks

For a long time European gas markets used to be dominated by 'national champions', vertically integrated firms, controlling local production, trunk pipes, hence imports, and distribution networks, hence access to customers. The EU Commission is trying to overcome this fragmentation by liberalizing pipeline access, breaking up vertical structures and fostering competition between the regions. Critics argue, however, that strong European players are needed to create buyer power against a small number of external gas suppliers, such as Russia, Norway and Algeria, on which the EU depends for more than half of its consumption.

In this paper we model the European gas supply system as a cooperative game and use the Shapley value as a power index for the players. We analyze how the

[13] The main exception is Netherlands, which produces gas in excess of its own consumption.

liberalization of access to the European high pressure transport system affects the power of the various regions. Such a measure would establish an integrated wholesale market by stripping the national champions of their power to block interregional gas transit. However, it falls short of creating a truly competitive internal market, because access to local customer through low pressure distribution networks is still monopolized.

We find that forcing the European companies to open access to their network of trunk pipes, on balance, strengthens the power of external suppliers and transit countries for Russian gas and weakens the regions within EU. There is, however, considerable variety on both sides of the market, which might explain the difficulties of implementing the reforms in the European context. Though market integration tends to strengthen outside producers, it reduces their possible gains from establishing a producer cartel. Overall, with respect to long distance gas transport, we find some support for the claim that it takes 'countervailing power' to curb the dominance of outside producers.

In a fragmented market, pairwise mergers of local champions tend to be profitable and increase bargaining power vis-a-vis outside producers in many cases. But there are also many instances where outside producers gain power. So depending on the particular case, the argument of countervailing power has some validity. However, once access to trunk pipes is liberalized, many pairwise mergers turn unprofitable for the merging parties, mostly because they increase the bargaining power of the Russian supply chain. We also analyze the effect of a centralization of EU gas policy. Independently of whether we start from a fragmented or an integrated market, the EU can benefit a lot by "speaking with one voice".

The next step towards a fully liberalized market would be to open access to customers, for example by unbundling local production from ownership of distribution networks. The national producer would loose its captured local customer base and have to compete against other producers inside and outside EU on level playing field. Most likely such a step will benefit customers within Europe, but again it might come at the expense of increased power of outside producers. In this sense the present paper provides only a partial answer to the question of whether it is worth to protect 'national champions' to curb the power of outside producers.

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A Appendix

Calibration

In this section we describe the functions and parameters used for the calculation of the value function (equation (1) in the main text). Let $f^*_{ij},\ \{i,j\} \in L(N)$ denote the solution to the program in (1) when solved for the grand coalition, which has access to all resources. To calibrate the model, we have to determine p_j and T_{ij} such that f^*_{ij} are reasonably close to observed consumption patterns and flows. As we assume that the players cooperate effectively, they will make efficient use of the existing network. Hence, in each region the marginal willingness to pay for gas, $p_j(f_{ij})$, will be equal to the local marginal cost of supplying gas, the nodal cost $c_j(f_{ij})$, which take into account the physical constraints of the system. We use this feature to calibrate first inverse demand and then supply cost using data on consumption and flows.

Demand

Transport costs within Europe are small compared to the cost of producing gas and transporting it to Europe's borders. As a first approximation, we neglect the small differences among local cost and assume a common constant supply cost c.[14] For each consumption region we assume a linear inverse demand function. To reduce the number of parameters we assume the same demand intercept $(a + c)$ for all regions. Efficiency requires $p_j(f_{ij}) = a + c - b_j f_{ij} = c$ for each region j. The slope parameters b_j are then calibrated as to replicate the consumption in 2009: $b_j = a/f_{ij}$, where f_{ij} is the consumption of gas in region j compiled from IEA (2010) and IEA (2011).[15] See Table 5 for the resulting parameter values.

The common supply cost c acts as a shift parameter, which does not affect the consumer surplus. A decrease of a, with b_j being adjusted, affects all players proportionally. Such a change has little impact on the *relative* Shapley value (measured in per cent of the surplus), hence, will have little effect on our index for bargaining power.

[14] For none of the links within Europe the capacity constraints were binding in 2009/10. So nodal cost differ only by the variable transportation cost between connected nodes which are small.

[15] All quantities are quoted in bcm/a. All prices or cost are quoted in mn €/bcm (giving the same figure as the more common €/tcm).

Table 5: Pipeline Network: Consumption links

Links		Consumption [bcm/a]	Slope given $a = 500$	Players needed for access
from	to	f_{ij}	b_j	
Russia	RussiaC	426.4	1.2	Russia
Belarus	BelarusC	17.9	28.0	Belarus
Ukraine	UkraineC	53.3	9.4	Ukraine
Belgium	BelgiumC	16.9	29.6	Belgium
Poland	PolandC	16.0	31.3	Poland
UK	UKC	90.5	5.5	UK
Balkan[a]	BalkanC	20.2	24.8	Balkan
Turkey	TurkeyC	36.4	13.7	Turkey
Center[b]	CenterC	104.6	4.8	Center
Center-East[c]	Center-EastC	41.4	12.1	Center-East
Italy	ItalyC	75.6	6.6	Italy
Netherlands	NetherlandsC	48.3	10.4	Netherlands
France	FranceC	44.1	11.3	France
SpainPort[d]	SpainPortC	38.8	12.9	SpainPort

[a] Romania, Bulgaria and Greece

[b] Germany, Denmark, Switzerland and Luxembourg

[c] Austria, Hungary, Czech Republic, Slovakia, Serbia, Slovenia

[d] Spain, Portugal

Production

For each region we introduce a production link, which connects the production site and the network. We present the parameter values for the production links in Table 6.

Our focus is on the imported pipeline gas, which is considered to be the marginal source of gas. For Russia, Belarus and Ukraine welfare includes the benefits from local consumption. We treat Norway, Algeria and Libya as pure producers which benefit only from export earnings. For these countries we consider only production which could be made available for exports to Europe and Turkey after deducting own consumption and exports to other markets. For all players, except Russia, we restrict the capacities of production links to be equal to the respective production volumes in 2009. The data on production volumes are collected from IEA (2010) and IEA (2011).

The differences in the operating cost of producing from existing fields are small compared to differences in the cost of developing new fields. In addition, meaningful information on wellhead production cost is difficult to obtain. As with demand we make a bold assumption by introducing a common production cost parameter c^P with some adjustments (Δ_{ij}) for few cases. Since it is more difficult to produce at maximal capacity k_{ij}, we assume production cost to be piecewise linear : $T_{ij}(f_{ij}) = (c^P + \Delta_{ij})(\min[f_{ij}, 0.75 * k_{ij}] + 1.2 \max[f_{ij} - 0.75 * k_{ij}, 0])$. Per unit production costs are constant, but only up to 75% of the pipe capacity and increased by 20% for the remaining 25%. These adjustments help to get more realistic flows for the network, but have only a negligible impact on our estimate of bargaining power. Since the demand system is adjusted to any choice of c^P, its absolute value is rather irrelevant and arbitrarily set as $c^P = 20$. To account for the regional differences in wellhead production cost we compute Δ_{ij} based on Table 13.6 (IEA (2009)). For most EU regions, as well as for Belarus and Ukraine, we ignore any cost of own production.

LNG

In case of all market structures a local champion (or a region itself) controls not only own production, but also LNG-imports. For all EU players we introduce LNG links, which represent the LNG terminals. The parameter values are reported in Table 7. The data on LNG-imports are collected from GIE (2010), IEA (2010) and IEA (2011). In accordance with Table 13.5 and Table 13.6 in IEA (2009) we set the total costs of using LNG to be equal to $2c^P$ which gives LNG a slight disadvantage

Table 6: Pipeline Network: Production links

Links from	Links to	Capacity [bcm/a]	Flow [bcm/a]	Operating Cost $c^P + \Delta_{ij}$ [€/tcm]	Players needed for access
Production outside EU					
RussiaP	Russia	650.8	550.5	c^P	Russia
NorwayP	Norway	99.4	99.4	$c^P - 7$	Norway
AlgeriaP	Algeria	77.7	77.7	$c^P - 5$	Algeria
LibyaP	Libya	15.9	15.9	$c^P - 8.8$	Libya
BelarusP	Belarus	0.2	0.2	0	Belarus
UkraineP	Ukraine	21.9	21.9	0	Ukraine
Production within EU					
BalkanP	Balkan	10.8	10.8	0	Balkan
BelgiumP	Belgium	0	0	0	Belgium
CenterEastP	CenterEast	4.9	4.9	0	CenterEast
FranceP	France	0.9	0.9	0	France
CenterP	Center	23.7	23.7	0	Center
ItalyP	Italy	8.1	8.1	0	Italy
NetherlandsP	Netherlands	78.7	78.7	$c^P - 4.4$	Netherlands
PolandP	Poland	5.8	5.8	0	Poland
SpainPortP	SpainPort	0	0	0	SpainPort
TurkeyP	Turkey	0.7	0.7	0	Turkey
UKP	UK	62.1	62.1	0	UK

Table 7: Pipeline Network: LNG links

Links from	Links to	Capacity [bcm/a]	Flow [bcm/a]	Operating[a] Cost $c^P + \Delta_{ij}$ [€/tcm]	Players needed for access
BalkanLNG	Balkan	0.8	0.8	$2c^P$	Balkan
BelgiumLNG	Belgium	3	3	$2c^P$	Belgium
FranceLNG	France	10.1	10.1	$2c^P$	France
CenterLNG	Center	0	0	$2c^P$	Center
ItalyLNG	Italy	2.9	2.9	$2c^P$	Italy
NetherlandsLNG	Netherlands	0	0	$2c^P$	Netherlands
PolandLNG	Poland	0	0	$2c^P$	Poland
SpainPortLNG	SpainPort	28.5	28.5	$2c^P$	SpainPort
TurkeyLNG	Turkey	6.1	6.1	$2c^P$	Turkey
UKLNG	UK	10.1	10.1	$2c^P$	UK

[a] The global parameter c^P is set equal to 20. We give the unit cost for flows up to 75% of the capacity. For the remaining 25% of capacity the numbers are increased by 20%.

compared to pipeline gas. As before, we assume a piecewise linear cost function: $T_{ij}(f_{ij}) = 2c^P * (\min[f_{ij}, 0.75 * k_{ij}] + 1.2 * \max[f_{ij} - 0.75 * k_{ij}, 0])$, where k_{ij} denotes the capacity of the link. We restrict the capacities of LNG links to the respective flows in 2009.

Transport

The total cost of transporting gas consists of operating cost and capacity cost. In the shortsighted assessment of power, capacity costs of existing pipelines are sunk and we do not take them into account. This simplification is based on the assumption that bargaining among rational players should not be influenced by sunk cost.

The operating cost is composed by management & maintenance cost and energy cost, which are proportional to the length of the pipeline as well as to the quantity of gas transported. Since it is difficult to run a pipeline throughout the year at maximal capacity, we assume a piecewise linear function: $T_{ij}(f_{ij}) = c^T_{ij} * (\min[f_{ij}, 0.75 * k_{ij}] + 1.2 * \max[f_{ij} - 0.75 * k_{ij}, 0])$, where k_{ij} denotes existing capacity. Per unit transportation costs are constant, but only up to 75% of the pipe capacity and increased by 20% for the remaining 25%. Capacities of the links between the transit nodes are compiled from ENTSOG (2010) and public sources. The data on flows are collected from IEA (2010) and IEA (2011). Capacities of the links, which are connected to the areas outside of the regional scope, are limited to the respective flows in 2009.

Table 8: Pipeline Network: Transit

Links from	Links to	Capacity [bcm/a]	Flow [bcm/a]	Operating Cost c_{ij}^{T} [€/tcm]	Capacity Cost[a] c_{ij}^{K} [€/tcm/a]	needed for access[b]
Transit outside EU						
Russia	Belarus	100	49.2	2.1	-	Russia, Belarus
Russia	RussiaN	165	0	2.3	-	Russia
Russia	RussiaS	240	8.9	2.1	-	Russia
Russia	UkraineE	415	109.1	2.0	-	Russia, Ukraine
RussiaS	UkraineE	200	24.6	1.2	-	Russia, Ukraine
UkraineE	Ukraine	122	95.1	2.5	12.6	Ukraine
TurkeyE	Turkey	20	11.8	2.4	12.1	Turkey
Transit into (out of) EU						
Algeria	Italy	30.2	25.4	6.2	-	Algeria*
Algeria	SpainPort	12	9.2	4.5	-	Algeria*
Libya	Italy	11	9	4.7	-	Libya*
Belarus	Poland	33	31.3	1.4	8.9	Belarus*
Norway	Belgium	15	12.2	5.2	-	Norway*
Norway	France	18.3	15.0	5.9	-	Norway*
Norway	Center	46	29.2	5.2	-	Norway*
Norway	UK	46.4	24.0	4.9	-	Norway*
UkraineE	Balkan	31.3	16.5	3.4	4.	Ukraine*
Ukraine	Center-East	105.8	77.0	1.9	9.5	Ukraine*
Ukraine	Poland	5	3.2	1.2	6.	Ukraine*
RussiaN	Center	0	0	6.9	26.8	Russia*
Balkan	Turkey	16.3	8.9	1.8	9.2	Turkey*
RussiaS	Balkan	0	0	5.6	23.8	Russia*
RussiaS	Turkey	16	8.9	4.8	11.9	Russia, Turkey
Transit within EU						
Belgium	France	30	14.9	0.8	4	In the integrated market access to transit pipelines within EU is free. *In the fragmented market both players from the left column are needed.
Belgium	Center	26	1.0	0.6	3	
Center-East	Balkan	1.7	1	3.3	16.5	
Center-East	Center	77.8	18.4	2.4	12	
Center-East	Italy	37.0	21.3	2.7	13.5	
Center	France	28	4.3	1.4	7.1	
Center	Italy	20.2	9.1	3.5	17.3	
Netherlands	Belgium	53	10.7	0.5	2.6	
Netherlands	Center	80	11.7	0.6	3	
Netherlands	UK	15.3	7.0	1.0	3.5	
Poland	Center	31.4	24.4	3.2	16.1	
UK	Belgium	25.5	7.5	1.5	4.9	
France	SpainPort	4.7	1.1	3.2	15.8	
Balkan	Italy	0	0	3.9	28.5	
Out of regional scope						
Azerbaijan	RussiaS	0	0	3.8	-	Russia
Azerbaijan	TurkeyE	4.5	4.5	2.4	-	Turkey
Iran	TurkeyE	7.2	7.2	1.2	-	Turkey
Iraq	TurkeyE	0	0	1.7	-	Turkey
Kazakhstan	Russia	0	0	5.1	-	Russia
Kazakhstan	RussiaS	32.3	32.3	3.6	-	Russia

[a] In the farsighted scenario we allow for investments in the links within EU and in the pipelines for Russian gas.

[b] We list the players which are needed in the integrated market. We mark with a * those cases, where there is a change for the fragmented market. Then both players from the left column are needed for access to a link.

To calculate the link specific cost parameter c_{ij}^{T}, we assume universal operating cost of 0.3 €/tcm/100km for onshore pipelines. For offshore pipelines we assume operating cost to be 50% higher to account for higher pressure and increased cost of maintenance. These coefficients are then multiplied by the distance between the nodes to obtain the link specific operating cost shown in Table 8 column 4.

Investment

In the farsighted scenario we allow for investment in new capacity for links within EU and in the pipelines for Russian gas. For additional capacities we add annualized capacity cost to the operating cost. To obtain capacity expenditures for new projects and enlargement of existing pipeline networks we refer to public sources for costs estimates of the project consortia, which are supplemented by own estimates if figures are unavailable. To simplify the analysis we abstract from economies of scale and assume constant capacity cost. We use a rather high discount rate of 15% to translate capital expenditures into annualized capacity cost. This rate is a common hurdle rate in the gas industry and reflects the real option nature of the investment and depreciation. For those links where investment is possible, transportation cost are given as: $T_{ij}(f_{ij}) = c_{ij}^{T} * (\min[f_{ij}, 0.75 * k_{ij}] + 1.2 * \max[f_{ij} - 0.75 * k_{ij}, 0]) + c_{ij}^{K} \max[f_{ij} - k_{ij}, 0]$, where c_{ij}^{K} denotes annualized capacity cost, measured in € per tcm per year (for figures see Table 8 column 5).