

Article

An Analysis of Countries' Bargaining Power Derived from the Natural Gas Transportation System Using a Cooperative Game Theory Model

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Abstract: A large consumption of natural gas accompanied by reduced production capabilities makes Europe heavily dependent on imports from Russia. More than half of Russian gas is exported by transiting Ukraine, so in the context of the underlying conflict between the two, this is considered uncertain. Therefore, in this article, we modeled the natural gas transportation system using cooperative game theory in order to determine the bargaining power of the major players (Russia, Ukraine, Germany, and Norway) by using a form of the Shapley value. We described the interaction between countries as network games where utilities from transport routes are considered and proposed three scenarios where the gas flow from Russia to Ukraine is either diminished or completely interrupted, with the purpose of finding out how the bargaining power on this market is shifted in case of network redesign. In this context, we included in the analysis the scenario where the Nord Stream 2 pipeline will be finished. Results showed that Russia dominates the market in any scenario, and by avoiding Ukraine, its position is even further strengthened. Moreover, Germany's position remains stable considering its diverse imports and large storage capabilities, and its bargaining power increases in the case of diminishing or avoiding the Ukrainian gas pipelines.

Keywords: natural gas market; game theory; cooperative games; Shapley value; bargaining power; Nord Stream 2 pipeline



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1. Introduction

The consumption of natural gas in Europe is very large, and projections suggest that it will remain the same for a long period of time. Nevertheless, considering the decreasing trend in domestic production makes Europe heavily dependent on importing it. Due to its specific form, much of the natural gas trade occurs through natural gas pipelines. Russia, through its state-owned company, Gazprom, fulfills around one-third of Europe's need of gas, out of which more than half is delivered through the pipeline system that transits Ukraine.

Given the situation between Russia and Ukraine, this specific supply route is considered a dangerously unstable one. Cutting the gas stream to Ukraine might face Europe with serious problems regarding gas supply. Therefore, in this paper, we try to analyze the impact of this potential cut off and how the rest of Europe can cope with that.

So far, numerous studies have investigated the evolution of trade indicators on the gas markets, analyzed many important players on this market, and researched the causes of different types of conflicts and their possible impact.

When analyzing the current natural gas market in Europe, we selected the four most strategic players on the European market and the connections between them. In Europe, Russia and Norway have the largest natural gas production. Germany in the

most important European hub on gas import and storage; meanwhile, Ukraine is the most important transition country for natural gas. Considering the actual parameters of the natural gas pipeline, we computed measures proposed by the theoretical models and determined the bargaining power of each player on the market. After assessing the status quo, we introduced variations in the pipeline networks and reassessed the position of each player on the market.

The novelty of the paper lays in the fact that we address the gas supply and demand as if the transit through Ukraine had been diminished or even stopped and assess how this will position Russia further in the market. Given the constant conflict between the two countries, this assessment is necessary in order to forward look on how the options look and how will they impact the other consumers in the market.

Currently, a similar player to Russia is Norway, so we try to see how this affects its production capacity, the prices, and what new routes have to be constructed. In order to find pertinent information, we see what the current situation looks like regarding the main players and important transit routes. Afterwards, using cooperative game theory, we try to establish the bargaining power of the major players by computing a form of the Shapley value. Moreover, given the network structure of the gas pipelines, we apply a Network Game Model, where pipeline networks are modeled as graphs.

In our study, we consider Russia and Norway as important exporters, while Ukraine and Germany are considered strategic importers. Beyond the fact that our modeled network confirms that Russia is in a dominant position on this market, given any situation, the results also suggest that Germany is also an important bargaining power. This can be attributed to the fact that it is not dependent on only one importer and also to its large storage facilities.

Given the fact that the gas market has multiple players that need to collaborate for different reasons such as in order to build a pipeline or ensure the maintenance and efficiency of a transmission system, an obvious method to model this market is through cooperative game theory. This revolves around the concept of computing the Shapley value.

The Shapley value is a solution concept in cooperative game theory that was introduced by Lloyd Shapley in his 1953 paper [1]. It gives a fair way of dividing the total surplus generated by the coalitions of n players. The Shapley value is also used to compute the bargaining power of players and has been intensively studied as part of cooperative game theory by authors such as McCain [2] and Vidal-Puga [3]. Other papers focused on different types of games where the Shapley value can be applied as is the case with graph games (for more details, see Khmel'nitskaya et al. [4]), bicooperative games (Bilbao et al. [5]), or in diverse fields such as airport and irrigation games (Márkus et al. [6]).

Given the limited nature of the natural gas resources and the fact that some countries have a large competitive advantage due to their large reserves led to the proposal of numerous descriptive as well as empirical models of the gas market (for a review on the optimization of natural gas transportation systems, see Rios-Mercado and Borraz-Sanchez [7]). The NATGAS model presented by the Netherlands Bureau for Economic Policy Analysis is an integrated model of the European wholesale gas market providing long-run projections of supply, transport, storage, and consumption patterns in the model region, which were aggregated into 5-year periods, distinguishing two seasons (winter and summer).

At the moment, Russia has the largest natural gas reserve and is one of the key players on the exports market; however, its situation has been long debated. Paltsev's [8] study on long-term scenarios on exports toward Europe and Asia concludes that demand will also remain high, especially in Europe, even though LNG imports will increase. The already existing pipelines to Europe should be enough, except for the case when Russia wants to avoid crossing Ukraine.

Peña-Ramos et al. [9] analyzed the Russian power supply goals (as a geo-energy super power) into the European zone. They studied the North Caucasian case of Russian intervention (due to its importance in terms of natural resources, especially hydrocarbons)

and underlined the importance of European Union's "European Green Deal" to reduce the European dependence on Russian energy.

Zhiznin and Timokhov [10] described some economic and geostrategic Nord Stream 2 gas pipeline project aspects. They analyze the role of the NS2 pipeline (especially the positive one) and also the supporters' and opponent's objectives for the project. The conclusion is that the NS2 pipeline is very important for EU and also for Russia and Baltic countries in order to increase the energy security for Western Europe and to diminish the conflict risk into the region.

The conflict between Ukraine and Russia (that was escalating in 2014) led to negative expectations regarding energy relationship between the European countries. Misik and Nosko [11] analyzed this situation from the Central and East European countries' perspective and argued for the necessity of developing a new pipeline (Eastring pipeline, that will connect the main European Gas Hubs with the Black Sea and Turkey Region) in order to improve the gas supply security.

Yemelyanov et al. [12] analyzed the possibility of reduction of natural gas consumption for the Ukrainian economy in order to reduce the dependence on imports. They showed that it is possible to reduce the imported gas quantities only if the internal gas production will increase and not in the short term.

Strong players on the natural gas markets are also some Central Asian countries. In Cobanli [13], the trade between Europe and Asia is represented as a cooperative game solved by using the Shapley value. Some assumptions are made with respect to demand competition, and results show that importing gas from Asia benefits European countries and Turkey in particular.

Moreover, the natural gas market has a high potential for conflict with respect to the diplomatic, political, economic, legal, and environmental aspects of pipeline networks, as mentioned in Nagayama and Horita [14].

Relatively new trends in studying the gas market are the use of game theory and genetic algorithms [15].

Ma et al. [16] analyze the impact of the Ukrainian crisis on the natural gas pipeline projects from Russia to the European Union. They use a multistage dynamic and two-level game theory model to study how the planning of the natural gas pipeline project Nord Stream 2 has been changed under the influence of energy geopolitics.

Ortiz et al. [17] proposed a cooperative game theory model to analyze the distribution of energy between different devices based on consumer satisfaction. They applied the concept of the Shapley value to solve a multi-objective optimization problem (consumer's satisfaction maximization and minimizing the power consumption) with limited resources constraints.

Pinto et al. [18] describe a game theory model that can be used in energy contract negotiations. They presented a decision support methodology, based on application of game theory, for electricity market players. They build and test alternative scenarios for expected price forecast based on players' historic contract settlements and previous price values.

This paper is based on the model of Nagayama and Horita [14]. Their model is used to measure the relative power structure among natural gas trading countries with emphasis on the case between Russia, Ukraine, Belarus, and Western Europe. Compared to previous results in the literature, this article concludes that Ukraine's relative bargaining power was already high even before the construction of the Nord Stream pipeline, which might be the cause of the conflict between Russia and Ukraine. Their work is mostly based on that of Hubert and Ikonnikova [19], which was among the earliest attempts to make use of cooperative games and the notion of "relative Shapley value" to calculate the change in power caused by changes in gas networks. In order to overcome some shortcomings of that early work, Nagayama and Horita [14] employed a network game approach similar to that described by Jackson [20], who analyzes how value is divided inside a network,

given the fact that the contribution, the incentives, and the power of each player inside the network differ.

2. Methodology and Model

The theoretical model that we use in this paper is the one proposed by Nagayama and Horita [14], which is a model that is based on the network game literature. They emphasize allocation rules in order to measure the relative power of the players involved. Unlike previous studies on which they base their research, the accent is on how allocations are made with respect to the entire structure of the network; therefore, the players as well as the links between them are taken into consideration.

They compute the relative power of players by using the Link-Based Flexible Network Allocation Rule proposed by Jackson [20].

In the following, we describe the model as it is presented in Nagayama and Horita.

Let $N = \{1, \dots, n\}$ denote a set of players. The set of unordered pairs of players $\{i, j\}$ denotes a network g , where each pair denotes a link between the two players. The set of all networks defined on N are denoted by $G = \{g \mid g \subseteq G^N\}$, where G^N represents all unordered pairs within N .

For each network g , a value function v must be defined, with $v:G \rightarrow \mathbb{R}$. The set of all possible value functions is denoted by V .

We use the value function instead of a characteristic function for a cooperative game, because as noted by Jackson [20] and Nagayama and Horita [14], a value function is better on account that it specifies the total value generated by a given network structure, therefore allowing the resulting value to depend not only on the specific coalition of players that is taken into consideration but also on the links that exist between the players, namely on the network structure.

The utility functions $u:G(N) \rightarrow R$ for each link ij in the network are defined, and the value function is defined as the sum of these utility functions.

$$v(g) = \sum_{ij} u_{ij}(g) \tag{1}$$

The pair (N, v) , the set of players, and the associated value function represent the network game.

Given a value function v , the monotonic cover \hat{v} is defined by

$$\hat{v} = \max_{g' \in g} v(g') \tag{2}$$

The method that allows for the value generated by a network to be divided between players is called the allocation rule [20].

The Flexible Network Allocation rule proposed by Jackson [20] allows for two variations: the value can be assessed on a player-by-player basis or on a link-by-link basis.

In this paper, we employ the Link-Based Flexible Network Allocation Rule, because this is better suited given the fact that we are interested in the value of links, pipelines in this case, and how players control these connections.

The Link-Based Flexible Network Allocation Rule is defined as

$$Y_i^{LBFN}(g, v) = \frac{v(g)}{\hat{v}(g^N)} \sum_{i \neq j} \left[\sum_{g \in g^N - ij} \frac{1}{2} (\hat{v}(g + ij) - \hat{v}(g)) \left(\frac{\#g! \left[\frac{n(n-1)}{2} - \#g - 1 \right]!}{\left[\frac{n(n-1)}{2} \right]!} \right) \right], \tag{3}$$

where $\#g$ denotes the number of links in g .

We also define the relative bargaining power of players as a percentage of the value of the entire network, where the sum of all relative bargaining powers is 1.

$$RBP_i^{LBFN}(g, v) = \frac{Y_i^{LBFN}(g, v)}{v(g)} \tag{4}$$

So far, we have defined the elements necessary to allow for the allocation of value inside a network, but we also have to relate it to the natural gas trade. Continuing with the model proposed by Nagayama and Horita [14], a utility function is assigned to each of these links, and the sum of the utility functions becomes the value function of the graph. For every given link ij , the utility function of the link is defined as

$$u_{ij}(g) = (p - T_{ij})x_{ij} \quad (5)$$

where

p is the price of natural gas.

T_{ij} is the link-specific transportation cost per unit of gas.

x_{ij} is the quantity of natural gas exported through link ij .

Similar to Nagayama and Horita [14], we use a fixed price irrespective of the modeled scenario, because we adhere to their opinion that “gas prices are highly political and arbitrary”, so these prices cannot be determined according to the total quantity traded in the pipeline network through an inverse demand function.

The link-specific transportation cost per unit of gas T_{ij} is defined according to the calibration by Hubert and Ikonnikova [19]

$$T_{ij}(g) = \frac{(m_{ij} + \beta_{ij} \times MC_0) \left(e^{\beta_{ij} \times \mu_{ij}} \right)}{\beta_{ij}} \quad (6)$$

where

m_{ij} is the management and maintenance cost (considered proportional to the distance and quantity of natural gas transported).

μ_{ij} is the length of the pipeline.

β_{ij} is the amount of gas used to power compressor stations located along the pipeline

MC_0 is the marginal cost of production.

In our analysis, we use data on four countries that we considered as being the most important on the market, namely Russia, Norway, Germany, and Ukraine.

Russia has the largest gas reserves in the world, being also the largest producer of natural gas. In Europe, in terms of production level, Russia is followed by Norway, who even if it has a low domestic demand of natural gas, it extracts large quantities of this natural resource from the North Sea. Whereas in total figures, natural gas demand has slightly dropped; in Europe, approximately 40% of imports come from Russia, while only about 18% of imports are from Norway. Yet, the two countries supply different regions of Europe. As it can be noticed from Figures 1 and 2, while Russian pipelines cross most of the continent, Norway delivers gas only to four important terminals: Germany, Great Britain, Belgium, and France.

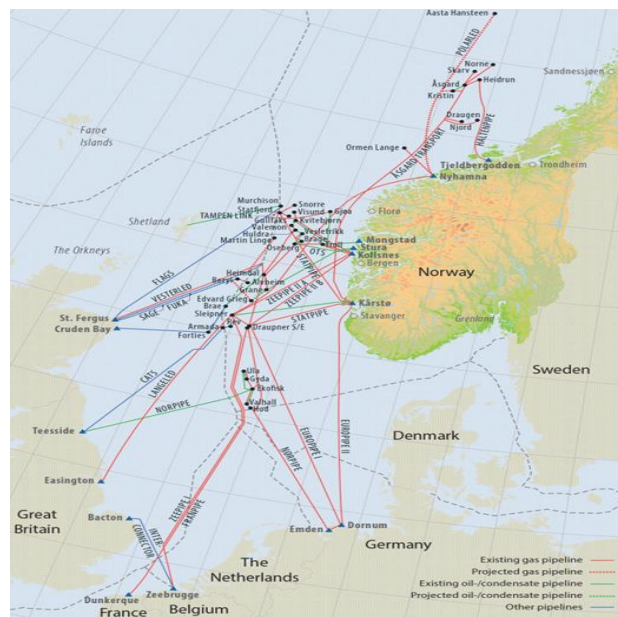


Figure 1. Pipelines from the North Sea (Norway) [21].

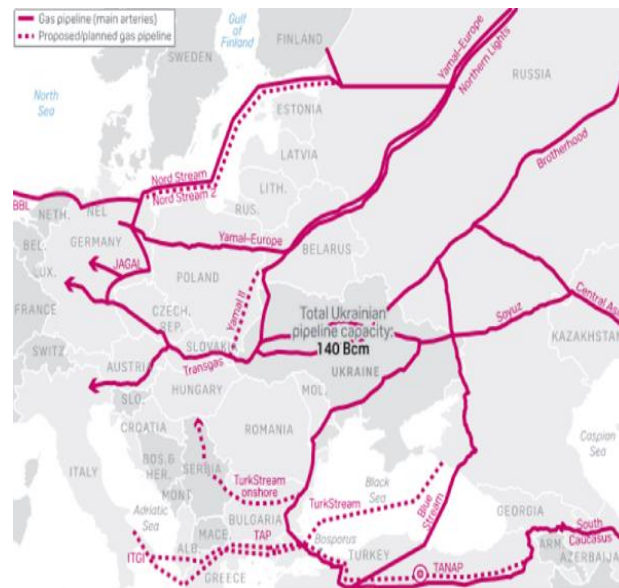


Figure 2. Pipelines from Russia [22] (p. 5). Reprint with permission [22], 2019, Jacques Delors Energy Centre.

While the decision of including Russia and Norway in the analysis is obvious, we also considered it important to include Germany as a strategic player. Its position cannot be denied, since Germany is one of the few countries that import gas directly from Russia as well as Norway, and it is also a hub for distributing gas across the rest of Europe. Moreover, Germany owns around 50 storage facilities with a total capacity of 24.6 bcm, thus having the largest storage capacity in Europe and the fourth largest around the globe, after the USA (128 bcm), Russia (70.4 bcm), and Ukraine (32.2 bcm) [23].

Gas deliveries from Norway reach Germany through three pipelines entering the country at Dorum and respectively Emden: Norpipe, Europipe I, and Europipe II, with a total capacity of 54 billion cubic meters (bcm). Each pipeline has a different length; more precisely, Europipe 1 has 620 km of underwater pipeline and 48 km onshore and Europipe II has 660 km. Norpipe has a length of only 440 km from the Ekofisk platform,

but to this length, we added the length of the Statpipe that carries gas from Norway to the Ekofisk platform, where Norpipe begins: 228 km from Kartso to Draupner and 203 from Draupner to Ekofisk. Even if there are some intermediary nodes in the network, this links between Norway and Germany are all considered direct links, since they do not cross any other country.

Deliveries from Russia enter Germany also through three entry points. Of these three entry points, Germany has two indirect connections with Russia and only a direct one through the underwater pipeline. The Yamal-Europe pipeline, with a capacity of 33 bcm reported by the German Federal Ministry for Economic Affairs and Energy, runs across four countries, namely Russia, Belarus, Poland, and only afterwards does it reach Germany. The pipeline was fully put into use in 2006, and it is comprised of the following sections before reaching Germany: a 402 Russian segment, a 575 Belarusian segment, and a 683 Polish segment [23,24].

The second important source of Russian gas is through the pipeline network that transits Ukraine. According to the Gas Transmission Operator of Ukraine, a total of 281 bcm of gas enter the country, the exit capacity being of 146 bcm per year. Of these, only 120 bcm are reported to enter Germany.

The only direct natural gas link between Russia and Germany runs from Vyborg, Russia to Greifswald, Germany and is represented by the Nord Stream pipeline that was inaugurated in 2011 and currently has a capacity of 55 bcm. A second direct pipeline, with the same course, length, and capacity was constructed but has not yet been put into operation. The length of the existing pipeline is of 1200 km, being the longest undersea natural gas pipeline in the world.

Including Ukraine is of interest considering that almost 50% of the Russian gas transits its Gas Transition System (GTS) and even more if we look at the conflictual relation that has taken place over the years, making the flow between the two countries a very unstable and non-reliable one, with periods when either Russia threatened to stop the gas flow to Ukraine, or Ukraine stated that it does not want to buy gas from Russia anymore.

Specifications about the length and capacity of the pipelines relevant to our analysis can be found in Table 1 with most recent figures available in March 2021.

Table 1. Specifications of the selected gas pipeline.

Route	Pipeline	Length	Capacity
Norway—Germany	Norpipe	871	17
	Europipe I	668	26
	Europipe II	660	11
Russia—Germany	Nordstream 1	1200	55
	Nordstream 2	1200	55
	Yamal—Europe	1660	33
Russia—Ukraine	Gas Transmission System	1000	281
Ukraine—Germany	Gas Transmission System	1600	120

Considering the constant underlying conflict between Russia and Ukraine, we assessed two situations in which the natural gas flow from Russia to Ukraine is either diminished or suspended.

In order to have a baseline for comparison, we established the current natural gas flow between chosen players as the status quo, in which Germany receives gas from Norway as well as from Russia. The link between Norway and Russia is represented by the total capacity that can be carried through the three existing and functional pipelines. The link between Russia and Germany is more complex, summing the gas from the Nord Stream 1

pipeline, the gas that comes from the Yamal-Europe pipeline, as well as the gas that arrives through the Ukrainian Gas Transmission System.

In the first designed scenario, we assume that the Nord Stream 2 pipeline is put into function, adding an additional 55 bcm transport capacity. Given a constant demand, the decrease through the Ukrainian system toward Germany will decrease with the corresponding volume, to a value of 65 bcm.

In the second scenario, we assume a total interruption of Russian gas delivery to Ukraine; therefore, Germany will receive gas from Russia only via the Yamal-Europe pipeline as well as through both Nord Stream 1 and Nord Stream 2. The total imports will decrease as compared to the status quo, but Germany's demand can still be met, the consequence being that less gas will be available for redistribution to the rest of Western Europe through this hub.

Being highly dependent on the existence of pipelines, the structure of the natural gas market is quite stable over time. Major changes can be implemented only by constructing new pipeline and power stations along the pipeline, which are actions that last multiple years. On the other hand, prices are negotiated through long-term contracts. Considering these aspects, we decided to perform our analysis on static data on capacities, distances, and prices.

The designs of the three studied situations are found in Figure 3.

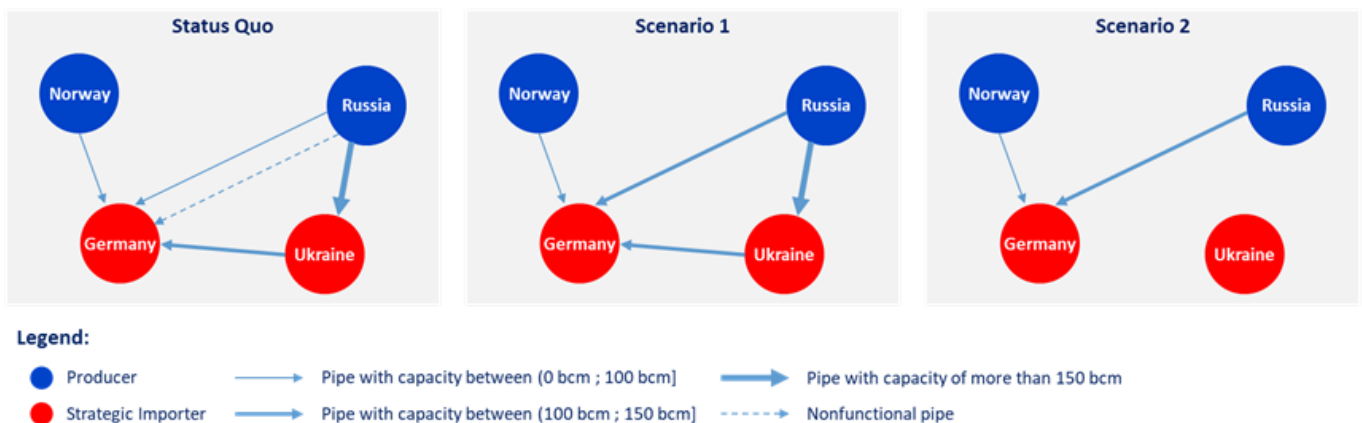


Figure 3. Designed scenarios.

3. Results

Based on the methodology and network models described and proposed in the previous section, we will further detail our computations and evaluate each of the scenarios in order to be able to draw some conclusions.

3.1. Status Quo

This represents the current situation, where Ukraine receives gas directly from Russia. Norway delivers only toward Germany and Russia distributes both through the Nord Stream and the Yamal-Europe pipeline, avoiding Ukraine but also through the Ukrainian Transmission Grid.

Given the fact that we have more than one pipeline for each link, we considered the total capacity that can be transported through it as the sum of the capacities of each pipeline. In addition, the length of the link is determined as the sum of all the pipeline lengths related to that specific link.

The capacities and distances for each pipeline sector are found in Table 2.

Table 2. Specifications and computation results related to links.

	Route	Transport Cost (\$/100 km)	Length (km)	Capacity (bcm)	Total Cost (mil.)	Link Utility (mil.)
Status Quo	NG	110	2199	54	1306	35,143.79
	RG	110	2860	88	2768	56,631.52
	RU	110	1000	281	3091	186,584.00
	UG	110	1200	120	1584	79,416.00
Scenario 1	NG	110	2199	54	1306	35,143.79
	RG	110	4060	143	6386	90,138.62
	RU	110	1000	226	2486	150,064.00
	UG	110	1200	65	858	43,017.00
Scenario 2	NG	110	2199	54	1306	35,143.79
	RG	110	4060	143	6386	90,138.62

For computations, we used a fixed price, which was estimated for the second quarter of 2018 in the European Union, in order to have comparability with the data on production and demand, which are also used for 2018. The price that we will further use is that of 600 million dollars per billion cubic meters (mil/bcm) [25].

In order to determine the cost of transportation as per Equation (6), besides the lengths and capacities of pipelines, we would also require information on the quantity of gas used in power stations that are placed along the pipelines. Although for some of the analyzed segments this information is available, for the most part this is not the case, therefore, for the transportation cost, we used a fixed cost across all networks based on the proxy suggested by Sheshinski [26] that the cost of transporting 1000 cubic feet of gas 1000 miles by pipeline is approximately 0.50 dollars. Given the unit measures used in our article, the value that we will further use is approximately 11,000 dollars/bcm/km.

The utility of each link u_{ij} is determined as the profit obtained from the gas transported through that pipeline, assuming all of it is distributed, thus the price being cashed out in full.

All of the above assumptions for link capacity, link length, price, and transportation cost are applicable also to the two analyzed scenarios.

3.2. Scenario 1

In this scenario, the players are Russia, Norway, Germany, and Ukraine; for each, we use their initials, so $N = \{R, N, G, U\}$. The network has the same structure as in the status quo; namely, Ukraine still receives gas from Russia, but the capacity of the direct link between Russia and Germany is enhanced by assuming that the Nord Stream 2 pipeline becomes functional with a capacity of 55 bcm. The extra capacity in this stream will be deducted from the capacity of the Ukrainian Gas Transmission System, decreasing from a total of 120 bcm to only 65 bcm.

Based on this assumption, we adjust the capacities as well as the lengths where is the case. The capacity and length from Norway to Germany remain the same. The length for the Russia–Germany connection increases because we consider a completely new pipeline. The capacity is also adjusted accordingly. The distance between Russia and Ukraine remains the same since the pipelines are still considered functional, but the capacity is diminished. The same capacity adjustment is performed for the Ukraine–Germany link.

Based on the newly determined capacities and lengths as well as the fixed transportation cost assumptions, for each of the links, a specific transportation cost is computed. Together with the fixed price of 11,000 dollars/bcm/km, it allows the assignment of utility functions for each of the routes: Norway–Germany (NG), Russia–Germany (RG), Russia–Ukraine (RU), and Ukraine–Germany (UG).

3.3. Scenario 2

In this scenario, we assume a total interruption of the natural gas flow between Ukraine and Germany; therefore, we will analyze only the connections Norway–Germany

(NG) and Russia–Germany (RG), so $N = \{R, N, G\}$. Capacities through links NG and RG are the same as the ones presented in scenario 1, where the Nord Stream 2 pipeline is considered operational with the complete capacity of 55 bcm. The route between Russian Ukraine and therefore also the one between Ukraine and Germany do not exist anymore. In this case, the total supply reaching Germany will decrease, but it still meets its requirements for internal use; therefore, what will be impacted is only its capacity to redirect gas to the rest of the European Union.

For the connections that are still considered operational, using the same fixed process and transportation costs, utilities are determined.

Considering the above described scenario specifications and assumptions, we determined the utilities for each transport route based on the pipelines' lengths, capacities, costs, and price, obtaining the results presented in Table 2.

The next step in our analysis is to assign utilities for each country and country coalitions, given different cooperation games between players.

In case of a standalone player, we considered the utility equal to the profit that would be obtained by selling natural gas from a country's own production to its domestic consumers. Since we do not have available a production and distribution cost inside the country, we used as a proxy for profit a percentage of 80% of total revenues. The revenue is determined as the price times the quantity that was sold. More precisely, in case the demand is higher than the total production capabilities, the revenue is price multiplied by the production volumes (as is the case of Germany). In case production is higher than the internal demand, the revenue is price multiplied by the demand volumes (as is the case of Russia).

As we add more players to a coalition, the utility of the coalition is determined as the individual utility of the player, since profit from internal production is a constant revenue source, to which we add the utilities of the routes that involve the players from the coalition.

In case a country fails to deliver the total capacity of a link if a certain player is missing from the coalition, we will cap the utility of the link to what volumes the respective country can deliver from their own resources or other resources that are in the coalition. More precisely, in case a coalition is formed only by Germany and Ukraine, the latter will not be able to deliver the entire 120 bcm capacity but only what is left from its production after ensuring its internal demand.

In order to determine coalition utilities, we used data on production and internal demand for natural gas based on data from 2018, which are presented in Table 3. There we added also our computations on the utility generated by internal production based on the assumptions described in the previous paragraphs.

Table 3. Country-specific indicators and results for domestic utility [27].

Country	Demand	Production	Domestic Utility
Germany	75.5	6.24	50,962.5
Norway	1.17	140.76	95,013
Ukraine	19.77	21.81	14,721.75
Russia	245.9	802.38	541,606.5

The utilities for all relevant coalitions that are used in determining the Shapley value are presented in Appendix A.

Having detailed utilities computed for each graph and after applying the formula for the flexible network allocation rule, we obtained a Y_i value for each country, as shown in Table 4. In addition, the total value $v(g)$ generated in that scenario is presented.

Table 4. Flexible network allocation rule results.

	Germany	Russia	Norway	Ukraine	Total
Status Quo	491,800.7	86,245.33	76,302.66	89,589.67	743,938.3
Scenario 1	490,616.9	84,935.87	91,316.37	75,024.29	741,893.4
Scenario 2	106,212.3	20,777.92	22,873.43	-	149,863.7

Based on these, we determined the Shapley value specific to our designed cooperative game of natural gas trading, in a similar way as the one proposed by Nagayama and Horita [14], from which we derived the relative bargaining power.

Numeric results for the three scenarios are in Table 5, where for each scenario we computed the relative bargaining power of each of the four countries, given the corresponding scenario under analysis.

Table 5. Results.

Scenario	Country	Relative Bargaining Power
Status Quo	Russia	66.05%
	Norway	11.58%
	Germany	10.30%
	Ukraine	12.07%
Scenario 1	Russia	66.13%
	Norway	11.45%
	Germany	12.31%
	Ukraine	10.11%
Scenario 2	Russia	70.87%
	Norway	13.86%
	Germany	15.26%
	Ukraine	0.00%

4. Conclusions

Starting from a theoretical model, we modeled the current natural gas market related to the four most strategic players in Europe. We first assessed the status quo and then presented two variations of the network. The idea emerged from the fact that the political situation between Russia and Ukraine is unstable. In case the two cease any relation, the other players have to look for other solutions. In addition, the article can be considered an assessment on the changes to this market in case the already constructed Nord Stream 2 pipeline is put into operation.

The decision to continue the construction of the Nord Stream pipeline is essentially a political one. Different possible scenarios will imply different economical results, especially for Ukraine. If the Nord Stream 2 pipeline will be finished (scenario 2), then there will be an additional pressure tool to meet Russia's demands.

Looking at the results, we see that irrespective of the scenario, Russia has more than half of the bargaining power on this market, which is a position that is consolidated by its large reserves and production capabilities, making the rest of Europe quite dependent on its natural gas.

We observe that even if Ukraine is not a big producer, it is transited by a very large quantity of Russia's exports; with respect to our chosen players, it is positioned even better than Norway in the status quo, despite the large difference in production capabilities. Nevertheless, this position is strongly dependent on the imports from Russia. The more these imports decrease, the less important Ukraine becomes on the market. Although Ukraine seems heavily dependent on Russian gas, it can actually cover its own demand from its own production, the impact being mostly on the supplementary revenues obtained from the redistribution of gas to the rest of Europe; therefore, such a scenario would probably lead to a significant increase in prices for Ukrainians.

Even if total Russian exports decrease, a total interruption of the relation between Russia and Ukraine will increase especially Russia's power on the market, since it might create a shortage of natural gas in Europe. The supply will be reduced from the Russian stream toward Europe, so we might be faced with two scenarios. In the short term, the prices for the rest of Europe that receives Russian gas via Germany will increase. In the long run, probably new investments in transporting natural gas from other parts of Europe will be made, and the prices will slowly decrease as the offer recovers.

On the other hand, it seems that if Russia succeeds in creating new routes that avoid Ukraine and does not decrease its exports, its position will only become more and more dominant at the expense of smaller producers and eventually of end users of this natural resource (Scenario 2 indicates a 4.8% bargaining power increase for Russia if the natural gas transport system avoids Ukraine).

Another notable fact that draws from all of the scenarios is that even though Germany is by far less powerful on the market than Russia, it is always better positioned than the others, even though compared to all others, its production capabilities can be neglected. This position is sustained by the fact that it imports from multiple producers, making it somewhat less dependent on some particular transport routes and moreover, by the fact that Germany owns very large storage capacities, thus being able to adjust variations of natural gas flows. In the long run, this ensures that price fluctuations in Germany are less probable.

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Appendix A

Table A1. Utilities for different coalitions.

	Status Quo	Scenario 1	Scenario 2
u(R)	385,142.4	385,142.4	385,142.4
u(G)	36,240	36,240	36,240
u(N)	67,564.8	67,564.8	67,564.8
u(U)	10,468.8	10,468.8	-
u(R,G)	471,413.92	500,796.02	500,796.02
u(R,U)	561,120.20	528,725.20	-
u(R,N)	452,707.2	452,707.2	452,707.2
u(G,U)	47,932.80	47,932.80	-
u(N,G)	134,898.59	134,898.59	134,898.59
u(N,U)	78,033.6	78,033.6	-
u(R,G,U)	645,279.72	643,234.82	-
u(G,R,N)	570,072.51	599,454.61	599,454.61
u(G,R,N,U)	743,938.31	741,893.41	-
u(G,N,U)	146,591.39	146,591.39	-
u(R,N,U)	628,685.00	596,290.00	-

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