Games the parties of Eurasian gas supply network play: Analysis of strategic investment, hold-up and multinational bargaining

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Abstract

We analyze cooperation and strategic investment in the Eurasian gas supply network. Russia and Turkmenistan are the producers of the region, Ukraine, Byelorussia, Azerbaijan, Georgia and Iran are the transiters. We apply a two stage game in partition function form. First, parties of the network cooperate to invest in capacities and sign contracts over returns sharing. Then, capacities are given, investment are sunk, parties form coalitions to supply gas and bargain over profit sharing. We assume, that some may renegotiate investment contracts and "hold-up". To strengthen its bargaining position with Ukraine and Byelorussia, Russia overinvest in expensive direct Baltic option. Turkmenistan initiates the bypasses along Azerbaijan and Georgia, or Iran to gain a leverage on Russia. Yet, if Turkmenistan and Russia can cooperate only Baltic pipeline is built.

Keywords: strategic investment, hold-up, coalitional bargaining, partition function form game, gas supply

JEL class.: L14, L91, L95, C71, C72, Q41

1 Introduction

Natural gas consumption in Europe is growing while the domestic gas production is declining. By 2015 over 65% of the total gas consumption will have to be covered by external producers. Algeria, Norway and African Republics are expected to contribute about 55% of import needs of the Western Europe. The rest of the import demand is left to be satisfied by gas from the former Soviet Union. Fields are distant, so the gas is delivered to the European market through a network of pipelines, passing through a number of countries-transiters. Gas producers and transiters involved in supply, form the Eurasian gas supply network. In the paper we examine the strategic interaction between the members of the gas supply network and look how it affects export supply. In particular, we explore endogenous formation of coalitions among the network parties and provide the strategic rationale for investments in the network development.

Currently, Russia is the only exporter from the former Soviet Union region. It plays a key role providing about 40% of the European imports. Russian gas passes through the network of pipelines, running through Byelorussia and Ukraine. For the cooperation Russia pays these two countries a rent, giving up a part of its export profits. The rent is fixed in the long-term contracts. In addition, Russia used to provide Byelorussia and Ukraine with the investment capital required to increase the transmission capacity, because the transiters could not afford investment costs upfront. Investments in pipelines are asset-specific and are sunk once capacities installed. Capacities confer the bargaining power to the transiters. Then, if the transiters can not commit not to renegotiate their long-term payoff, the standard "hold-up" problem arises. In the past, Ukraine and Byelorussia did reveal the lack of the ability to commit and had constant renegotiations of their payoff with Russia. Such opportunistic behavior led to inefficiency. Lucrative cheap options to extend the pipelines in Ukraine and Byelorussia were abandoned and an expensive project of the direct link through the Baltic Sea appeared.

Other former Soviet Republics have a potential to enter the market. The so called Caspian Republics, including Turkmenistan, Kazahkstan, Uzberkistan, and Azerbaijan, could export twice as much as Russia does and at lower costs. The rise of gas demand and the encouragement of Europe, which is eager to diversify its portfolio of suppliers, suggest that the Caspian producers will take a chance on export. This would intensify the competition on the market and threaten to displace Russia from its essential position. At present the Caspian Republics are connected to the European market only through the Russian system of pipelines. For a decade Russia managed to block the Caspian producers. Recently, it has started cheaply purchasing Caspian gas for its own export contracts. Now the Caspian producers are considering two projects aimed to overcome the transport bottleneck and to gain direct access to the European market. The first is the Trans-Caspian pipeline going through Azerbaijan and Georgia. The second is the Nabucco pipeline bypassing Russia through Iran. Both pipelines will send Caspian gas to Europe through Turkey.

The formation of the Caspian supply chains will impose a kind of "externality" on Russia's supply. Additional competition will reduce Russia's profits from export. Therewith the payoffs of Ukraine and Byelorussia will decrease. In contrary, the Caspian producers will increase their profits, and so do their transiters. Hence, the earnings of the network parties will depend on the overall cooperation in the region.

The cooperation of the Caspian countries raises a number of concerns. The prospective transiters are not able to finance the building of pipelines, so it is the producers, who will have to invest. Azerbaijan, Georgia and Iran lack political and economical stability and are unlikely to sustain a long-term commitment. Hence, the investments of the Caspian producers might suffer from the "hold-up" problem too.

In the paper we develop a framework for the analysis of coalition formation among the Eurasian gas supply players and their strategic interaction. We use a two stage multilateral bargaining game assuming heterogenous players, some lacking the ability to make long–term commitments. At the first stage the players form coalitions to invest in transport capacities and sign contracts over sharing of returns on the joint investments. At the second, investment costs are sunk and capacities are fixed. The players form coalitions to supply and bargain over export profits sharing.

The analysis is complicated by the presence of "externality", that prevents us from describing the game in coalitional form, presented by "characteristic function". Solved with the Shapley value (1953) and Owen value (1976), such games imply, that coalitions may secure their payoffs irrespective to the outsiders' behavior. Instead we resort to a game in "partition function form" (PFFG). Introduced by Thrall and Lucas (1963), PFFG allows to capture the existence of externalities evaluating the worth of coalitions given the entire coalition structure formed by the players and is called partition.

The theoretical literature distinguishes two approaches to solution of PFFG: an extensive form game (Bloch (1996), Ray, Vohra (1999), Gomes (2001)) and axiomatic approach (Do, Norde (2002), Maskin (2003), Ju (2004)). The first branch describes the situation in which players in turn propose a coalition and a payoff division that the other players in turn may accept or reject. However, such coalition formation process is sensitive to the rules of proposing and depends on the commitment assumption for intermediate coalitions. On the other hand, axiomatic approaches formulate a set of desirable properties, which the solution will possess. Most of the works, though, focus on the expected payoff as a solution of the game, neglecting the question of a coalition structure formed. In our analysis we use an axiomatic solution recently proposed by Maskin (2003). Maskin formulate the axioms, which answer all three questions of games with endogenous coalitions: which coalitions form in equilibrium, how the coalitional worth is shared among the members and how the presence of the other coalitions affect the incentives to cooperate. So we can simultaneously determine the equilibrium coalition structure and the corresponding payoffs of the players. The axioms provide the rational behind the supply chains formed as well as the network development.

In the quantitative part of the paper we numerically solve for the equilibrium coalition structure, investments and profit sharing. The knowledge on production and transport technologies as well as the available information on investment needs for the new pipeline projects enable us to estimate the cost functions. We derive the linear residual demand for the former Soviet Union region gas and accept the Bertrand competition among the region suppliers under the capacity constraints. We assume that the bargaining among the network players is efficient and so is the use of the existing network, though investments in the capacities may be inefficient for strategic reasons. Based on the assumptions we calculate coalitional profits and the expected payoffs to the players. In this sense the European supply chain provides for a rather unique opportunity to confront the theoretical solutions of game theory with real world experience. Applied works, which explicitly address to both bargaining process and endogenous coalition formation issues, are scarce (e.g. Eyckmans, Tulkens (2001)). So the current work contributes to the development of the methodology on the issues and its approbation on real world data.

Our qualitative analysis predicts excess capacities in equilibrium and explains overinvestment in some tracks and underinvestment in others as an attempt to create countervailing power. The ability of the countries to commit to long term sharing turns out to be of an overriding importance. It diminishes the role of difference in investment cost between onshore and offshore pipelines. Our results show, that if the transiters cannot commit, Russia and the Caspian producers will form a coalition and invest in the direct pipeline through the Baltic sea. The resulting overcapacity is justified by the addition in profit, which the producers earn. The pipeline enables to bypass all the transiters and hence, brings a significant increase in bargaining power resulting in the rise of the producers' share in profit. This goes along with the underinvestment in the cheap and more efficient Ukrainian and Byelorussian links, which will not be extended. An interesting change would happen if the producers were not able to commit too. The Caspian producers would build the Trans-Caspian and Iranian pipelines and enter to the European market. Russia would still build the Baltic pipeline, though with less overcapacity. The calculations reveal the rational behind the grand coalition, currently observed in the network supply.

The paper is related to the current literature on gas market, in particular perspectives for the development of Eurasian gas supply network. Studies of Grais, Zheng (1996), Stern (1999), Opitz, von Hirschhausen (2000) and von Hirschhausen, Meinhart, Pavel (2005) quantify the impact of cooperation on the supply network extension. The authors consider the incentives to extend the pipelines along Ukraine and Byelorussia under different cooperation regimes. The Stackelberg leadership, Nash barganing, Nash product concepts have been applied to predict investments and payoffs of the countries. All the previous works address the question of vertical integration considering Russia as the only producer. Including the Caspian producers, we tackle the problem of both vertical and horizontal integration.

Considering the bargaining problem with externalities, our work relates to other studies, including: a Kyoto protocol investigation, where players are countries and externalities are emissions affecting the environment of others (Eyckmans, Tulkens (2001)); a study on patent or license acquisition problem, where the firms involved in oligopoly, may collude to buy an innovation, which creates negative externalities if the innovation is acquired by a rival (Jehiel, Moldovanu (1996)); a study on preemptive mergers, where firms merge with the hope of avoiding the negative externalities of being an "outsider" (Fridolfsson, Stennek (2002)); analysis of political parties formation , where players choose which party to join (or support), in the presence of cross-party externalities (Calvert, Dietz (1998)).

We abstract from many potentially relevant considerations. One of the most prominent is the strategic interaction of Russia and the Caspian producers with the other European exporters. We take the investment plans on capacity extension for Algeria, Norway and the African LNG producers as their capacity constraints. Even though these countries might increase their production, the capital required for these purposes would make the supply costs soar and approve the capacity limits we assume. Deriving the demand function, we assume gas from different producers to be perfect substitutes, i.e. exclude political preferences and diversification concerns of the buyers. We also ignore the dependence of gas consumption on preferences over alternative energy sources like oil or coal.

The remainder of the paper is organized as follows. Section 2 introduces the parties of the Eurasian supply network, explains the conflicts among them and develops the questions of the research. Section 3 presents two stage investment game, a coalition formation and a bargaining model. In Section 4 we give the assumptions of the quantitative analysis, describe the demand, supply and transportation cost functions, provide the basis for the competition vs. monopoly supply choice. Section 5 shows the results of the calculations and their interpretation. Section 6 concludes.

2 Players and their Relations: Games the countries play

We will refer to the parties of the Eurasian gas supply network as *players* and distinguish two types of them: producers and transiters. The producers are Russia and the Caspian Republics.[1] Production fields are distant and to reach the European market the producers turn to countries-transiters for transportation services. Ukraine and Byelorussia help to deliver Russian gas. Azerbaijan, Georgia and Iran are the new prospective transiters for the Caspian gas.[2]

The European gas market is covered by a small number of long-term "take-or-pay" contracts.

[1]International gas affairs in the Former Soviet Republics are run by state monopolies, therefore, we will refer to respective countries instead of naming the companies, e.g. Russia instead of Gazprom.

[2]We do not consider other countries involved in gas transportation, e.g. Poland, Czech Republic, Turkey and etc. Assuming the open access and regulated tariffs there, we focus on interactions between the Former Republics only.

These bilateral contracts are signed between producers and customers. They set the price a buyer guarantees to pay and the quantity a producer promises to deliver within the contracted period, which is usually 15 to 20 years. That puts the delivery risk on producers and leaves them to tackle transportation issues including: payments for transit and coordination of investments into transport capacity. Although consumers often also contribute investment capital, they stay away from the supply and transit issues as such.[3]

Before the Soviet Union collapsed, Russia signed export contracts with European buyers and controlled their fulfillment ensuring investments on behalf of all the Republics. In the 80s, to satisfy its contracts, Russia commanded to exploit gas fields in Siberia and open low cost fields in Turkmenistan, Kazakhstan and Azerbaijan. To deliver gas to the European market a network of pipelines was built. It run through the Russian and Ukrainian territories and connected fields with the Western market through the Eastern Bloc. Payments to the Republics, involved in export, were also reckoned by Russia, which paid them a rent from the export profits obtained often in kind.

After the dissolution of the Union, Republics got out of Russia's control and became independent countries. Until the late 90s the Ukrainian pipeline *Soyuz* was the only link to Europe. Russia found itself in a shaky bargaining position with the owner of the only export corridor. The countries turned out to be involved in permanent disputes over transit payments. To solve the conflict and help to secure its supplies Russia made a few attempts to buy a control stake in the NaftaGas, the Ukrainian monopolist controlling the export grid, but failed.[4] As there is no international court system, conflicts are resolved through bargaining. Seeking for a remedy to discipline Ukraine and strengthen its bargaining position, Russia initiated an alternative transport link bypassing Ukraine through Poland and Byelorussia. The so called $Yamal1$ pipeline went into operations in 1998. The strong dependence on Russia economically and politically was considered to ensure a favorable behavior of Byelorussia. However, once the pipeline was installed, Byelorussia started the renegotiation of its payoff, like Ukraine.

Both Ukraine and Byelorussia buy Russian gas for their domestic needs on special reduced prices. So Byelorussia pays less than a half of the European price, and Ukraine slightly more than a half. Every attempt of Russia to raise these prices has resulted in renegotiations over the proportional increase in transit fees, these two countries receive from Russia for the gas transit. When Russia stopped delivering the gas, Byelorussia and Ukraine threat to syphon the required gas from the export pipelines and storages. To fulfil its export obligations Russia had to compromise. A number of short-term agreements have been produced to settle the feuds, but the countries are still stalling

[3] See "Energy Information Administration" on http://www.eia.doe.gov for more information on international pipeline investment projects.

[4] For more detail about the situation around Russian gas supply chain in early 90s see Stern (1996) and Hubert, Ikonnikova (2003).

on a long-term agreement.

Pipeline is a specialized asset and investment is irreversible. Ukraine and Byelorussia enjoy investments Russia did and exploit their improved bargaining position to expropriate quasi-rents. The situation presents the standard "hold-up" problem. The opportunistic behavior of the transiters led to distortions in further investment plans of Russia. In the view of the opportunistic behavior of Byelorussia, the initially planned second band - $Yamal2$, was abandoned. Then, as the quarrels with Ukraine continued, Russia postponed its investment in the extension of the Ukrainian transmission system - *Upgrade* too. Thus, the cheapest options to extend the gas supply network have been rejected.

To plan its future supplies, Russia has to build extra transport capacities and prevent supply disruptions. To suppress the haggles with the transiters, Russia has revived the project to build a direct pipeline. The North European Gas pipeline (*NEG*) is planned to run at the bottom of the Baltic sea and will bring Russian gas directly to Germany bypassing Ukraine and Byelorussia. Despite higher costs, the offshore pipeline stands as an important outside option for Russian supply and promise to confer a higher profit with the increase in bargaining power.

Along with the loss of control over its export routes Russia lost a full control over the production. Newly independent gas producers appeared in the Caspian region, where vast gas reserves were opened. They emerged as new potential competitors for Russia. However, the fall of the Soviet Union coincided with the drop of the gas demand in Europe in 1992. Russia blocked the access of the Caspian producers to its export pipelines and hence, squeezed the rivals out of the market.

As the demand has recovered by 1997 and started steadily growing, the Caspian producers get a new chance to enter the European market. At present, fields in Siberia are at peak production or in decline. To increase its export Russia has to develop new fields on the Yamal peninsular. This requires significant investments and will raise the supply cost of Russian gas. The Caspian Republics kept their fields idle for the last decade, and could provide gas at much lower cost. The largest Caspian producer, Turkmenistan, may cover up to 80% of Russia's deliveries and export over 100bcm/a. The inflow of gas from the other Caspian producers can more, than double this amount. As long as the Caspian Republics have no other access to the European market but through the Russian pipelines, they agreed to sell their gas to Russia, who then exports it to Europe. The cooperation, however, highly depends on the outside options of the Caspian producers.

Recently, to change the situation with a transport capacity bottleneck USA and UK proposed to build an alternative route for the Caspian export. The project initiators aim to abate the dependency on the Russian gas supply and give the Caspian producers an alternative to access the European market independently. The Trans-Caspian Pipeline, *TCP*, is intended to bypass Russia crossing the territories of Azerbaijan and Georgia. It will connect Turkmen fields with the Turkish pipeline system running to Europe.[5]

To finance the TCP project Turkmenistan will resort to the financial support of USA. Azerbaijan and Georgia have tight budgets and can not pay $4bn of investment costs up front. Clearly, the threat of the "hold-up" problem appears, if the countries can not commit to stick to the future payoff agreements. Currently the Trans-Caspian project is stalled, because of the civil war in Georgia and the war between Azerbaijan and Armenia. The unstable political situation in Georgia puts a question how long the transit agreement signed will be valid. The conflict with Armenia threaten the security of the route, or may lead to inclusion of Armenia into the number of transiters. This obstacles damage the attractiveness of the project and delay its realization.

Meanwhile, Turkmenistan came to an idea of another export route for its gas. The pipeline called *Nabucco*, will run between Korpedje in Western Turkmenistan and Kord-Kou in North-Eastern Iran. It will link Turkmenistan to Iran's network of gas pipelines and via Turkey send gas to European borders, bypassing as Russia so Azerbaijan with Georgia. Iran holds huge gas reserves and seems to be interested in the project for itself. Although it is ready to invest up front, it seems to be prone to renegotiate the quantities delivered by Turkmenistan in favor of its own supply.[6] The Iranian pipeline is opposed to the TCP project promoted by the USA, which promises to withdraw its financial support, if Iran is involved.

An objection for the new Caspian routes may also concern Turkey. The country is located at the crossroad between Caspian and Middle East Countries. As the gas flow going through Turkey to Europe is growing, the country became ambitious to establish itself as an exporting country. Raising the gas directed to Europe, Turkey could win a significant share on the market.[7] This makes the eagerness of Turkey to cooperate in running the Trans-Caspian project illusory. Turkmenistan may exchange one reexporter for another. Europe, however, have some leverage over Turkey in a view of the latter's intentions to join EU. This concerns are likely to hold Turkey back, so that Turkmenistan can rely on the access to the transit capacities.[8]

[5]For the detailed description of the project and associated conflicts among the countries involved see Nabiev (2003).

[6]A pipeline, which connects Nebit Dag, Korpedze and Okarem fields in Turkmenistan with internal Iran grid in the Kord-Kul node was launched in 1999. Currently it delivers less than 10bcm/a to Iran, but the increase to 20bcm/a with a further connection to Turkey is planned. Iran covered about 80% of the construction costs of the pipeline installed and agrees to pay for the extension of the project. Turkmenistan will pay Iran its part back in kind by natural gas.

[7]Currently Turkey has an import contract with Russia, which delivers the gas with the Blue stream pipeline through the Black Sea. The amounted contracted leaves Turkey with 6-8 bcm/a of excess gas. Recently, Turkey won the right to resale that excess to Europe. Together with 5bcm/a of Iranian gas and over 20bcm/a of Turkmen gas, Turkey may export up to 30bmc/a.

[8]Turkey can be pushed to sign the Energy Treaty, the agreement obliging its members to undertake a third party access to transit facilities. Then Turkey will not be permitted to compel a resell contract from Turkmenistan. Moreover, this will encourage others Middle Asia producers, like Iran, to supply gas to Europe.

Despite the problems, the TCP and Nabucco keep Russia under the viable threat of future loss of Turkmen gas inflow and of increasing competition. It can lose a substantial part of its export profits. This profit loss will present a kind of "negative externalities", which Russia will experience if fails to keep the coalition with the Caspian producers and if the Caspian Republics manage to form a coalition to build the bypass options.

This seems to be an argument in recent negotiations on the export price for Caspian gas, which Russia buys. In January 2005 Russia signed an agreement guaranteeing a drastic increase of Turkmen export volumes from 10 bcm/a in 2006 to 80 bcm/a in 2025. Another breakthrough for Turkmenistan was the promise of Russia to calculate the price for gas based on the consumer market price instead of a long-term fixed price level.[9] These concessions turned the Turkmen gas away from the Turkish path. The bypass projects were postponed.

Turning to a formal model we restrict ourselves to the seven main players. The Caspian Republics are loosely defined as including the countries of Turkmenistan, Azerbaijan, Uzbekistan, and Kazakhstan. We address to Turkmenistan, implying the Caspian producers, for it possesses over a half of gas reserves in the region. Assuming reliable behavior of Turkey and its tight relation to Europe, we will not separate it as a player.

3 The model

We model cooperation and investment decisions of the producers and transiters in the gas network as a two-stage game. The model is an extension of the Kreps and Scheinkman (1988) model. At the first stage players invest in capacities, at the second stage capacities are fixed and producers compete by prices. We incorporate endogenous coalition formation among producers and transiters in both stages. Then, capacities installed at the first stage matters for a competition outcome and change the bargaining power of the players at the second stage, and, hence, affect their payoffs. Thus, there are two driving forces of investments: competition and bargaining position. Let us now proceed with the formal model.

The set of players in the gas supply network $N = \{r, t, u, b, a, g, ir\}$ includes Russia, Turkmenistan, Ukraine, Byelorussia, Azerbaijan, Georgia, and Iran respectively. At the first, or *investment stage*, labelled with I, the players invest in capacities k_l of the different links $l \in L$. To coordinate their investments, the player may form coalitions S^I. The set of formed coalitions $P^I = \{.., S^I, ..\}$ is called *partition*. We assume embedded coalitions S^I are pairwise disjoined $S^I_j \cap S^I_h = \emptyset$ for all $j \neq h$, so that $\bigcup_{j=1}^{m} S^I_j = N$. If none of the players cooperate, the partition is presented by the set of singletons $P^I = \{\{i\}, \{j\}, ..\}$, if the players make an investment decision all together, then $P^I = \{N\}$ and we say a grand coalition forms.

[9] It has already brought Turkmenistan a 20% increase in prices from 44\$/tcm to 56\$/tcm (RBC daily 01.04.2005).

The worth of the cooperation S^I is the profit, which the members earn over the investment costs. It depends on the entire partition P^I, i.e. on cooperation and investment choices of players inside and outside the coalition. The function $w^I(S^I; P^I)$, which assigns investment profits to coalitions embedded in a given partition P^I, is the partition function. We assume, that upon cooperation the members of each coalition sign a long-term contract, which sets the distribution of the joint investment profit. We denote by the vector $\psi^I = (\psi_r^I, \psi_t^I, ..)$ the payoffs obtained by the players in the investment game.

At the second, or *supply* stage marked by the superscript S, capacities of the network $\bar{k} = \{.., \bar{k}_l, ..\}$ are fixed and investment costs of the installed pipelines are sunk. The players form coalitions $P^S = \{.., S, ..\}$ to supply gas, earn export profits $w^S(S; P^S)$ and bargain over their sharing. The vector $\psi^S = (\psi_r^S, \psi_t^S, ..)$ will present the expected payoffs to the players in the bargaining of the second stage.

The functions w^I and w^S, assign profits given the partition, and are called partition functions. Together with the corresponding sets of feasible coalition structures $P^I \in \mathbf{P}^I$ and $P^S \in \mathbf{P}^S$, partition functions describe the game in partition function form (PFFG).[10] Such a presentation of bargaining game allows to capture the presence of externalities and show how profit of a coalition changes with alterations in a coalition structure. Formally one speaks of externalities whenever:

$$\exists S: \;\; w(S;P) \neq w(S;P^{'}) \;, \quad \text{where} \quad P \neq P^{'} \;\; \text{and} \;\; S \in P \cap P^{'} \;\; P, P' \in \mathbf{P} \tag{1}$$

If the inequality sign is changed for "greater", the externalities caused by the variation in P are negative. If the inequality is replaced by "less", the externalities are positive, so that S free-rides on the change in the partition.

Bargaining and coalition formation We proceed with the solution of the underlying coalition formation and bargaining game. For consistency, we apply the same solution concept of PFFG on both stages and first, formulate it without reference to the stages. We employ the axiomatic approach developed by Maskin (2003) to study endogenous coalition formation and define payoffs to the players.

Maskin's approach is based on the notion of random order bargaining (Weber (1988)). Formally such a bargaining procedure suggests, that players enter the coalition formation process one by one in an order $\theta \in \Theta$. Each makes an irreversible decision to join one of the existing coalitions and agree on a payoff $\psi_i(\theta)$, or to set up a new coalition. The next player does not enter until the allocation and the payoff of the previous entrant are known. We assume every player knows the profits achieved in coalitions, as well as each coalition knows the profits of the outside coalitions.

[10] Further on we will use general notations, i.e. without indexes specifying the stage, for the statements, which are just for the both stages of the game.

For a given order, an allocation of a player and his payoff are defined in accordance with the following axioms of Maskin (2003):

(i) the sharing of joint profits within every coalition should be Pareto optimal

$$\sum_{i \in S} \psi_i(\theta) = w(S; P) \text{ for } \forall i, S \in P$$

(ii) each player is allocated to the coalition S, to which his gross marginal contribution is greatest

$$w(S \cup i; P_{S \cup i}) - w(S; P_{S' \cup i}) \geq w(S'' \cup i; P_{S'' \cup i}) - w(S''; P_{S \cup i})$$

$$\forall S'' : \quad S'' \neq S \qquad S' = arg \max_{S''} [w(S'' \cup i; P_{S'' \cup i}) - w(S''; P_{S \cup i})]$$

(iii) every player earns his opportunity wage, or stays with his "stand alone" value

$$\psi_i = w(S' \cup i) - w(S'; P_{S \cup i}) \quad \text{for} \quad \psi_i \geq w(\{i\}; P \cup \{i\})$$

(iiii) the final vector of payoffs $\psi(\theta)$ and the partition $P(\theta)$ should be consistent for all i, θ if (i)-(iii) holds:

$$\text{if } \{i \cup S\} \in P(\theta(i)) \ , \ \text{ then } P(\theta(i)) \subset P(\theta) \text{ and } \psi_i(\theta) \in \psi(\theta)$$

where $P(\theta(i))$ is observed after the allocation of i^{th}player

By the first axiom, coalitions do not give the profits away, but distribute them fully among their members. The second axiom requires a player to confer his resources to a coalition which benefits from them at most. Hence, the axiom (i) and (ii) state an efficiency limited by consideration of coalitions formed by i^{th} arrival, and neglecting new coalitions, which may arise later.

According to (iii) each player gets his highest alternative payoff, that implies incentives to join the coalition and exposes the value of an outside option. Therewith the third axiom states the incentives for coalitions to bid the player away, once they could be worse off giving him up. The forth axiom involves sequential rationality and sub-game perfectness, that leads to backward induction. The choice the best alternative $P(\theta(i))$ is made in accordance with the anticipation of the development of the game till the terminal $P(\theta)$, foreseeing the allocations of the followers. Thus, in short (i)-(iiii) provide incentive compatibility and individual rationality constraints along with a consistency of the final outcome with the intermediate decisions.

Applying the presented axioms to all possible orders, one ends up with a set of outcomes of a bargaining game $\{\psi(\theta), \ P(\theta)\}_{\theta \in \Theta}$. We assume, that the players are risk neutral and therefore interested in their expected payoffs. To obtain the expected outcome of the bargaining we randomize over all possible orders from Θ. We take, that all orders are equally likely, and account them with the probability $1/|\Theta|! = 1/|N|!$, where $|\cdot|$ gives the number of elements in the set. Finally we obtain the expected payoff as:

$$\psi_i \;=\; \sum_{\theta\in\Theta} \frac{1}{|N|!} \cdot \psi_i(\theta)$$

To assign payoffs and allocations of the players, we have to evaluate partition functions. With the next step we specify the functions w^I and w^S.

Value functions The returns on the investments are derived from the profits of the capacity usage, therefore we start with the second stage and define supply profits w^S. The basic assumption of a PFFG is that across coalitions players act non-cooperatively, whereas within coalitions players combine their resources to maximize the surplus from cooperation given the actions of the outsiders.[11] At the second stage $\bar{k}(i)$ is the resources of the ith player, then, $\bar{k}(S) = \{\bar{k}(i)\}_{i\in S}$ are the capacities available to the coalition. Following the assumption we define coalitional profits as the non-cooperative Nash equilibrium. The profit of the coalition π_S is the function on the capacities of the members of the coalition as well as the capacities at the disposal of the coalitions of the outsiders. In other word, the worth of a given coalition depends on the entire partition. We take the profits, i.e. the values of the partition function to be the maximum profit the players can achieve playing against the other coalitions. Leaving the specification of the profit function and details on Bertrand competition among the coalitions for the quantitative section, we write down:

$$w^S(S; P^S) = \max_{p_S} \pi_S(\bar{k}(S_1), .., \bar{k}(S), .., \bar{k}(S_m), p_{S_1}, ..p_{S_m}) \tag{2}$$

Based on w^S values we find the vector of expected payoffs applying the axioms of Maskin (2003). A payoff ψ_i^S of each player is calculated given the capacities installed at the first stage.

At the investment stage, the players foresee the outcome of the price competition on the second stage and invest in capacities as to maximize the profit:

$$w^I(S^I; P^I) = \max_{k(S^I)} \pi_{S^I}(k^*(S_1^I), .., k(S^I), .., k^*(S_m^I)) \;\text{ for } S_j^I \in P^I \tag{3}$$

given the capacities $k^*(S_j^I)$ chosen by the other coalitions. The value w^I is the total payoff the members of S^I represented through the payoffs achieved at the second stage as follows:

$$\pi_{S^I}(.., k(S^I), ..) = \sum_{i\in S^I} \psi_i^S - \sum_{k_l\in k(S^I)} I_l k_l \tag{4}$$

where I_l is the unit investment cost of a given link.Then, we again use the axioms to calculate the equilibrium payoffs and partitions, considering all feasible $\mathbf{P}^I$. The vector ψ^I that we determine, will present the payoffs obtained by the members of S^I. The capacities $k^*(S_j^I)$ invested by the coalitions embedded in the equilibrium partition will show the expected development of the network.

[11] The assumption was introduced by Ray and Vohra (1996), who first address the question of the endogenous distribution of the coalitional profit. It is now generally adopted by the coalitional bargaining theory. See the survey of Bloch (2003) for further discussion.

Hold-up The hold-up problem would not arise, were investments contractable or were all the players able to commit to long term payment contracts, or pay for the increase in bargaining power up front. Then we would solve the one stage game, like Ikonnikova (2005), and find first best efficient investments.

However, we assume, that players may not be able to commit to stick to the contracts over ψ_i^I. Expecting $\psi_i^S \geq \psi_i^I$, players i will have incentives for recontracting. Thus, the "hold-up" problem will arise. If credible members of the coalition expect to forfeit the non-credible partners their second stage payoff and thus, to reduce their expected profits form investments, will lose the incentives to cooperate. Hence, non-credible players are left as singleton coalitions and do not take part in the coalition formation of the first stage. So the set of feasible coalition structures is limited to that formed by credible players $\widehat{\mathbf{P}}^I \subset \mathbf{P}^I$. In ultimate case, when all the players can not commit the set of possible partitions consists of one element and the expected payoffs of the game are given as: $\psi_i^I = \max_k \psi_i^S - \sum I_l$.

4 Quantitative assumptions

In this section, we present the assumptions of the second - supply stage, and then, proceed with descriptions of investments, which are the instruments of the first stage.

4.1 Parameters and functions of the second stage

We start with the assumptions on gas demand and supply costs, used to calculate supply profits of coalitions, describe the competition, in which coalitions are involved, and then, derive profit functions.

Demand The market, we have in mind, is represented by the core 15 members of the European Union[12], who are the major importers in Western Europe. The peculiarity of the European gas market is, that it is covered by the long-term bilateral contracts as these contracts are confidential. So it is impossible to trace the direct linkage between the quantities supplied and the prices paid. Buyers do not deal with all the exporters simultaneously. A new contract with a given supplier is signed, when the previous is expired, meanwhile the contracts with the other suppliers may still be valid. This prevents us from estimating the demand explicitly. We propose to derive the demand indirectly, based on the data on the marginal costs of the producers and on the quantities they export to Europe.[13]

[12] So called EU15 is presented by Austria, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, Switzerland, and the UK.

[13] The figure for the future demand, marginal supply and transportation costs for the EU exporters are presented in Observatoire Mediterraneen de L'Energie(2003).

We take, that the gas consumption in Europe for the year of 2020 is exogenously given as 630bcm/a. Subtracting the domestic gas production of the European countries, we end up with about 400bcm/a to be imported.[14] This demand is satiated by Algeria, Norway, the African Republics, Russia and the Caspian Republics. We deduce the demand for Russian and Caspian gas, as a residual demand[15] left uncovered by cheaper suppliers, i.e. from the difference of the total imports of Europe and the supplies of the other exporters. We assume, the cheapest exporter supplies first. If he can not satisfy his demand fully, his share is transferred to the next cheapest producer, and so on. We take, that countries may increase deliveries, but with the higher costs. Hence, each exporter has capacity constraint for every given level of costs.

We suppose linear form of the inverse demand function $p(q) = \alpha - \beta q$. We estimate and adjust the parameters assuming, that producers charge some mark-up. Referring to the European border prices, we do not reckon mark-ups of the distributors. It is a common knowledge, that gas prices follow oil prices, though little about the binding mechanism is disclosed. In our estimations we reflect this relation by putting the restriction for the gas price at the oil price level.[16]

We arrange the producers by the values of supply costs in ascending to build the inverse supply curve. The highest costs are assigned to the African producers of liquified natural gas (LNG). The next cheapest is Russia with its gas from the new West Siberian fields. Thus, the price of LNG is taken as a back-off value for Russian gas. Fixing the mark-up on 20% we obtain α =170\$/tcm corresponding to the price for LNG. Extrapolating the curve, we estimate β in the range of 0.38 to 0.41, that gives about 140bcm/a left for export from the former Soviet region at the price of about 115$\$/tcm$.

Production costs The total cost of gas supply includes production and transportation costs. Production costs depend on terrain, climate conditions as well as infrastructure on place. Hence, they vary with fields and the producers. We assume the producers allocate gas production as to minimize their costs. They start producing on the old cheap fields and develop new expensive fields as larger quantities are required. This implies an increasing function for the marginal production cost, which we assume to be linear $mc(q) = m + c \cdot q$.

We estimate the slope parameter looking how the cost of gas changes with the increase in export

[14]Different consumption scenarios are introduced in R.Ter-Sarkisov (2003).

[15]We address to the aggregate demand for the gas from the former Soviet Union region, and neither specify demand for each individual European country nor look at the demand on each link. Although links are directed to specific countries, European gas market becomes integrated. The introduction of Energy Treaty, accepted by most of the EU countries, secures gas transit under regulated tariffs. This supports, that Europe becomes a common marketplace.

[16]Total gas demand is forecast taking into account economic drivers and trends in primary energy consumption, including oil. Oil is considered as a gas substitute, and ignoring specific consumer preferences, one can look at these two goods as competitors.

quantities. For Russia we estimate c_r=0.4.[17] The intercept to be equal to the cost of the field preservation, i.e. keeping it open but idle. For Russian old depleting fields, like Medvegje it gives m_r=15$\$/tcm$.

For the Caspian producers, we look at the increase in price, which Russia pays for Turkmen gas. The Republics has no possibility to market its gas but through Russia and therefore can not discriminate. Hence, the price the Caspian producer asks is to cover the production cost plus some fixed mark-up.[18] We obtain c_t=0.35 and take The milder climate of the Caspian region, as opposed to that of Siberian permafrost region, leads to lower cost for Turkmenistan m_t=10$\$/tcm$.

Under the cooperation, the producers combine their fields and produce at minimum cost. We derive the joint marginal cost function to be $mc_{rt} = 11 + 0.3q$ for $q \geq 14bcm$ and $m_{rt} = m_t,\ c_{rt} = c_t$ if the smaller quantities are exported. We calculate the unit production cost for a given level of the total supply $\bar{q}$ as $pc(\bar{q}) = \frac{1}{\bar{q}} \int_0^{\bar{q}} mc(q)dq = m + \frac{c}{2}\bar{q}$, that accounts the increase in costs with every additional unit of gas supplied.

Transportation costs Transport costs account for operation costs and gas losses, which are related to the length of pipelines and specific features of the track. The operation cost imply expenses mm on management and maintenance of pipelines and compressor stations. The gas losses present the per cent of gas g utilized by compressors on pumping to keep the pressure in pipelines. The both cost components are proportional to distance d, presenting the length of the pipe. Losses are known to be $g = 0.25\%$ of gas lost along every $100km$ of an onshore and 0.5% along an offshore pipeline.[19] The maintenance costs are the same for all the onshore links $mm = 0.1\$/tcm \cdot 100km$, and are doubled for high pressure underwater pipelines $mm = 0.2\$/tcm \cdot 100km$.

We derive the cost function of gas at the European border as to cover the expenses on the way:

$$\frac{\triangle tc(q)}{\triangle d} = mm + g \cdot tc(q) \tag{5}$$

We solve the differentiation equation and substitute the production cost for the cost at zero distance.[20] Then, given the quantity $\bar{q}$, which has already supplied, the cost of supply of additional amount of gas q_l delivered through the pipeline l are expressed as:

$$tc_l(q_l) = ((\frac{mm_l}{g_l} + (m_i + \frac{c_i}{2}(\bar{q}))e^{g_l \cdot d_l} - \frac{mm_l}{g_l})q_l \tag{6}$$

[17]We refer to the cost of gas declared to be at Russian border, that is the export node in Torgok. The data on the past and future changes were presented for the consideration in the "Strategy for the Russian gas industry development" (2004).

[18]Turkmenistan claims, that the price it asks from Russia reflects its marginal costs of production and delivery plus a normal return. Given that the transportation costs and norm stay the same all the time, one can take the changes in price to be equal to the change in marginal costs. The data on the gas price the Caspian Republics charge were collected from "EurasiaNet.org" publications (2003, 2004, 2005).

[19]See Oil, gas and coal supply outlook (1995) for further explanations of the transportation technology.

[20]For more detailed description of how the function was derived see Hubert, Ikonnikova (2004)

Note, that the transportation parameters are specified for a given pipeline l, whereas the production costs refers to a producer i. For the total supply costs of a coalition, we take a sum over the links used: $tc(q) = \sum_{l:k_l \in k_S} tc_l(q_l)$. Our computations suggest, that a coalition uses for deliveries first, the most efficient pipeline, then switches to the less efficient one, when the capacity of the previous is fully used.

Competition among coalitions Now we can calculate the export profits earned by the coalitions at the second stage. We assume that prices and quantities are determined through Bertrand price competition given the capacity constraints determined by the investments of the first stage. The supplying coalitions S compete given their capacities $\bar{k}(S)$ if they may form a complete supply chain to deliver gas to the market. Thus, a coalition should include a producer and have access to a transport link. As there are only two producers in our game, two cases to be distinguished:

(i) Russia and Turkmenistan stay in different coalitions $\Rightarrow$ competition among:

$$r \in S_r, \;\; t \in S_t \quad \text{such that} \quad S_r \cap S_t = \emptyset$$

(ii) The producers stay in one coalition, or one producer has no access to transport capacities $\Rightarrow$ monopoly supply:

$$r, t \in S_{rt} \;\; \text{or} \;\; i \in S_i : \; \bar{k}(S_i) \neq \emptyset \;\; \bar{k}(S_j) = \emptyset \;\; \text{for } i, j \in \{r, t\}$$

In the case of monopoly, zero externality is exerted in the supply model. The profit of the supplying coalition $w^S(S_{rt}; P^S)$, does not depend on the outsiders, who can not supply and hence, not compete. The producers solve a maximization problem with respect to the available capacities $\bar{k}_{S_{rt}}$:

$$w^S(S_{rt}; P^S) = \max_{q \leq k(\bar{S}_{rt})} \pi^m(\bar{k}_{S_{rt}}) \tag{7}$$

$$\pi^m(\bar{k}_{S_{rt}}) = p(q^m)q^m - tc(q^m) \tag{8}$$

$$\text{and} \;\; w^S(S; P^S) = 0 \quad \text{for all } S \neq S_{rt} \; \in P^S \tag{9}$$

The quantity q^m supplied by the coalition of producers, depends solely on the capacity constraint. For the case of symmetrical players, when the links are identical one will obtain:

$$q^m = \min[\bar{k}_{S_{rt}}, \frac{\alpha - \frac{mm}{g}(e^{dg} - 1) - me^{dg}}{2\beta + ce^{dg}}] \tag{10}$$

$$\pi^m(\bar{k}_{S_{rt}}) = q^m \cdot [\alpha - \frac{mm}{g}(e^{dg} - 1) - m_i e^{dg}] - (q^m)^2 \cdot [\beta + \frac{c_i}{2} e^{dg}] \tag{11}$$

To express the profits of the competing coalitions S_r, S_t in the case (i), we look at the results of Kreps and Scheinkman (1983). The authors link the Cournot competition outcome with the price competition occurred with capacity constraints. Under the Bertrand competition the lower price coalition would supply first. It would serve the demand up to available capacities: $q(S_i) = \min[\, p^{-1}(q(S_i)),\ \bar{k}(S_i)]$ and leave the residual demand of $q(S_j) = \min[\, \max[\, 0,\ p^{-1}(q(S_j)) - \bar{k}(S_i)\ ],\ \bar{k}(S_j)]$ to its competitor. As Davidson and Deneckere (1986) showed for the efficient-rationing of demand assumption the result holds, that the competitors will:

(i) earn Cournot profits, while their capacities lie inside the Cournot region, that is $|\bar{k}(S_i)| \leq r^c(\bar{k}(S_j))$ for $i, j = \{r, t\}$ with $r^c(\cdot)$ - the Cournot best response function:

$$w^S(S_i; P^S) = \pi_{S_i}(\bar{k}_{S_r}, \bar{k}_{S_t}) = p(|\bar{k}_{S_t}| + |\bar{k}_{S_r}|)q_{S_i} - tc(q_{S_i})$$
$$r(\bar{k}_{S_j}) = arg\max \pi_{S_i}(\bar{k}_{S_i}, \bar{k}_{S_j}) = \frac{\alpha - \beta\bar{k}_{S_j} - \frac{mm}{g}(e^{dg} - 1) - me^{dg}}{2\beta + c_j e^{dg}}$$

(ii) earn the Stackelberg profit if the capacities are outside the best response area $\bar{k}_{S_i} \leq \bar{k}_{S_j},\ \bar{k}_{S_j} \geq r(\bar{k}_{S_j})$

The supplier S_i with the smaller capacities calls a lower price and supplies first on the lower price, whereas the larger supplier S_j acts as a follower and sells $r(\bar{k}_{S_i})$. The revenue of the larger supplier is $R_{S_j} = p(\bar{k}_{S_i} + r(\bar{k}_{S_i}))r(\bar{k}_{S_i})$ and depends on the own capacities and those available to the rival. The profits are expressed as:

$$\pi_{S_j} = R_{S_j} - tc(q_{S_j})$$
$$\pi_{S_i} = \frac{\bar{k}_{S_i}}{\bar{k}_{S_j}} \cdot R^c_{S_j} - tc(q_{S_i})$$

In this case of competing producers externalities are exerted, whenever one producer succeeds in attracting transiters, who help his export or manage alluring transiters complement to the rival, that makes the latter a weaker, negative externalities appear.

4.2 Assumptions and values of the first stage

We describe the data on investment cost of the projects, which enter the capacity choice problem of the first stage. The costs of supply as well as the demand function are used to calculate profits of coalitions π_S at the second stage. Further, we describe investment costs, which appear in the maximization of π_{S^I} problem of the first stage. The expected payoffs are calculated on an annual basis, therefore we have to annualize investment costs.

Investment costs Investment costs are irreversible and sunk once capacities are built. The approximate lifetime of pipes is given as $t = 25$ years. We derive annual investment cost of a given project l as $I_l = r \cdot \bar{I}_l/(1 - (1 + r)^{-t})$, with $\bar{I}_l$ - total investment per unit capacity and $r = 0.15$ - real interest rate. If a pipeline opens a new track it takes one-two years more before it goes into operation. We take this into account by adding a multiplier $(1 + r)$ to investment cost. We present

Table 1: Description of the links

Link[a]	capacity k_l[bcm/a]	investment cost I_l[$/tcm]	distance d[100km]	supply cost tc(1tcm)[$]	countries, forming a supply link
Souyz	70	sunk	20	12.8	Russia, Ukraine
Yamal1	28	sunk	16	12.2	Russia, Byelorussia
Upgrade	15	7.7	20	12.8	Russia, Ukraine
Yamal2	∞	13.2	16	12.2	Russia, Byelorussia
NEP*	∞	21.5	16	14.2	Russia
TCP*	30	20.6	35	18.5	Turkmenistan, Azerbaijan, Georgia
Nabucco*	30	22.5	37	15.1	Turkmenistan, Iran

[a]We mark with a star the options, for which $I_l^* = (1+r)I_l$

the supply and investment costs for the links in the table1. The first two lines of the table describe the existing pipelines. Their capacities are fixed and investment costs are already sunk. The next two links are the extension of the first two existing pipelines, upgrade of Ukrainian pipeline system and the second band of the Yamal project.

The technology of pipelines implies some economies of scale. It is cheaper to extend a pipeline, by putting more compressors on it or lay a pipeline parallel to the existing track. To install a pipeline along a new path one has to invest in infrastructure around it, this leads to higher I_l. The last three pipelines introduce new export routes. As one can see, investment costs of these new links much higher, than those of Yamal2 and Upgrade options.

Another reason for such high both investment and supply costs relates to the length of these pipelines and whether it is an offshore or onshore link. Under the see installation and operation of a pipeline is more expensive, than that of on-shore. The length also adds to investment costs of pipeline. Therefore the unit investment of NEP is less, than that of TCP. Moreover, delivery along longer path leads to higher losses of gas, which will be included in the supply cost. That explains why the TCP is cheaper than NEP in installation, but more costly in tc. The Nabucco pipeline is longer than TCP, so that the supply costs of gas are higher, and investment cost are greater.

The second column of figures shows the capacity limits for the pipelines. They are fixed for the TCP, Upgrade and Nabucco as long as further increase will suggest the extension of the rest of the connected transmission network (e.g. the complement pipelines in East Europe and Turkey). The difficulty to attract an investment capital and secure returns, make the investment cost soar. Conceive an ultimate case when marginal investment cost raise to infinity for the capacities above the given limits. Then one ends up with the capacity constraints. The Yamal2 and NEG are considered to enter the European gas network at once. As Europe is assumed to adjust the internal grid to the import needs on its own, no restrictions are put on the pipelines going direct to the EU border.

5 Empirical results

Based on the quantitative assumptions we compute the profits of the coalitions for all possible partitions on the first and the second stages. We find equilibrium coalition structures and investments for the three scenarios: "the first best", when all the players could commit, "$\{r,t\}$ commit" when the transiters do not commit, and "$\{\emptyset\}$ commit", when none of the players could stick to the investment stage contracts.

In the table 2 we present the results of our calculations: equilibrium capacities of the network, supply prices and quantities, net aggregate profit of the network and total investment costs. The vectors of expected payoffs for the corresponding scenarios are given in the table 3. The first column of payoffs for every corresponding scenario shows the final payoffs of the investment game ψ^I, the second presents the expected payoffs at the supply stage. It is clear, that the first best scenario

Table 2: Equilibrium capacities, quantities, profits

scenario	capacity [bcm/a]					$\sum_S q_S \parallel \sum_l \bar{k}_l$	price[a]	net profit	$\sum_l I_l$
	NEP	TCP	Nab	Uup	Yam	[bcm/a]	[\$/tcm]	\$mln	\$mln
first best	0	0	0	15	42	155 ‖ 155	116	13473	670
$\{r,t\}$ commit	84	0	0	0	0	150 ‖ 183	117	11646	1828
$\{\emptyset\}$ commit	91	30	30	0	0	150 ‖ 250	117	11820	3250

Table 3: Expected payoffs of the supply chain parties in \$mln

	first best		$\{r,t\}$		$\{\emptyset\}$	
	ψ^I	ψ^S	ψ^I	ψ^S	ψ^I	ψ^S
Russia	9967	7438	8008	11326	7427	9374
Turkmenistan	2921	814	2539	1039	1938	3231
Ukraine	982	3259	888	888	229	219
Byelorussia	273	2632	211	211	63	63
Azerbaijan	2	0	0	0	563	563
Georgia	2	0	0	0	563	563
Iran	2	0	0	0	1037	1037

[a] for the residual demand parameters $\alpha = 0.35$, $\beta = 170$

would be associated with $P^S = P^I$. The grand coalition forms, so that the equilibrium partition would be $P^I = \{\{r,t,b,u,a,g,ir\}\}$. Cooperation would enable the players to *invest efficiently*, had everyone stuck to the contracts. The capacities along the cheapest tracks in Ukraine and Byelorussia would be installed. They would be equal to the monopoly quantities and fully used. The net profit of \$13473 would be earned under the equilibrium market price of 116\$/tcm. Incremental capacities of 57bcm along the South pipeline and Yamal would be installed and \$670mln of investment costs be paid. The players would share the joint profit according to the first column of figures in the table3. Russia will obtain the net payoff of \$9967mln, that is 70 % of the total profit of the network. Looking at the accompanying ψ^S column, one may notice, that if renegotiate, the transiters may gain a substantial profits, leaving the producers to pay for the capacities. Thus, Ukraine gets just \$982mln, instead of 3259mln, that would be 7% instead of 23%. The same tendency is observed n the case Byelorussia, which receives almost ten times less payoff.

The second case refers to the situation, when the transiters can not commit. Then there are only two partitions P^I, which are feasible. The first refers to the case when Russia and Turkmenistan form a coalition $S^I = \{r, t\}$, while the rest players stay singleton. The second would be the set of singleton coalitions and hence, would coincide with the third scenario. The equilibrium partition at the first stage is $P^I = \{\{r, t\}, \{a\}, \{b\}, \{g\}, \{ir\}, \{u\}\}$ and the grand coalition forms $P^S = \{\{r, t, a, b, g, i, u\}\}$ for supply at the second. Comparison of ψ^I of the second and the third scenarios reveal, that both producers will benefit from cooperation, and therefore cooperate if credible. As the transiters can not commit, the producers cooperate and invest strategically, as to gain the bargaining power, which increases their payoff. Russia will not invest in capacities of unreliable Ukraine and Byelorussia, as well as Turkmenistan will find building own path to Europe not worthwhile. No capacities will be installed in Azerbaijan, Georgia and Iran. Hence, *underinvestment* in cheaper pipelines will take place. Instead producers will substantially investments in the North European Pipeline, resulting in almost 30bcm/a of overcapacities. So the *overinvestments* in strategic direct link are predicted. Although, the producers invest \$1828mln against 670mln of the efficient investments, they win \$10547mln against 8252mln, which they would obtain if invest efficiently, but then met renegotiation which lead them to $\psi^S|_{first\,best}$.

In the second equilibrium the producers form and obtain higher profits by playing as a monopolists, instead of Bertrand competition. Russia gets access to cheaper Turkmen gas, that allows to reduce the costs of supply. Turkmenistan gets an opportunity to sell its gas through more efficient Russian transportation system. The merger of the producers weakens the transiters significantly. Turkmenistan postpones building of the alternative TCP and Nabucco routes, but only till Russia is a credible player.

In the third equilibrium, when the producers act independently, so that the partition consists of a set of singleton coalitions, the players would invest strategically as to gain the bargaining power with the others. In an attempt to strengthen their own bargaining position vis-a-vis the other players, huge excess capacities would be built. The total incremental capacity of 161bcm/a will be build, that is almost three times more, than we obtain for the efficient outcome. Russia would invest in NEG, which is, though, the most expensive option to extend its transport routes, would bring a leverage on all its transiters. To increase its bargaining power with Russia, Turkmenistan would build the TCP and Nabucco pipelines to have an option to bypass Russia. Meanwhile Ukraine and Byelorussia would think to extend their pipeline, but would give up given the investments in NEG. Azerbaijan, Georgia and Iran would enjoy the investments from Turkmenistan. Even anticipating recontracting, the Caspian producer would like to realize the projects, for it would lose almost \$1000mln, if would not do this. The preliminary calculations also show, that Turkmenistan would like to keep its transiters with roughly equal capacities. Giving an advantage to any of them, the producer, would weaken the position of the other and therewith his own. So, when $k_{TCP} = 30, k_{Nab} = 20$ Turkmenistan would lose \$57 if builds additional 10bcm along the TCP instead of Nabucco.

Hence, we predict even *further overinvestments* when the cooperative agreements upon investments are not possible. Along with it we observe, however, that Turkmenistan will strengthen its position and obtain 22% of total profit under $\{r, t\}$ cooperation versus 20% obtained in the first best case, though only 16% in the last scenario. In the noncooperative third case, Azerbaijan and Georgia, as well as Iran will gain a lot of power, as their role in the play versus Russia increases. The Caspian gas transiters exploit their bargaining position to extract quasi-rent, putting the burden of investments on Turkmenistan.

Further, we estimate, the required amount of external financing for the Trans-Caspian and Nabucco pipelines in order to attract Turkmenistan from cooperation with Russia. Recently the USA and some EU countries offer to support the Caspian producers, to induce their competition with Russia. Reducing I_{TCP} and $I_{Nabucco}$ costs of pipelines' installation, we find that already by paying about 30% of costs one can cause a breakdown of a coalition of the producer. Russia will not be able to compensate the Caspian producers for their cooperation.

6 Conclusions

In the paper we analyze strategic interaction and coalition formation among the parties of the Eurasian gas supply network. We investigate how the producers, Russia and Turkmenistan, and the transiters, Ukraine, Byelorussia, Azerbaijan, Georgia, and Iran, cooperate to invest in the transport capacities and to supply gas to the European gas market.

The analysis is complicated by the externalities exerted under the endogenous coalition formations. If Turkmenistan succeeds in forming a coalition with the Caspian transit countries and is able to bypass the Russian transportation system, the competition will occur as a result. The competitive supply chain would reduce the profits of coalitions involving Russia. This "externality" prevents us from solving the game using the Shapley value, instead we have to describe the game in a so called "partition function form". We employ the axiomatic solution concept recently proposed by Maskin (2003), to determine the equilibrium coalition structure and the corresponding payoffs to the network parties.

Based on estimated demand, cost of supply, and incremental investment cost functions, we numerically solve for the equilibrium coalition structure, investment and profit sharing. In this sense the European supply network analysis provides us with a rather unique opportunity to confront the theoretical solutions of cooperative game theory with the real world experience.

Our qualitative analysis predicts excess capacities in equilibrium with respect to the first best case, when all the parties can commit and no hold-up problem arises. The ability to commit to long term sharing turns out to be of an overwhelming importance. It diminishes the role of difference in investment cost. Overinvestments in links, presenting outside options, are made by players to increase their bargaining power. Thus, if the transiters cannot commit, the producers will form a coalition and invest in a direct pipeline through the Baltic sea. This leads to underinvestments in links, owned by the players who can not commit, show reluctance of investors to get involved in further renegotiations. The cheap and more efficient Ukrainian and Byelorussian links will not be extended.

If the producers refused to cooperate, the Caspian producers would build the pipelines, which enable them to enter the European market, despite the inability to commit of the Caspian transiters. The competition would force Russia to install even greater overcapacity. However, the detrimental effect of a competition will not allow either producers to earn as much as under the cooperation. Hence the coalition of producers is renegotiation-proof.

The USA and the EU countries offer a financial support to the Caspian producers, to induce their competition with Russia. Changing the costs of pipeline installation, we find a condition under which the coalition of producers will breakdown, since Russia will not be able to compensate the Caspian producer for their cooperation. Put it differently we calculate how much of investment costs should be covered by third party in order to make the Caspian producers to refuse to cooperate with Russia.

The final results look striking for such a large overcapacity is observed. We refer to some remedy, which might help to decrease overcapacity, although could hardly help underinvestments. Our model is *static* in a sense, that we consider the terminal possibility to invest, so that no further strategic investments to prevent opportunistic behavior are done. However, if one will look at the case when more period of investments follow, so that the investments are graduate, the hold-up problem effect is diminished. The collaborative research is performing by Hubert and Sulejmanova (2006) confirms the possibility to reduce the distortions.

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