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Options for Transporting Russian Gas to Western Europe - A Game-theoretic Simulation Analysis

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Options for Transporting Russian Gas to Western Europe - A Game-theoretic Simulation Analysis*

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Abstract

This paper examines the perspectives of Russian gas exports to Western Europe and the strategic options of the CIS gas transiting countries, namely Ukraine and Belarus. The development of a new transit corridor through Belarus (the Yamal-Europe pipeline), depriving Ukraine of its former monopoly, has modified the situation profoundly. The thrust of the paper is an analysis of the strategies that Ukraine and Belarus may pursue in transiting Russian gas: non-cooperative duopoly, cooperative duopoly, and individual or collective cooperation with Russia. Using a demand function for Western European gas imports from Russia, we estimate prices and quantities for gas transit, the expected profits for Russia, Ukraine, and Belarus, and the resulting import prices for Western Europe. The results indicate that Ukraine suffers a loss of several hundred million USD annually from the market entry of Belarus, Belarus has an incentive to increase its gas transit capacity to at least 56 billion cubic meters, and Russia's profits increase, in particular when it unites its gas sector with Belarus and Ukraine, a strategy pursued by Russia's Gazprom presently. For Western Europe, all scenarios indicate an increase in welfare through the new pipeline, but also an increasing importance of gas imports from Russia.

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1 Introduction

The West European dependence upon gas imports from the Soviet Union and, since 1991, from Russia have been and continue to be a critical issue studied both from an energy economic and from a geopolitical perspective. The political and economic dependence of Western Europe upon gas imports from Russia has been dealt with in the literature from the beginning of the first long-term contracts in the late 1970s (see Greer/Russel, 1982, Banks, 1983). The most extensive quantitative analysis of interdependence in European East-West gas trade was carried out by Grais/Zheng (1996) showing that an improved reliability of gas supply from Russia is beneficial to the Russian gas exporting industry, to the gas transiting countries *and* to the West European gas importers. However, political and economic instability in Russia and in the main transit country, Ukraine, have raised doubts on the reliability of supply, thus containing the market share of Russian gas on the West European market.

The rules of the game have been changed significantly by the completion in late 1999 of a parallel gas pipeline allowing Russian gas exports via Belarus to Poland and on to Germany, the so-called Yamal-Europe pipeline. In addition, Russia and the West European gas industry are considering to construct a "by-pass" pipeline from Belarus through Poland to Eastern Slovakia, in order to circumvent the politically unstable Ukraine even further. Thus, the former monolithic gas trade between Russia and Western Europe has become a multiplayer game with significant effects on strategies and potential outcomes.

In this paper, we analyze the perspectives of the Russian gas exports in the light of potential pipeline development in Belarus and Ukraine. The market entrance of Belarus gives rise to a duopolistic market structure which we examine with respect to its effects on transit fees and transit volumes, the investments into new capacities, and the profits of the three countries. The paper is structured in the following way: Section 2 provides a survey of recent developments in Russian gas exports and provides a qualitative analysis of the planned pipeline project in Belarus. The core of the paper is the modeling and subsequent quantification of possible development scenarios in Section 3. We run different scenarios on the capacity- and price-decisions of Belarus, Ukraine, and Russia, using four different cases (cooperation and non-cooperation between the transit countries themselves, and between the transit countries and Russia, respectively). Having approximated a demand function of Western European gas imports from Russia, we can quantify the scenarios and attach concrete figures for quantities, prices, and profits for all players under different assumptions (Section 4). Finally Section 5 compares the results of the model with recent political developments and discusses the potential repercussions on Russia, the transit countries, and Western Europe.

2 Recent Developments in Russian Gas Exports and Transits

2.1 Transit Problems with Ukraine

In spite of the political, economic and social upheaval of the post-Soviet transformation crisis, the transit of Russian gas to Central and Western Europe has continued, and even expanded, smoothly. This trend is strengthened by the debate over the phasing out of nuclear energy in Europe, and the possible exhaustion of gas reserves in the North Sea. Russian gas exports to non-CIS countries have increased from 107 bcm (1994) to 133 bcm (1999) and the West European gas importers expect a further increase. However, until very recently, the reliability of Russian exports was limited, amongst other factors, by the political and economic instability in Ukraine, the monopolistic transit country. The dissolution of the Soviet Union and the independence of Ukraine made it possible for the latter to exercise monopolistic power in transit. Evidence for this is provided by the fact that Ukraine charges a transit fee of about $0.88 - 1.09$ USD/tcm/100km, whereas its marginal costs are about $0.15 - 0.24$ USD/tcm/100km (Opitz, Hirschhausen, 2001, 155). In addition, Ukraine was regularly accused by Russia of illegally withdrawing transit gas.[1] Whereas few changes have occurred in the gas sector during the first decade of independence, the pressure on Ukraine to modify the functioning of its gas transit activities is increasing.[2] The rents from the gas transit business also contributed to the general political climate of rentseeking, corruption, and to the difficulty of separating state and economy and introducing efficient corporate governance in Ukraine. All in all, political instability in Ukraine added credibility to scenarios in which, as happened in October 1992, Ukraine might be unable or unwilling to transit Russian gas to Central and Western Europe.

[1] In 2000, Gazprom estimated the gas theft by NaftogazUkrainy at 15 bcm this year (Infodienst 44/2000, 17); in contrast to this NaftogazUkrainy admitted an illegal withdrawal of gas of only one bcm for which it wanted to reimburse Gazprom.

[2] For example, the issue of Ukrainian debt towards Russia stemming from unpaid energy bills is increasingly challenging the country's independence, and thus the gas sector's independence. As of late-2001, unpaid bills to Russia have cumulated to 1.4 bn. USD. Russia is intensifying its lobbying efforts towards debt-equity deals, seeking ownership of the transit pipeline and the two underground storage facilities. Also, the technical state of the pipeline is critical. Indeed the under-investment of the last ten years is bearing its fruits, be it increasing compressor fuel consumption, or corrosion problems. Estimates of investment requirements for the transit system alone vary between 0.5-2 bn. USD.

2.2 Alternatives for Gas Transit

Since the early 1990s, different options were discussed to contain the monopolistic power of Ukraine over gas transit to Western Europe. However, it took until the late 1990s for Russia, Belarus, and the West European gas importing industry have taken concrete action in creating alternative transit capacity to meet additional demand on the West European market, and at the same time to weaken the monopoly power of Ukraine (see Figure 1 in annex):

- New capacities to transit large amounts of gas through Belarus and Poland were built within the framework of the "Yamal-Europe" pipeline. Initially conceived to transport gas from the Yamal peninsula to Western Europe, the Yamal-Europe pipeline is now used as a transit pipeline for gas from Western Siberia that transits through Belarus (Minsk - Nesvizh) and Poland (Kondratki - Wloclawek) to Germany (Frankfurt/Oder, Mallnow). The connection of the first 56" trunk was completed in November 1999, with a nominal capacity of 28 bcm, to which a second (and third) line could be added to carry the capacity to 56 bcm (84 bcm, respectively);

- The next step to circumvent Ukraine is the project of the so-called Yamal-2 pipeline connecting Kondratki (Poland) to Velke Kapuzany (Slovakia), with a projected capacity of 60 bcm. This would allow the Western importers to use the Central corridor (with its high capacity and convenient connections to West European markets) while still not depending entirely upon Ukraine for transit. Yamal-2 has attracted significant interest by West European gas importers (e.g. Ruhrgas, Wingas, Gaz de France, Shell) who are ready to participate in the financing of this approximately 1 bn. USD project.

Whereas the profitability of the second alternative, the so-called bypass, is yet to be proven, a simplified financial analysis of the Yamal-Europe pipeline, shows it to be highly profitable, even when considering the risks. For the Belarus pipeline project, two major risks have to be considered:

- *Political risk*, i.e. the fact that the Belarus government may sequestrate a part or all of the profits from the pipeline business from the investor.

- *Transit price risk*, which reflects the fact that additional capacity may reduce the transit price.

A cash-flow analysis shows that the project is highly profitable.[3] Given a project life of 30 years, the Belarus investment project reaches a net present value of nearly 3 bn. USD, which corresponds to an internal rate of interest of approximately 20% (aasuming a transit price of 0.80 USD/tcm/100km.)
An analysis of the investment project as a real option shows that for most probability distributions, investors are better of investing immediately instead of waiting one or more periods.[4] The following section describes the different opportunities for the three parties - Russia, Ukraine, and Belarus - with regard to their activities in the future.

See annex

Figure 1: Transit pipeline system between Russia and Western Europe

3 Modeling the Three Players Export-Transit Game

3.1 Four possible constellations between Russia, Ukraine, and Belarus

In this section, we sketch out the possible constellations that can arise among the three key players in the export-transit game, i.e. Russia, Ukraine, and Belarus.[5] We distinguish between four types of coalitions, within which different price-setting mechanisms can be applied. The four constellations are:

[3] We made the following assumptions: transit volume (first stage): 28 bcm; pipeline construction costs for 1200 km pipeline: 1200 mn. USD; basis costs for 3 compressor stations: 60 mn. USD; unit costs per aggregate in 2 compressor station: 36 mn. USD; pipeline fixed costs: 0.5% of construction costs; compressor fixed costs: 3% of construction costs; variable costs: 1% of the gas price; construction time horizon: 2 years; credit period: 10 years; grace period: 2 years; USD annual inflation rate: 2%; interest rate: 16%.

[4] For our investment analysis according to the Dixit/ Pindyck (1994) real option approach, we estimated the future transit price development in the following way: with a probability of 40% the transit fee will be constant, with a 10% probability the transit fee will rise on 1.20 USD/tcm/100km and hence, with 50% will fall to 0.80 USD/tcm/100km; the political risk was captured by the probability of 15 % that the government will take 50% of the transit gains which the new pipeline yields, and a 5% likelihood that the government sequestrate all the yields by 100%.The full calculations of the cash-flow analysis and the real option analysis are available from Berit Meinhart upon request.

[5] We consider the other transit countries to Western Europe (Poland, Hungary, Slovakia, Czech Republic) as already being part of the enlarged Europe, and do not model their behavior specifically.

Transit Monopoly (point of inception) Russia-Ukraine, non-integrated. This situation prevailed in the sector until recently. Ukraine is the transit monopolist; as an independent player (i.e. not vertically integrated with the Russian gas industry), it charges a monopolistic transit fee;

Transit Duopoly Russia-Ukraine-Belarus, no integration. In that constellation, Ukraine and Belarus form a transit duopoly. We assume that both players know the West European demand function for Russian gas. In the short-term, with given capacities, each one has to decide upon the profit-maximizing transit fee; in the long-term, they have to decide upon capacities as well. Russia as the gas exporter has to fix the profit-optimizing price, including transit charges, that it offers to West European gas wholesalers.
Within this constellation II, four situations are conceivable for the duopolists Ukraine and Belarus:

- Π_c cartel: Ukraine and Belarus decide to form a coalition against Russia, and thus charge a monopolistic price p_m;

- $\Pi_{R_1 R_2}$ describe a restricted competition situation, where one of the players supplies the market with its whole capacity, while the other firm demands monopolistic prices for the residual quantity (assuming the quantity of the first player is capped). We define R_1 as the strategy where Ukraine charges the monopolistic fee for the residual quantity, and R_2 describes the reverse situation where Ukraine uses its full capacity and Belarus charges monopolistic prices for the residual capacity.[6] In the present situation, R_1 is more likely, as the Belarus capacity is limited (28 bcm), and Ukraine can charge a monopolistic fee on the residual quantity.[7] The inverse situation, where Belarus charges a monopolistic fee and Ukraine uses its full capacity, is unlikely for the time being (as it requires that Belarus has higher transit capacities than Ukraine);

- Π_{cap} full capacity utilization, is the traditional non-cooperative price competition, where Ukraine and Belarus undercut each other's price until both have fully used their respective capacities. The emerging price

[6] Theoretically, R_1 and R_2 are not necessarily stable equilibria, as the supplier of the residual capacity may have an incentive to undercut the price of the competitor marginally, and thus make a larger profit; this may lead to a downward-spiraling price competition. However, we assume that R_1 and $R_2 are$ stable.

[7] This scenario suggests that Russia has an incentive to support capacity creation in Belarus to reduce the dependence upon Ukraine.

depends upon the total available capacity and the elasticity of West European gas demand.

Restricted Transit Monopoly ("Northern coalition") Ukraine vs. Belarus and Russia, the latter forming a coalition: Russia and Belarus integrate the gas production and gas transit, and thus apply marginal cost pricing for the Belarussian transit; Ukraine only transits the residual quantity at a monopolistic price. Given recent political proximity between Russia and Belarus, constellation III seems a plausible scenario for further pipeline extensions.

Cartel ("Slavic cartel") coalition between Russia, Belarus, and Ukraine. Last but not least, one has to examine the cartel situation where Russia joins its production with the transit activities in both Ukraine and Belarus, and where this trio optimizes the total profit as an oligopolistic gas supplier to Western Europe. Again, this coalition would apply marginal-cost pricing internally, and thus obtain a lower price and a higher share on the West European gas market. In order to incite Ukraine and Belarus to renounce to their monopolistic transit fees, Russia would have to commit itself to a profit sharing with Ukraine and Belarus.

3.2 The Modeling

Due to the fact that the transit fee setting decision is influenced by the expected sale and that the production decision depends on both transit and sale, we shape the three players game in our analysis in a reverse chronological order: sale, transit and production. As we presented in the former subsection we will examine four constellations:

- transit monopoly
- transit duopoly
- restricted transit duopoly (R_1, R_2) and
- transit cartel

We reduce the quantitative analysis of gas sales to the three most important markets for Russian gas: Germany, France and Italy.[8] Together these three countries account for almost 100% of West European gas imports from Russia.

[8] See Chollet (2001), p.12

3.2.1 Transit Monopoly

Modeling the transit monopoly situation we can assume that player UKR has certainty about sales quantity. Therefore, the decision for the transit fee is economically unequivocally determined.
Ukraine acts in a profit maximizing way by setting the transit fee:

$$\Pi_{ukr} = \tau_{ukr} \cdot x \tag{1}$$

$$\tau_{ukr} = p_{ukr} - p_{rus} - c_{ukr} \tag{2}$$

with τ_{ukr} as transit charge and x as sold quantity. The transit charge τ_{ukr} can be written as the selling price at the West European border p_{ukr} minus the Russian sales price at the Ukrainian border p_{rus} minus the Ukrainian transit costs. We assume a linear demand function for Russian gas in Western Europe (that will be quantified later on):

$$p = a \cdot x + b \tag{3}$$

Then we can write the Ukrainian profit as:

$$\Pi_{ukr} = (a \cdot x + b - p_{rus} - c_{ukr}) \cdot x \tag{4}$$

Maximizing the profit of Ukraine

$$\frac{\partial \Pi_{ukr}}{\partial x} = 2ax + b - p_{rus} - c_{ukr} \stackrel{!}{=} 0 \tag{5}$$

$$\implies x = \frac{1}{2a}(p_{rus} + c_{ukr} - b) \mid x \leq C_{ukr} \tag{6}$$

with C_{ukr} designating the Ukrainian transit capacity.

The behavior of Russian as a profit maximizer can be modeled as follows:

$$\Pi_{rus} = (p_{rus} - c_{rus}) \cdot x \tag{7}$$

we can utilize 6 in 7:

$$\Pi_{rus} = \frac{1}{2a}(p_{rus} - c_{rus}) \cdot (p_{rus} + c_{ukr} - b). \tag{8}$$

Thus, Russia's profit only depends on the parameter p_{rus}. Setting the first derivative to zero, we get

$$\frac{\partial \Pi_{rus}}{\partial p_{rus}} = \frac{1}{2a}(2p_{rus} - c_{rus} + c_{ukr} - b) \stackrel{!}{=} 0 \tag{9}$$

$$\implies p_{rus} = \frac{1}{2}(b + c_{rus} - c_{ukr}) \tag{10}$$

and for the price at the Western Europe boarder:

$$p_{ukr} = a \cdot x + b = \frac{1}{4}(c_{rus} + c_{ukr} + 3b) \tag{11}$$

3.2.2 Transit Duopoly

In case of the transit duopoly three actors are involved in the game: Russia (RUS), Belarus (BEL), and Ukraine (UKR). Knowing the West European linear demand function the two transit players UKR and BEL have to take the decision about their transit fee. Player RUS has to decide about the sales price at the Western Europe border anticipating the transit fee decision by BEL and UKR.

Hence follows a strategy room with four possible solutions:

a) the Bertrand competition price p_b;

b) the restricted capacity price p_{cap};

c) the collusion price p_{coll} (upper limit) and;

d) the prices arising from a restricted price competition $(p_{R_1,}, p_{R_2})$.

a) Marginal cost price (competition C) In the case the marginal costs for both players are different, the marginal cost price will be set slightly below the level of the higher marginal costs. The player with the smaller marginal costs has no incentive to reduce the price further, since the competitor is not yet making a profit.

$$p_b = max \begin{cases} p_{rus} + c_{ukr} - \epsilon \\ p_{rus} + c_{bel} - \epsilon \end{cases} \tag{12}$$

b) Capacity price (p_{cap}) The capacity price results from the maximum exhausted capacities C_{bel} and C_{ukr}:

$$p_{cap} = a \cdot (C_{bel} + C_{ukr}) + b \tag{13}$$

c) Monopoly price (collusion p_{coll}) In case of collusion both players BEL and UKR act jointly as one profit maximizer. Assuming that the operating costs plus the price at the Western Europe border ($c_i + p_{rus}$) are different for both players, two possible quantities x_{mon} arise depending on the players' capacities:

$$\begin{aligned} \Pi_i &= \tau_i \cdot x^i_{mon} \\ &= (p - (p_{rus} + c_i)) \cdot x^i_{mon} \\ &= (a \cdot x^i_{mon} + b - (p_{rus} + c_i)) \cdot x^i_{mon} \end{aligned} \tag{14}$$

Maximizing the profit by setting the first derivative to zero we get:

$$\begin{aligned} \frac{\partial \Pi}{\partial x^i_{mon}} &= 2a \cdot x^i_{mon} + b - (p_{rus} + c_i) \stackrel{!}{=} 0 \\ \iff \quad x^i_{mon} &= \tfrac{1}{2a}(p_{rus} + c_i - b) \end{aligned} \tag{15}$$

To identify the monopoly price we assume that as long as capabilities are not binding, the data of the player with the smaller $\sum c_i + p_{rus}$ will be used.[9] The developed total sales quantity x_{mon} will be distributed at the rate of the players capacities, such that the following single selling quantities arise:

$$x_i = x_{mon} \cdot \frac{C_i}{\sum C_i} \mid x_i \leq C_i \tag{16}$$

Respectively the resulting price is:

$$p_{mon} = a \cdot x_{mon} + b \tag{17}$$

d) Restricted competition price (restricted competition R_1,R_2) In the case of restricted competition, one player is confronted with a shortened market by the capacity of the other player. Since both cases R_1,R_2 are symmetric, we choose the case R_i that reflects the player i using its total capacity, and player -i behaving like a profit maximizing monopolist on the residual market.

The demand function for player -i can be written as:

$$p_{-i} = a \cdot (x_{-i} + C_i) + b \tag{18}$$

and yields to the profit maximizing quantity:

[9] Choosing the maximum of both quantities x^i_{mon}, since $c_1 + p_{rus} < c_2 + p_{rus} \Longrightarrow x^1_{mon} > x^2_{mon}$.

$$
\begin{aligned}
\Pi_{-i} &= (p_{-i} - p_{rus} - c_{-i}) \cdot x_{-i} \\
&= (a \cdot (x_{-i} + C_i) + b - p_{rus} - c_{-i}) \cdot x_{-i} && (19) \\
\frac{\partial \Pi_{-i}}{\partial x_{-i}} &= 2a \cdot x_{-i} + a \cdot C_i + b - p_{rus} - c_{-i} \stackrel{!}{=} 0 && (20) \\
\Longleftrightarrow x_{-i} &= -\frac{C}{2} - \frac{b - p_{rus} - c_{-i}}{2a} && (21)
\end{aligned}
$$

The quantity x_i will by definition be set to:

$$x_i = C_i \tag{22}$$

Hence the following price results:

$$
\begin{aligned}
p_{R_i} &= a \cdot (-\frac{C_i}{2} - \frac{b - p_{rus} - c_{-i}}{2a} + C_i) + b \\
&= a \cdot \frac{C_i}{2} + \frac{b - p_{rus} - c_{-i}}{2} && (23)
\end{aligned}
$$

3.2.3 The Restricted Transit Duopoly

The restricted transit monopoly reflects the situation that player RUS and BEL build a cooperation and act like one player. In this case only two actors dominate the game: RUSBEL as producers with their own export capacities and UKR as a pure transit player.

Starting from the following profit function:

$$\Pi_{ukr} = (a \cdot (x_{ukr} + x_{bel}) + b - c_{ukr} - p_{rus}) \cdot x_{ukr} \tag{24}$$

we can compute Ukrainian quantity, given the quantity x_{bel} and the price p_{rus}:

$$
\begin{aligned}
\frac{\partial \Pi_{ukr}}{\partial x_{ukr}} &= a x_{bel} + 2a x_{ukr} + b - p_{rus} - c_{ukr} \stackrel{!}{=} 0 \\
\Longleftrightarrow x_{ukr} &= \frac{1}{2a}(p_{rus} + c_{ukr} - a x_{bel} - b) && (25)
\end{aligned}
$$

RUSBEL will use the information on Ukraine's quantity in order to maximize its own profit:

$$\Pi_{rusbel} = (p_{rus} - c_{rus}) \cdot (x_{bel} + x_{ukr}) + (p - c_{bel} - p_{rus}) \cdot x_{bel} \tag{26}$$

The selling price at the Western Europe border p is included in equation 2 for the Belarus route by the transit fee τ_{bel} ($\tau_{bel} = 0$, because RUSBEL does not levy a transit fee on its own transit), the Russian selling price p_{rus}, and the Belarus transit costs c_{bel}. Therefore we can simplify equation 26 as:

$$\Pi_{rusbel} = (p - c_{bel} - c_{rus}) \cdot x_{bel} + (p_{rus} - c_{rus}) \cdot x_{ukr} \tag{27}$$

Substituting x_{ukr} from 25 into 27, the profit of RUSBEL depends only on the two variables, x_{bel} and p_{rus}:

$$\begin{aligned} \Pi_{rusbel} &= (ax_{bel} + \frac{1}{2}(p_{rus} + c_{ukr} - ax_{bel} + b) - c_{bel} - c_{rus}) \cdot x_{bel} \\ &+ \frac{1}{2a}(p_{rus} - c_{rus}) \cdot (p_{rus} + c_{ukr} - ax_{bel} - b) \end{aligned} \tag{28}$$

By differentiating equation 28 we can show that both variables depend only on the exogeneously given parameters:

$$\frac{\partial \Pi_{rusbel}}{\partial x_{bel}} = ax_{bel} + c_{ukr} - \frac{b}{2} - c_{rus} - c_{bel} \stackrel{!}{=} 0 \tag{29}$$

$$\begin{aligned} \Longrightarrow x_{bel} &= \frac{1}{a}(c_{rus} + c_{bel} - c_{ukr} - \frac{b}{2}) \\ &= f(c_{rus},\, c_{bel},\, c_{ukr},\, b) \end{aligned} \tag{30}$$

$$\frac{\partial \Pi_{rusbel}}{\partial p_{ukr}} = \frac{1}{a}(p_{rus} + \frac{b}{2}) \stackrel{!}{=} 0 \tag{31}$$

$$\begin{aligned} \Longrightarrow p_{rus} &= \frac{b}{2} \\ &= f(b) \end{aligned} \tag{32}$$

Substituting x_{bel} in equation 25 by equation 30 we get Ukraine's transit capacity:

$$x_{ukr} = \frac{1}{2a}(2c_{ukr} - c_{rus} - c_{bel} - b) \tag{33}$$

But Belarus' transit quantity computed by equation 30 could exceed its capacity C_{bel}. In this case we substitute x_{bel} in equation 25 with C_{bel} and get RUSBEL's profit:

$$\begin{aligned}\Pi_{rusbel} &= (aC_{bel} + \frac{1}{2}(p_{rus} + c_{ukr} - aC_{bel} + b) - c_{bel} - c_{rus}) \cdot C_{bel} \\ &+ \frac{1}{2a}(p_{rus} - c_{rus}) \cdot (p_{rus} + c_{ukr} - aC_{bel} - b) \end{aligned} \tag{34}$$

The only variable value in equation 34 is RUSBEL's price p_{rus}. Thus RUSBEL maximizes its profit accoarding to the first order condition:

$$\frac{\partial \Pi_{rusbel}}{\partial p_{rus}} = \frac{1}{2a}(2p_{rus} + c_{ukr} - c_{rus} - b) \stackrel{!}{=} 0 \tag{35}$$

$$\Longrightarrow p_{rus} = \frac{1}{2}(c_{rus} - c_{ukr} + b) \tag{36}$$

3.2.4 Transit Cartel

Within the transit cartel all three players act together as one player and optimize the profits of this one player. The difference with respect to the single monopoly case is that two alternative export routes now exist, which can be combined. As long as the marginal costs are identical, the optimal price will be determined by the marginal costs equal to marginal revenues. In case of different transit costs on the two routes ($c_{bel} \neq c_{ukr}$), we get two constant but different marginal costs ($c_{bel} + c_{rus}$ resp. $c_{ukr} + c_{rus}$). Hence, the linear demand function can be written as:

$$\frac{\partial \Pi_{cartel}}{\partial x} = 2ax + b = c_{bel} + c_{rus} \ \vee \ c_{ukr} + c_{rus} \tag{37}$$

Without any capacity restrictions, only the pipeline with the lower marginal costs would be used. In the case that the optional export quantity exceeds the capacity of the lower cost pipeline, the new optimal export quantity will be determined by equalizing the marginal revenues and the higher marginal costs.

4 Data Analysis and Results

The analysis of the three player game described in the last section is based on the assumption of a linear demand function for Russian gas. [10] Thus the

[10] This is a strict simplification, but necessary for computing results. We neglect the reactions of other gas exporting countries (Netherlands, Norway, Algeria) on price changes

demand function for Russian gas at the West European border depends only on two parameters:

$$p = a \cdot x + b \tag{38}$$

The parameters a, b used in this paper are calculated using a simplified version of the model of Golombek u.a. (1995): Parameter $a = -0.1812 \frac{USD}{tcm \cdot 10^9 cm}$ and parameter $b = 58.9122\, USD$.[11]

The Ukrainian transit capacities (Belarus, Progres, and Sojuz) total approximately 110 bcm per year. In 1999 some 60 bcm of gas were transited to Western Europe, and some 40 bcm to Central Europe. Together with exports to countries in the South-East of Europe the utilization rate of these pipelines is near 100%. [12] We assume that Central European countries require a constant capacity of 40 bcm. Thus the maximum transit capacity of the Ukrainian system for transit to Western Europe is 70 bcm. The capacity of the Yamal-Pipeline via Belarus and Poland is taken as 28 bcm per year during the first stage. It is planned that capacity be expanded to a total of 56 bcm in the second stage. Hence, we have two capacities for the Belarussian route. $C_{bel,1} = 28$ bcm and $C_{bel,2} = 56$ bcm.

Transport costs Transport costs for Belarus and Ukraine are taken from Golombek et al. (1995). It is important that only variable costs are taken into account for short-term supply. The transport costs are thus computed as $c_{bel} = 5.865 \frac{USD}{tcm}$ and $c_{ukr} = 11.73 \frac{USD}{tcm}$.[13]

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of Russian export gas. Thus, the price elasticity of demand for Russian gas might be overestimated. It is planned to extend the present model in order to better model the West European gas imports.

[11] Chollet (2001, pp. 27 sq.) contains a detailed computation of parameters a, b. In essence, Golombek et al. (1995) provide a functional form of the demand curve, using various technical parameters. The coefficients a and b of the West European demand curve are obtained as best choices from a regression, using different intervals in the demand curve (up to 100 bcm). We acknowledge that this is quite a rough estimate, however, given substantial data constraints, it is the best one available.

[12] Opitz/Hirschhausen (2000)

[13] Golombek et al. (1995) have stated the following formula for variable transport costs for gas in the CIS:

$$c_{CIS} = \frac{l}{100\, km} \cdot 0.62 \frac{USD}{toe}$$

However, it is known that the new Belarussian pipeline is technically more efficient than the old Ukrainian one, which is notoriously outdated, leaky, and has high operation costs. Thus we take the Golombek et al. formula as an average and add 10% for the Ukrainian

Production costs Production costs for Russia are derived from the transit monopoly model. We can find a dependency between price p_{ukr} and quantity x (cf. equation 11) that must be valid for 1998 when the transit monopoly was still untouched. With given Ukrainian transport costs we get production costs for RUS:

$$c_{rus} = 4 \cdot p_{ukr} - 3 \cdot b - c_{ukr} \tag{39}$$

Thus, $c_{rus} = 6.21 \frac{USD}{tcm}$. This corresponds quite closely with estimates from gas sector specialists, varying between $3 - 8 \frac{USD}{tcm}$.

Table 1 shows the results from the simulation analysis for the four strategies (transit monopoly, transit duopoly, restricted transit duopoly, and cartel case); we calculate prices, quantities, and profits for different transit capacities of the market entrant Belarus (28 bcm and 56 bcm, respectivly).[14]

Prices One important result arising from the simulation analysis is that Western Europe will benefit from the market entry of Belarus, due to the rising quantity supplied by Russia at lower prices. The sales price of Russian gas at the Western European border decreases from the former Ukrainian transit monopoly situation ($p_{ukr} = 48.3$ USD/tcm), down to the transit duopoly case ($p_{ukr} = 47.6$ USD/tcm) and to the restricted transit duopoly case, where $p_{ukr} = 46.2$ USD/tcm; finally, in the case of the cartel between Russia, Ukraine, and Belarus, the sale price falls even further to $p_{ukr} = 41.2$ USD/tcm; this

costs and reduce Belarussian costs by 10%.

$$c_{ukr} = \frac{l}{100\,km} \cdot 0.68 \frac{USD}{toe}$$

$$c_{bel} = \frac{l}{100\,km} \cdot 0.56 \frac{USD}{toe}$$

We simplify and define the Ukrainian transport lenght as $l_{ukr} = 2000\,km$ (i.e. Russian/Ukrainian border to Western Europe); then Ukrainian transport costs are:

$$c_{ukr} = 13.6 \frac{USD}{toe} \cong 11.73 \frac{USD}{tcm}$$

With a further simplification, we set $l_{bel} = 1200\,km$ (i.e. Russia/Belarus border to Polish/German border) and thus get Belarussian transport costs:

$$c_{bel} = 6.72 \frac{USD}{toe} \cong 5.865 \frac{USD}{tcm}$$

[14] Unless stated differently, the following results are valid for Belarus transit capacities of 28 bcm; the nature of the results can be transposed to the case of 56 bcm.

price results from a profit maximization of all three players (Russia, Ukraine, Belarus) jointly, whereas Russia has to compensate Ukraine and Belarus for the lost transit profits.

Inversely, the sale price of Russian gas to the transit countries increases from the monopoly case (sale price at the Ukrainian border: $p_{rus} = 26.6$ USD/tcm), to the transit duopoly: Due to the emergence of an additional transit route, Russia can increase its sale price at the Ukrainian and Belarus border (to $p_{rus} = 29.3$ USD/tcm). The redescending of that price in the restricted transit duopoly ($p_{rus} = 26.6$ USD/tcm) can be explained by the fact that the Nortern coalition (Russia and Belaurs) faces no transit mark-up, and that it can therefore offer gas at a lower price to Western Europe; in order to satisfy West European demand at the lower price, Russia sells to Ukraine at a price that assures market clearing, while the Northern pipeline (28 bcm) is fully used; hence, the residual Ukrainian quantity amounts $x_{ukr} = 43$ bcm.

Quantities According to our model, the described fall in sale price at the West European border will lead to an increase in the export quantity.[15] Russian gas exports to Western Europe increase from the monopoly case (60 bcm) to 98 bcm in the cartel case. Therefore, Western Europe will increase its dependence on Russian gas on the producer side, but diversify the risk on the transit level by demanding Russian gas on two pipelines - the Belarus pipeline and the Ukraine pipeline. The utilization of the Ukrainian transit network falls to 45 bcm (in the case of the transit duopoly) or even to 43 bcm (in the restricted transit duopoly, where Belarus uses its full capacity of 28 bcm). Should Belarus expand its capacities to 56 bcm, the loss of transit volumes for Ukraine is significantly larger still (down to 29 bcm).[16]

Profits In all case, Russia benefits from the market entry of Belarus, and Russian profits increase with the degree of integration with the transiting countries. For Belarus, it is also profitable to enter the market, but Belarus gets a higher profit by forming a coalition with Russia instead of playing together with the Ukraine in the transit duopoly. The additional profit of extending the capacity from $C_{bel} = 28$ bcm to $C_{bel} = 56$ bcm is much lower in the transit duopoly case ($\Delta = 46$ mn. USD) then in the restricted transit duopoly game

[15] Remember that we assumed no strategic behavior of the other exporting countries.

[16] Note that our model is based on a relatively high price elasticity, which may be contradictory to other studies; a price reduction of approximately 15% (from $p_{ukr} = 48.3$ USD/tcm to $p_{ukr} = 41.2$ USD/tcm) leads to an increase in the demanded quantity of about 50%.

($\Delta = 514$ mn. USD). One unexpected result that we shall call the *Ukrainian paradox* is that, once Belarus has entered the market, Ukraine *benefits* from the Northern coalition between Russia and Belarus. In case of the restricted transit duopoly Russia sets a lower sales price at the Ukrainian border as in the transit duopoly, so that the profit margin of Ukraine is higher in this case ($\Pi_{ukr} = 328$ mn. USD, as compared to the transit duopoly game $\Pi_{ukr} = 289$ mn. USD), even though the quantity falls from $x_{ukr} = 45$ bcm to $x_{ukr} = 43$ bcm.

The RUSBEL coalition is beneficial for both players. While the sum of the individual profits amounts 1682 mn. USD, the profit of the coalition amounts to 1825 mn. USD. Last but not least, the coalition of all three players (Russia, Ukraine, Belarus) would still increase total profits further, to $\Pi_{cartel} = 2439$ mn. USD, compared to the sum of the individual profits: $\Pi_{rusbel} + \Pi_{ukr} = 2153$ mn. USD.

Table 1: Results of the data analysis

Strategy	**Price in USD/tcm**	**Quantity in bcm**	**Profit Π in in mn. USD**	**Capacity bcm**
Transit Monopoly	$p_{ukr} = 48.3$ $p_{rus} = 26.6$	$x_{rus} = 60$ $x_{ukr} = 60$	$\Pi_{rus} = 1221$ $\Pi_{ukr} = 588$	$C_{ukr} = 70$
Transit Duopoly	$p_{ukr} = p_{bel} = 47.6$ $p_{rus} = 29.3$	$x_{rus} = 63$ $x_{ukr} = 45$ $x_{bel} = 18$	$\Pi_{rus} = 1461$ $\Pi_{ukr} = 289$ $\Pi_{bel} = 221$	$C_{bel} = 28$ $C_{ukr} = 70$
	$p_{ukr} = p_{bel} = 46.2$ $p_{rus} = 31.7$	$x_{rus} = 71$ $x_{ukr} = 39$ $x_{bel} = 32$	$\Pi_{rus} = 1803$ $\Pi_{ukr} = 104$ $\Pi_{bel} = 267$	$C_{bel} = 56$ $C_{ukr} = 70$
Restricted Transit Duopoly	$p_{ukr} = p_{bel} = 46.2$ $p_{rus} = 26.6$	$x_{rus} = 71$ $x_{ukr} = 43$ $x_{bel} = 28$	$\Pi_{rusbel} = 1825$ $\Pi_{ukr} = 328$	$C_{bel} = 28$ $C_{ukr} = 70$
	$p_{ukr} = p_{bel} = 43.4$	$x_{rus} = 85$ $x_{ukr} = 29$ $x_{bel} = 56$	$\Pi_{rusbel} = 2349$ $\Pi_{ukr} = 147$	$C_{bel} = 56$ $C_{ukr} = 70$
Cartel	$p_{cartel} = 41.2$	$x_{cartel} = 98$	$\Pi_{cartel} = 2439$	$C_{bel} = 28$ $C_{ukr} = 70$
	$p_{cartel} = 38.3$	$x_{cartel} = 114$	$\Pi_{cartel} = 2644$	$C_{bel} = 56$ $C_{ukr} = 70$

5 Conclusion

In this paper we have discussed different options for strategic positioning of the world's largest gas exporter, Russia, and the two key CIS gas transit countries, Ukraine and Belarus. The issue is increasingly gaining in importance with finishing of a second large trunk pipeline from Russia through Belarus, thus opening a variety of strategic options among the three players. Simplifying the West European demand function for Russian gas, it is possible to model the export decision by Russia, taking into account the adaptive behaviour by the transit countries. Thus, it becomes possible to attach concrete figures to different strategies, and evaluate the underlying political decisions in favour of or against closer cooperation among the gas industries in Russia (Gazprom) and its neighbouring countries.

The simulations indicate three winners and one looser emerging from the new pipeline construction: Ukraine clearly loses from the the new constellation, suffering from lower profits in the range of several hundred million USD. Since this result could have been anticipated, it is surprising that Ukraine has not made more serious attempts to prevent Russia and Belarus from constructing the northern pipeline, e.g. through earlier reductions of the transit fee. Among the winners, Russia expands both sales to Western Europe and profits significantly, due to the end of the transit monopoly by Ukraine. These additional profits may explain why Russia was the driving force behind the pipeline extension through Belarus.[17] Belarus also stands to win from the new situation: it obtains profits from the transit activity of several hundred million USD. According to our calculations, Belarus has strong incentives to increase its transit capacities from the present 28 bcm to 56 bcm, and eventually even beyond that, if the West European market can absorb these quantities. Belarus will particularly benefit from a coalition with Russia, the restricted transit duopoly. Last but not least, the Western European gas importers also benefit from the diversification of Russian gas transit options. Gas imports from Russia increase significantly, from the estimated 60 bcm in the transit monopoly, to 71 bcm in the restricted transit duopoly (with Belarus at 28 bcm transit capacity) and even to 98 bcm in the cartel solution.

From a geopolitical perspective, what we have called the Northern coalition, Russia and Belarus, seems to be the most probable outcome for the time being. The partnership agreement and the economic union between Russia and Belarus can to a large extent be explained by the profits resulting from

[17] Besides the directly quantifiable profits, Russia also stands to gain from a soft fact, i.e., an increased feeling in Western Europe on gas imports from Russia.

intensified cooperation in the gas (and oil) sector; in gas, this cooperation is worth about USD 300 mn. per year. The big remaining question is whether Ukraine will join the two other countries in forming a "Slavic coalition", and thus establish a gas export cartel vis-à-vis Western Europe. In purely economic terms, the cartel solution is beneficial to all three countries *and* to Western Europe; but whether Ukraine will renounce on its political independence will depend on the profit-sharing agreement offered by Russia.[18] With the diversification of transit routes to Western Europe, Russia has become a player in its own rights on the European gas market.

[18] Recent moves by Russia towards intensified cooperation with the Ukrainian gas industry, including the nomination of ex-Gazprom Chief and Prime Minister Victor Tchernomyrdin as ambassador to Ukraine, seem to indicate that Russia is seeking a wide cartel *including* Ukraine.

6 References

Banks, F.E. (1983). "European Reliance on Soviet Gas Exports." *The Energy Journal* 4(3): 95-96.
Chollet, A.(2001). *Russische Gasexporte für Westeuropa.* Berlin: Master Thesis at Free University.
Dixit, A.K.; Pindyck, R.S. (1994). *Investment under Uncertainty.* Princeton: Princeton University Press.
Greer, B.I.; Russel, J.L. (1982). "European Reliance on Soviet Gas Exports: The Yamburg-Urengoi Natural Gas Project." *The Energy Journal* 3(3): 15-37.
Golombek, Rolf; Gjelsvik, Eystein; Rosendahl, Knut Einar (1995). "Effects of Liberalizing the Natural Gas Markets in Western Europe." *The Energy Journal*, 16(1): 85-111.
Golombek, Rolf; Gjelsvik, Eystein; Rosendahl, Knut Einar (1998). "Increased Competition on the Supply Side of the Western European Natural Gas Market." *The Energy Journal* 19(3): 1-18.
Grais, Wafik; Zheng, Kangbin (1996). "Strategic Interdependance in European East-West Gas Trade: A Hierarchical Stackelberg Game Approach." *The Energy Journal* 17(3): 61-84.
Opitz, Petra; von Hirschhausen, Christian (2001). *Ukraine as the Gas Bridge to Europe? Economic and Geopolitical Considerations.* in: Hoffmann, Lutz, and Felicitas Möllers (eds.)(2001). Ukraine on the Road to Europe. Heidelberg, New York, Springer.

Figure 1: Transit pipeline system between Russia and Western Europe