Competition and Security of Supply:

Let Russia Buy into the European Gas Market!

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Abstract

We propose a model of the European gas market where the risk that Russian deliveries are interrupted is endogenized. While Russia's attempts to buy considerable parts of the European downstream industry have faced strong political opposition, we argue that Russian participation in the downstream market would decrease consumer prices and increase the security of supply. Under a more general point of view, we investigate vertical integration with an upstream firm whose supply is insecure. We show that the conventional wisdom of advantageous vertical integration (Spengler, 1950, Abiru, 1988) need not apply under such circumstances. In Russia's case, however, it does.

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I. Introduction

Russia has become the largest supplier to the European gas market and, as it owns the largest reserves, its market share will certainly not decrease for many years. This dependence on Russia is worrying. For four days in January of 2006, Russia halted part of its deliveries to Western Europe in order to discipline the transit country Ukraine and enforce higher prices for its gas supplied to Ukraine.[1]

On the other hand, Russia's (Gazprom's) tremendous profits, based on the oil and gas price increases in the last few years, allows it to invest in the downstream sector in Western Europe. Gazprom's attempts, however, to buy into the European gas industry have encountered strong political opposition. Therefore its shares in the European gas industry are rather restricted (see Table 4 in the appendix). But why be afraid? Why should Gazprom not become one of the major European pipelines, comparable to Ruhrgas (E.ON) or GdF? In this paper, we will argue that competition as well as security of supply can be improved.

We need not assume that Gazprom is an *additional* player in the European gas market; it is sufficient to assume that it substitutes (buys) one of the existing European players (or some of the national pipelines). The reason for the increased competition is that the producer Gazprom will deliver according to a best reply function based on its marginal costs while the pure traders' best replies will be based on the price in the upstream market. As a trader Gazprom will (partially or totally) avoid double marginalization. This is the intuition for the improvement of competition and it has, in principle, been analysed in Industrial Economics literature (Spengler, 1950, Abiru, 1988).

The new element in our formal analysis is the consideration of an endogenously determined probability α that Russian deliveries are interrupted. If we assume other deliveries to be safe, then $1-\alpha$ can be called "security of supply". For the time being, Russia is the most dependent on transit through third countries' territories and

[1] This was not the first interruption due to problems with a transit country. In February 2004, the pipeline via Belarus was closed for one day.

is, of all producers, most endangered by terrorist attacks. Therefore we disregard the risk of non-delivery for all other producers and concentrate solely on Russia.

"Problems in the commercial and political relationship between Russia and these transit countries present unresolved problems between these states which have the biggest potential to create gas disruption risks for the European gas market *as a whole.* While the risk of disruption is not urgent, it will exist as long as there is no enforceable *long term* commercial/legal framework between Russia and its gas transit countries. "[2] (Stern, 2004, p.1,2)

In our model, non-delivery by Russia does not cause complete disruptions of supply in any Western country. Its consequence is higher prices, i.e. from the consumers' point of view there is a price risk instead of a "security" risk. Nonetheless, in the following we will argue with α and with "security of supply".

Security of supply is increased because of two components, one "inside" our model and one "outside". The outside argument is that Gazprom's affiliates are under Western legislation. Illegal practices in Europe or even hostile measures by the producer Gazprom are no longer without an effective reply as its property in Europe is effectively held hostage. From inside the model the intuition is that disruption of supply is caused by high costs of delivery (say, because a transit country unilaterally increases the transit fee and enforces its claim by taking away a certain share of the gas for its own use). If Russia enjoys higher prices after vertical integration, its opportunity costs of disrupting its supply to Western Europe increase.

If things are that simple, then why do we propose a formal model? As far as we know, disruptions of supply have not been investigated in vertical structures. A supplier (Russia in our case) that might not deliver the contract quantities will receive a lower price than its competitors. Will the price which Russia receives under vertical integration really increase under these conditions? Or could it be that Russian prices (in the downstream market) are now lower than its former prices in the upstream market, with the consequence that security of the supply decreases? In addition, after vertical integration, Russia will deliver larger quantities and Russia's expected profits

[2] Emphases by the author of this quote.

will increase. Therefore it is not certain that expected consumer prices will decrease, i.e. the expected advantage of avoiding double marginalization (Spengler, 1950; Abiru, 1988) need not apply under these circumstances. As Russia's competitors will deliver less than before Gazprom becomes a trader, in the case of an interruption of Russian deliveries the downstream price will be larger than under such circumstances before. It is not even sure, that the downstream market price in periods with Russian deliveries is decreased. The reason is that, because supply is not secure, in the upstream market Russian gas is sold under a lower price. This may result in lower downstream market prices than in the case where Russia serves the downstream market directly.

So, the following results of our analysis are not self-understanding: (i) Under some technical assumptions and if there are only small changes after Gazprom becomes a trader, the downstream market price will decrease and security of supply will increase. (ii) Calibrating the model with respect to the German gas market shows that, again, the downstream market price will decrease and security of supply will increase. In addition, consumers' surplus will increase.

Currently, the European gas industry is (hopefully) transitioning to more competition. The European commission and also the governments of the individual European countries are striving to break up old monopoly structures on the wholesale as well as on the retail level. An important instrument for this purpose is the unbundling and regulation of transport. In some cases (Germany, Denmark, and other countries) gas release auctions should support the emergence of strong new competitors (Bolle and Breitmoser, 2007). We assume that, as a result of such attempts, competition *among* pipelines will increase in the downstream market as well as in the upstream market where these pipelines compete for contracts with the producers. An additional reason for the latter development is that two of the current sources of European gas supply are going to fade away, namely Dutch gas and domestic production (in some European countries). So the remaining producers (Russia with Gazprom as the only exporter, Norway under the leadership of Statoil) will gain market power. Producers of rising importance may be Algeria, and LNG based imports. The model we propose is adapted to such a future scenario. It provides the importing pipelines with less and the producers with more market power than they currently appear to have.

Our model of the European gas market has the following properties. In the first stage, the producers P_j determine their capacities x^j, j = 1, …, m, and j=R=Gazprom. Then the traders T_i, i = 1, …, n compete for these capacities as "price takers". If i=R=Gazprom is also a trader, it does not compete for these capacities but will be served by extra capacities which Gazprom has reserved for its trader. Therefore T_R takes into account Gasprom's expected marginal costs $\bar{c}_R$. The traders form tight oligopolies on each regional (downstream) market, but in their (upstream) supply market there are "many" of them compared with the "few" producers. This is a strong but not unusual simplification which allocates "market power" in the upstream market mainly to the producers. A "price taking" trader offers quantities in the downstream market as if the price in its supply market were fixed, i.e. while acting strategically in the downstream market they act non-strategically in the upstream market. The reason for this, the multiplicity of regional markets, is not modelled explicitly. For the sake of simplicity, we assume that there is one downstream market with atomistic demand. Note that this downstream market is a wholesale market with the pipelines on one side and retailers and large industrial customers on the other.

In the European gas market producers and traders sign long-term Take or Pay (ToP) contracts. Producer i is obliged to supply trader j with a certain quantity x_{ji} for which i is obliged to pay px_{ji}, whether or not he takes it. There are additional provisions, in particular an oil and/or coal price dependency of p, the opportunity to buy certain limited additional quantities at an increased price, and perhaps fines in the case of non-delivery (depending somewhat on whether non-delivery is caused by "force majeur"). Limited re-negotiations are possible in cases of fundamental market disruptions. It is well-known that ToP contracts have such clauses but details are not available. In the following we want to concentrate on long-term contracts between producers and traders with a given price. The problem of non-delivery is simplified and attributed to Russia only.

In order to determine α, we interpret all the above-mentioned risks as (random) additional costs for Russian deliveries. In the case of a transit country "stealing" certain amounts of the transit gas, costs are apparent. In the case of terrorist attacks which may reduce the Russian capacity, the costs of delivering to Western Europe may consist of economic and “political” opportunity costs of non-delivery to Russia’s own population or to other contract partners. In every case, Russia decides whether to deliver under such increased costs. In the model, we use as a criterion for the interruption of delivery whether the costs are above the price of Russian gas. We could, of course, argue that Russia’s critical costs may be below this price (reputation as a tough negotiator with transit countries) or above this price (reputation for security of supply). Our assumption seems to be the reasonable compromise if one does not want to model such considerations explicitly. We will see that the result of Gazprom’s entrance as a trader in the downstream market is that – in the long-run – Gazprom will no longer sell quantities in the upstream market but distribute its gas solely via its trade arm. The price q in the downstream market will decrease. As this price is larger than the price of Russian gas when Gazprom is not a trader, competition as well as security of supply would increase.

The security of supply issue has thus far been discussed as an exogenous risk which has to be measured (Neumann, 2004; Jansen et al., 2004) for example by concentration or diversity (Sterling, 1998) indices of the supply structure of a country. Hoel and Strom (1987) derive an optimal supply structure for exogeneously given probabilities of interruption.

Models of the European gas market usually give the producers and, in particular, Gazprom, a lot of market power. Golembeck et al. (1995) assume Cournot competition among producers. Sagen and Tsygankova (2006) assume Gazprom to be a monopolist who is faced with a competitive fringe (Norway, Algeria, and others). Grais and Zheng (1996) assume a vertical relationship among Russia (as the dominant producer), a transiter, and a welfare maximizing supplier (to West European customers). Other models with the explicit consideration of transit countries as players are von Hirschhausen et al. (2005) and Ikonnikova (2006). Holz et al.’s (2006) approach is close to ours because they also use a two-stage Cournot model (which necessarily allocates all market power in the upstream market to the producers). No interruption of supply is considered, however, in all these papers.

An exogenous measure to reduce the consequences of a supply interruption, namely maximum market shares for certain players, is investigated by Breton and Zaccour

(2001). A non-formal discussion of security of supply issues and an appeal to leave this problem to market forces is provided by Egenhofer et al. (2004). To the best of our knowledge, however, no paper has tried to evaluate Russia's attempts to become a player in the downstream markets or has tried to endogenize the risk of the interruption of Russian deliveries.

In the next section, in order to show that we are not talking about hypothetical goals, we report on Russia's (often unsuccessful) attempts to buy into the European downstream market. In Section III we will set up the model. In the fourth section the determination of α will be described, in the fifth section the supply of the downstream market will be derived, initially only with traders who buy in the upstream market and then also with Gaszprom as a trader. In both cases demand functions for quantities in the upstream market will be derived. In the sixth section the equilibrium supply of the producers will be determined. The seventh section will offer some rough estimates which are necessary for the evaluation of the model. The last section is the conclusion where we also discuss the application of our model to other cases.

II. Gazprom in the European Downstream Market

The Introduction gave us the intuition (and the formal model below shows) why Russia can profit from vertical integration. So it is plausible that a number of attempts were recently undertaken by Gazprom to obtain direct access to markets in Europe. This goal is supported by Gazprom's tremendous profits. From 2005 to 2006 Gazprom's export earnings increased by 44 percent: from €19.0 billion to €27.3 billion. (Neftegas.ru, 2006). With the recent announcement of a €9 billion rise in its revenue in 2007 (WGI, 2007), the company has even more money for an expansion into European markets.

The large European markets (Italy, Germany, France and the UK) are of supreme priority within Russia's strategy. When attempting to penetrate these foreign downstream markets, however, Gazprom – different from E.ON or GdF – faces strong political opposition. In Great Britain, Gazprom established a 100% subsidiary in 1999 (Gazprom Marketing and Trading), which owns all the licenses for gas supply to industrial end users. Since then, a slow and gradual takeover policy in the British market can be observed. Gazprom’s interest in buying the UK gas-distribution company Centrica[3] in the first half of 2006 (valued at over €15 billion) was thought to be the most significant step of this policy. Although no concrete bid emerged, the mere possibility caused the British government to immediately undertake defensive actions. UK business law allows the government to intervene in mergers if there is an "exceptional public interest". Finally, an unspecified governmental security consideration blocked the potential takeover of Centrica by Gazprom.

Russia still has openly set the goal to hold 20 percent of the British gas market by 2015. Thus, other acquisition attempts were undertaken. In January 2006, the press reported on Gazprom’s interest in Scottish Power (that is, 5 million customers in Britain), but without any real action to be observed. In June 2006, Gazprom bought the small company Pennine Natural Gas, engaged in retail gas trading to 900 end users (including a few major companies). It also entered into an agreement with Natural Gas Shipping Services Ltd for administering Gazprom’s supply to UK customers (Russia Newswire, 2006).

Gazprom’s penetration of the German downstream sector dates back to 1993 when Wingas – the second largest gas distributor in Germany – was established as a joint venture of Wintershall and Gazprom. Its original capital distribution was 65 percent (Wintershall) and 35 percent (Gazprom). Since 2006, each partner holds 50 percent with a majority of one additional share held by Wintershall. Redistribution of forces took place following an asset swap: Wintershall received a 35-percent stake[4] in Gazprom's Yuzhno Russkoe gas field in Western Siberia, while Gazprom has increased its share in Wingas (Russ Oil-Gas, 2006). Thus a corporate oriented approach may be the only way Gazprom can gain access to certain European markets in the short run. Gazprom’s deal in July 2006 with another German energy concern – E.ON – may result in the strengthening of its downstream business in Hungary. E.ON gets 25 percent minus one share in the Yuzhno Russkoe field, while Gazprom receives 50 percent minus one share in Hungarian E.ON Foldgaz Storage and Foldgaz Trade and 25 percent plus one share in E.ON Hungaria (Russ Oil-Gas, 2006). This swap is still subject to approval by regulators.

[3] Centrica, as UK’s largest gas supplier, has market shares of 60 percent in the household sector and 15 percent in the market for industrial and commercial customers.
[4] Only 25 percent of those stocks have voting rights.

As of September 2006, Italian Eni and Gazprom have been discussing a strategic partnership envisaged to involve Eni into exploration and production in Russia, in return for Gazprom being allowed to sell gas directly to end users in Italy (EBR, 2006b). These proposals have faced opposition from Italian regulators. Gazprom had already held talks to acquire two of Eni's sales subsidiaries (Snam Rete Gas and EniPower), but in vain. Gazprom was successful, however, in the Italian retail sector in November 2006, by signing a collaboration deal with the supplier Gas Plus intended to facilitate the distribution of Russian gas in Italy (EBR, 2006a).

In Portugal, Gazprom is relying upon an investment strategy. In November 2006 it acquired a stake in a holding company that owns 31.6 percent in Galp Energia, the Portuguese corporation with a strong presence in gas distribution across the Iberian Peninsula. Gazprom's French strategy stands in sharp contrast to this. Despite a long-standing relationship with GdF, it has stated that it will compete directly for French customers. No details have emerged (ERB, 2006a). In 2004, Gazprom did not succeed in a public tender in Romania for the acquisition of 51 percent the two regional gas distributors, Distrigaz Nord and Distrigaz Sud (Ionesen, 2004).

All this shows how large Gazprom's interest is to expand downstream. In this paper, we argue that such an expansion is also in the best interest of Europe – even without taking into account Russia's alternatives if it were to be prevented entering the European downstream market. Europe's interest in security of supply is not stronger than Russia's interest in "security of demand", which could be ensured by a stake in the European downstream market. Currently, Gazprom is seeking new markets – North America and China.

III. The model

We have producers P_1, …, P_m and P_R = Gazprom. Producers' marginal (long term) production costs c_1, … c_m, are constant. Russia, however, may bear additional costs. The reason is that there is, for example, the possibility of a quarrel about transit fees between Gazprom and a transit country. Say, the transit country demands a certain fee, expressed as a share of the gas transported, and, when negotiations fail, simply takes this share. Russia's reaction may be further negotiations, sanctions of all kinds or, as ultima ratio, no longer feeding gas into the respective pipeline. Whether Russia adopts this ultimate measure will certainly depend on the respective costs of continued delivery and interruption of supply. Gazprom's costs of delivery c_R are a random variable, the value of which is determined only after all contracts have been concluded. In the last stage of our game (the ***third stage***), after c_R is determined by chance, Gazprom decides whether to deliver. Viewed from earlier stages, there is only a probability α that deliveries are interrupted. For the sake of simplicity, this interruption is assumed to be a full interruption.

One may argue that a transit country would take into account decreased or increased criteria of interruption by decreasing or increasing its demands. This may be true but it would not completely offset the derived effects. For the sake of simplicity, we do not include the transit countries as players in our model.

In the ***second stage*** of the game, which describes the downstream market, there are traders T_1, … T_n and (possibly) T_R = Gazprom. The traders T_i supply quantities $x_i+x_i^R$ and T_R the quantity x_R to the downstream spot[5] market which is described by a linear (inverse) demand function

(1) $q = a - b\left(x + x^R + x_R\right)$ or $q = a - bx$ if Gazproms deliveries are interrupted,

with x = $\sum_{j=1}^{m} x_j$, x^R = $\sum_{j=1}^{m} x_j^R$ and $x_R = 0$ if Gazprom is not a trader. Trader j buys $x_j+x_j^R$ non-strategically under the assumption of given prices (p, p_R) and sells strategically in the downstream market. Remember that we rationalized these differing attitudes with the fact that there are many regional downstream markets with few competitors, while altogether, the number of traders is large compared to the number of producers.

[5] Currently these downstream markets with retailers and large industrial firms as customers are predominantly contract markets. Under future, more competitive conditions, however, spot markets may dominate.

The traders' supply in the downstream market determines their demand in the **upstream market**. This market is described by an oligopoly of producers who are faced with (inverse) demand functions

(2) $p = f\left(x, x^R, \alpha\right)$

(3) $p_R = g\left(x, x^R, \alpha\right)$

with x = $\sum_{j=1}^{m} x^j = \sum_{i=1}^{n} x_i$, $x^R = \sum_{i=1}^{n} x_i^R$ x^j = supply of producer j to the upstream market, x_i and x_i^R demand of trader i in the upstream market, and α = probability of Russian interruption of the gas supply. In this ***first stage*** of the game, the suppliers determine quantities (capacities) x^j.

In the following we want to determine the unique subgame perfect equilibrium of this game by working backwards from Stage 3 to Stage 1. From now on, symbols with primes describe the case when Gazprom is a trader.

IV. Stage 3: Security of supply

After all contracts have been concluded, Gazprom's costs c_R of delivery are determined. To fix ideas let us assume that production costs in a narrow sense are as expected but that there are random costs connected with transit through countries with which disputes may escalate to the point where these countries unilaterally take as much gas from the pipeline as they claim to be their adequate transit fee. Thus c_R is random and Gazprom has to decide whether to deliver under such conditions or to stop feeding gas into this transit route. For the sake of simplicity we do not model restricted flows after certain pipelines have been closed but assume a complete stop of Russian deliveries. In particular, this means that Gazprom cannot decide to deliver to its own trade arm (if it exists) while interrupting deliveries to all other contract partners. We thus avoid a lengthy discussion on distributed effects and rationing rules.

Gazprom's profit from delivering gas is

(4) $G^R = (p_R - c_R)x^R$

if it is not a trader and

(5) $G^R = (p'_R - c'_R)x'^R + (q' - c'_R)x'_R$

if it is. So, if Gazprom is not a trader it will deliver gas as long as

(6) $c_R < p_R = \tilde{c}_R$.

If Gazprom is a trader it will deliver as long as

(7) $c_R < \dfrac{p'_R x'^R + q' x'_R}{x'^R + x'_R} = \tilde{c}'_R$

where q is determined by (1) without interruption. Note that we do not assume partial interruption.

(8) $\alpha = \int_{\tilde{c}_R}^{\infty} f(c_R)dc_R$ and $\alpha' = \int_{\tilde{c}'_R}^{\infty} f(c_R)dc_R$

are the probabilities that gas deliveries from Russia will be interrupted. $f(c_R)$ is the density of c_R.

Viewed from earlier stages, Gazprom's expected profit is

(9) $EG^R = \int_0^{\tilde{c}} G^R f(c_R)dc_R$ or $EG^R = \int_0^{\tilde{c}'} G^R f(c_R)dc_R$

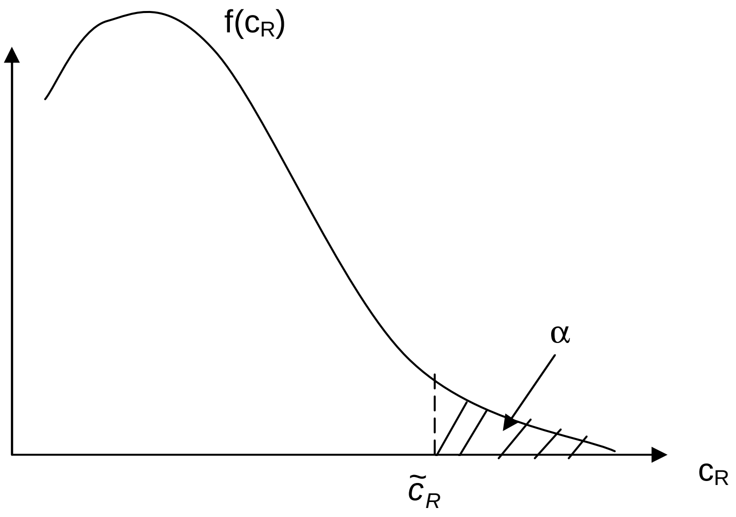

Figure 1: The distribution of Russia's costs c_R.

V. Stage 2: The downstream market

Let us now investigate the downstream market. Note that the traders i = 1, …, n do not assume that they have influence on prices p, p_R. For them, these prices are only unit costs of the quantities they want to sell in the downstream market. They have rational expectations about the resulting α but they do not assume that they have influence on α (i.e. on $\tilde{c}_R$) either. Only T_R decides about x_R with respect to its influence on α. T_R does not buy in the upstream market; his costs are Gazprom's marginal costs c_R. The traders sell their gas on a spot market with a price q determined by (1). In the following, we determine the Cournot equilibrium in the downstream market with n traders having costs p and p_R when buying their gas and (in the other case) a trader T_R who has costs c_R.

The traders i = 1, …,n have ordered quantities x_i of non-Russian gas and x_i^R of Russian gas. The latter is delivered only with probability 1 - α. If Gazprom is not a trader this results in profits

$$(10)\quad G_i = (1-\alpha)\left[\left(x_i + x_i^R\right)\left(a - bx - bx^R\right) - x_i p - x_i^R p_R\right] + \alpha\left[x_i\left(a - bx\right) - x_i p\right].$$

The best responses of traders i are derived from

(11) $$\frac{\partial G_i}{\partial x_i} = (1-\alpha)\left[a - b\left(x + x^R\right) - b\left(x_i + x_i^R\right) - p\right] + \alpha\left[a - bx - bx_i - p\right] \qquad = 0,$$

(12) $$\frac{\partial G_i}{\partial x_i^R} = (1-\alpha)\left[a - b\left(x + x^R\right) - b\left(x_i + x_i^R\right) - p_R\right] \qquad = 0.$$

By adding up (12) for all i we get

(13) $$p_R = a - \frac{n+1}{n} b\left(x + x^R\right),$$

which will serve as the inverse demand function for Russian gas in the upstream market. By adding up (11) for all i we get

(14) $$p = a - \frac{n+1}{n} b[\,x + (1-\alpha)x^R\,]\,,$$

which describes the inverse demand function of non-Russian gas in the upstream market.[6] The difference of the demand functions (13) and (14) is due to the insecurity of Russian gas. Thus the "law of one price" does not hold in the upstream market.

If **Gazprom is a trader** we have to substitute in (10) x^R by $x'^R + x'_R$. Then we can compute the best responses of traders i as in (11) and (12). The best response x_R is determined by maximizing G^R from (9) and (5) and $\tilde{c}_R$ from (7). Taking into account the definition of $\tilde{c}_R$ we get

(15) $$\frac{\partial EG^R}{\partial x_R} = G^R\left(c_R = \tilde{c}_R'\right)\frac{\partial \tilde{c}_R'}{\partial x_i^R} + \int_0^{\tilde{c}_R'}\left(q - c_R - \frac{dq}{dx_R}x_R\right)f\left(c_R\right)dc_R = 0$$

[6] Though x and x^R are given and therefore (when Gazprom is not a trader) q is determined, the traders act as if they could influence q by the quantities they supply. Keep in mind that there may be many regional markets. Assuming a given q would take away all market power from the traders because they would compete for quantities as long as q>p.

Because of $G^R\left(c_R = \hat{c}_r^{'}\right) = 0$ and (1) we get

(16) $$x_R = \frac{a - \bar{c}_R^{'}}{2b} - \frac{x + x^R}{2}$$

with

(17) $$\bar{c}_R^{'} = \frac{1}{1-\alpha}\int_0^{\tilde{c}_R^{'}} c_R f\left(c_R\right) dc_R ,$$

the conditional expectation of c_R.[7]

Now we compute

(18) $$\frac{dG_i}{\partial x_i^R} = (1-\alpha)\left[a - b\left(x + x^R + x_R\right) - p_R^{'} - bx_i^R - bx_i\right] = 0$$

where, again, i does not assume to have influence on α. Using (16) we substitute x_R and get

(19) $$\frac{a + \bar{c}_R^{'}}{2} - \frac{b}{2}\left(x + x^R\right) - p_R^{'} - b\left(x_i^R + x_i\right) = 0 .$$

Adding up (19) we get

(20) $$p_R^{'} = \frac{a + \overline{C}_R^{'}}{2} - \frac{n+2}{2n} b\left(x^{'} + x^{'R}\right)$$

Adding up $\frac{\partial G_i}{\partial x_i^{'}} = 0$ provides us with

[7] Note that $f(c_R)$ is not without unit of measure. As $f(c_R)\, dc_R$ has to be an element of IR, f's dimension has to be quantity unit/money unit.

(21) $$p' = \frac{1+\alpha'}{2}a + \frac{1-\alpha'}{2}\overline{C}_R' - (\frac{n+2}{2n} + \frac{\alpha'}{2})bx' - (1-\alpha)\frac{n+2}{2n}bx'^R .$$

VI. The upstream market

In this market the producers fix quantities under the assumption that prices result as described by the inverse demand function (13) and (14) or (20) and (21). Producer R's profit is described by (9), the other producers' profits are

(22) $$G^j = x^j\left(p - c_j\right)$$

if Gazprom is not a trader. Otherwise p is substituted by p'. Note that x and x' are the aggregate quantities provided by the producers (except Gazprom) and that all producers take into account their influence on α and $\overline{c}_R$. When differentiating (22) with respect to x^j we have to take into account that p depends on x and α and that the latter depends on p_R. So, the best response for j in the case that R is not a trader is given by

(23) $$\frac{dG^j}{dx^j} = p - c_j - \frac{n+1}{n}b(1+\beta)x^j \qquad = 0$$

with

(24) $$\beta = -x^R\frac{d\alpha}{dx} = \frac{n+1}{n}bx^R f\left(p_R\right)$$

which is computed by using (8), (6), and (13).

Adding up (23) for all j results in

(25) $$p - c - \frac{n+1}{n}b(1+\beta)\frac{x}{m} \qquad = 0$$

With $c = \frac{1}{m}\sum c_j$.

R's profit in this case is given by (9) and (4), its derivative with respect to x^R implies

(26) $$p_R - \bar{c}_R - \frac{n+1}{n} b x^R = 0 ,$$

where $\bar{c}_R$ is defined by the equivalent of (17) with $\tilde{c}_R = p_R$ instead of $\tilde{c}_R{}'$.

From (26) and (13) follows

(27) $$\frac{n+1}{n} b x^R = \frac{a - \bar{c}_R}{2} - \frac{n+1}{2n} bx .$$

From (14), (25) and (27) follows the producers' supply when **Gazprom is not a trader:**

(28) $$\frac{n+1}{n} bx = \frac{a - c - (a - \bar{c}_R)\frac{1-\alpha}{2}}{\frac{1+\alpha}{2} + \frac{1+\beta}{m}} ,$$

and because of (27)

(29) $$\frac{n+1}{n} b(x + x^R) = \frac{(a - \bar{c}_R)}{2} + \frac{n+1}{n}\frac{bx}{2} .$$

Interestingly, (13), (14), (28), and (29) show that p and p_R depend on m but not on n. The reason is that n influences only the slope of the inverse demand functions with which the producers are confronted.

Proposition 1: When **Gazprom is a trader** it will not be active (in the long run) in the upstream market. It will distribute its gas entirely through its trade arm T_R.

Proof: In the case where R is a trader we get (see Appendix)

(30) $$\frac{dEG^R}{dx^R} = (1-\alpha)\left(-\frac{n+1}{2n} b \cdot x^{'R} - \frac{1}{n} b\left(x^{'} + x^{'R}\right)\right)$$

with EG^R from (5) and (9), q, p_R and x_R from (1), (13) and (15). As $\frac{dEG^R}{dx^R} < 0$, we get $x^{'R} = 0$. ■

From (7) and $x^{'R} = 0$ follows

(31) $$\tilde{c}_R^{'} = q^{'} = \frac{a + \bar{c}_R^{'}}{2} - \frac{bx^{'}}{2} .$$

Together with (8) and (17), (31) is an implicit function for $q^{'}(x^{'})$, where $q^{'}$ describes the price in periods in which Gazprom delivers. The Implicit Function Theorem implies

(32) $$\frac{dq^{'}}{dx'} = -\frac{\left(1-\alpha^{'}\right)b}{2\left(1-\alpha^{'}\right) - \left(q^{'} - \bar{c}_R^{'}\right)f\left(q^{'}\right)} .$$

After these preparatory computations we can determine the equivalent to (26), the aggregate best response conditions in the case where R is a trader. For this purpose we substitute in (22) p with $p^{'}$ and compute the derivative with respect to $x^{'j}$

(33) $$\frac{dG^j}{dx^{'j}} = p^{'} - c_j + x^j \frac{dp^{'}}{dx^{'}} = 0 .$$

Adding up (33) for all j yields

(34) $$p^{'} - c + \frac{x^{'}}{m}\frac{dp^{'}}{dx^{'}} = 0 .$$

From (21) we get

(35) $$\frac{dp^{'}}{dx^{'}} = -\left(\frac{\alpha'}{2} + \frac{n+2}{2n} + \beta'\right)b ,$$

$$(36) \quad \beta' = f(q')\frac{1}{2b}\frac{dq'}{dx'}(a - bx' + q').$$

$$= f(q')\frac{(a - bx' + q')(1 - \alpha')}{4(1 - \alpha') - 2(q' - \bar{c}_R')f(q')}$$

From (34), (35), and (22) follows

$$(37) \quad bx' = \frac{a - c - \frac{1 - \alpha'}{2}(a - \bar{c}_R')}{(\frac{n+2}{2n} + \alpha')(1 + \frac{1}{m}) + \frac{\beta'}{m}},$$

and because of (15) with $x'^R = 0$

$$(38) \quad b(x' + x_R) = \frac{a - \bar{c}_R'}{2} + \frac{bx'}{2}.$$

(38), (37) and (29), (28) provide us with the quantities and therefore with the prices in the downstream market (in periods when Gazprom delivers) as well as with p_R. The comparison of q and q' as well as p_R and q' is difficult in general. After a calibration of our model with data from the German gas market (Section VII) we can, however, compare numerically determined values. In the next proposition, we concentrate on a special case where α and thus the security of supply changes only a little. More specifically, we assume $f(c_R)$ to be rather small between $c_R=p_R$ and $c_R=q'$ which implies

$$(39) \quad \alpha \approx \alpha', \ \bar{c}_R \approx \bar{c}_R', \ \beta \approx \beta' \approx 0.$$

Proposition 2: (i) If (39) applies and if n > m then the downstream market price (in times when Russia delivers gas) decreases when Gazprom becomes a trader.
(ii) If (39) applies then the security of supply $1 - \alpha$ increases if and only if

$$(40) \quad \alpha > \frac{n - m - 2}{n(m + 2)}.$$

Proof: From (28), (29), (37), (38) and (39) follows

$$(41)\qquad \frac{\frac{n+1}{n}b\left(x+x^{R}\right)}{\frac{n+1}{n}b\left(x^{'}+x_{R}\right)} \approx \frac{a-\bar{c}_R+\dfrac{a-c-(a-c_R)\cdot(1-\alpha/2)}{(1+\alpha)/2+1/m}}{\frac{n+1}{n}\cdot\left(a-\bar{c}_R\right)+\dfrac{a-c-\left(a-\bar{c}_R\right)\cdot(1-\alpha)/2}{\left(\frac{n+2}{2n}+\alpha\right)\frac{m+1}{m}\cdot\frac{n}{n+1}}}<1.$$

The inequality is implied by $\frac{1+\alpha}{2}+\frac{1}{m}>\left(\frac{n+2}{2n}+\alpha\right)\cdot\frac{m+1}{m}\cdot\frac{n}{n+1}$ which is true for $n>m$. So $q'<q$.

Under (40), we get $\frac{1+\alpha}{2}+\frac{1}{m}<\left(\frac{n+2}{2n}+\alpha\right)\frac{m+1}{m}$ and therefore

$$(42)\qquad \frac{\frac{n+1}{n}b\left(x+x^{R}\right)}{b\left(x^{'}+x_{R}\right)}>1.$$

So we get $p_R<q'$ and $\alpha>\alpha^{'}$. ■

n > m is a sufficient but not a necessary condition for Proposition 2 (i). On the other hand, $q^{'}<q$ does not always apply.

Counterexample with $q^{'}>q$. If, in addition to (39), we assume $\alpha=1/2$, $c=\bar{c}_R$, $n=5$, and $m\geq 8$, then the inequality (41) is reversed, i.e. $q^{'}>q$.

But even if $q^{'}<q$, vertical integration need not be an improvement for the customers in the downstream market. With a probability α, Russia will not deliver. As Russia's competitors provide smaller quantities after Gazprom becomes a trader, the price in such periods is higher than before. So the average price in the downstream market and/or consumers' surplus may decrease.

Proposition 2 contains an important message for the case that α is not negligible but the change of α is small. The latter condition need not be true. In the next section we will calibrate our model and will thus be able to make rough estimations with "realistic" parameters.

VII. Calibration and evaluation of cases

Russia has been delivering gas to Western Europe for 30 years. Only for one day in 2004 and for four days in January 2006, part of its supply was stopped. These periods were too short to cause any shortages. Better, let us ask what the probability of an interruption for a period of, say, two months or longer could be. On the basis of 30 years experience with Russian deliveries, this probability would be practically zero. But times have changed and we have to expect a number of conflicts with transit countries who are also recipients of Russian gas and who are now expected to pay Western prices, the earlier the better. While this paper was written negotiations between Gazprom and Belarus ended with a compromise – the threat of an interruption of gas deliveries was explicitly mentioned, however, and in addition, it is not clear whether Belarus will be able to pay the compromise price. Only one week after this compromise was concluded, a quarrel concerning Russian transit fees for oil began.

So, an α larger than zero seems to be appropriate. In our simple model, α does not depend on the length of the period, but rather must be reinterpreted in every case. For a period of two months, α is the probability of a complete shut-down. For a period of five years it is the share of (longer) interruptions. Let us view Gazprom's situation as intermediate between the old secure regime and a completely insecure situation as, for example, pipeline transport in Iraq. Perhaps a slightly exaggerated guess is α = current probability (share) of interruption = 0.05, i.e. we expect to observe, for a five years period, three months of interruption.

In the insurance business the distribution of damage claims is often described by an exponential distribution; if Gazprom's "damage" is its additional costs, we have

(43) $c_R = c_R^0 + \varepsilon$

(44) $f(\varepsilon) = \lambda e^{-\lambda e}, \lambda > 0$,

with f describing the density of ε.

α = Prob $(c_R^0 + \varepsilon > \tilde{c}_R) = 0.05$ means

(45) $\int_{\tilde{c}_R - c_R^0}^{\infty} \lambda e^{-\lambda\varepsilon} d\varepsilon = -e^{-\lambda\varepsilon} \Big|_{\tilde{c}_R - c_R^0}^{\infty} = 0.05$, and therefore

(46) $\lambda = \dfrac{\ln 20}{\tilde{c}_R - c_R^0}$.

Presently, Russia sells its gas at about p_R = 200 Euro/1000 m^3, i.e. 2.3 cents/kwh (price at the German border), to several importing pipelines. C_R^0 is about 0.7 cent/kwh[8]. We identify the present $\tilde{C}_R$ with p_R = 2.3 cent/kwh (Russia isn't a trader). Thus (44) implies

(47) $\lambda = \dfrac{\ln 20}{1.6 cent / kwh} = 1.88 kwh / cent$.

There are no really reliable estimates of gas demand. Liu (2004) finds long run price elasticities for natural gas between -0.78 and +0.08 for OECD countries. Holz et al. (2006) use an elasticity of -0.7 and Sagen and Tsygankowa (2006) use -0.5 in their respective models of the European Gas market. Let us take, as a rough estimate, η = -0.5 for the demand of retailers and large industrial consumers. As van Damme (2004) proposes when applying a linear demand model to the Dutch electricity market, we "calibrate" our linear demand to the elasticity, i.e. we assume a =

[8] Production costs c_R^0 depend on the gas field and on the development of transit fees. We choose a relative small value based on estimations by Hafner (no date), C_R^0 may as well increase to 0.8 or even 1.0 cent/kwh. This would, however, not affect the qualitative results of our calculations.

$\left(1-\frac{1}{\eta}\right)q$ where q =3 cent/kwh is the current price in the (German) downstream market with retailers and large industrial customers (Pfaffenberger and Gabriel, 2006). So we get a=9 cent/kwh. Note that, as long as costs are linear, we can look at each regional (national) downstream market independently from the others. We can imagine that certain quantities in the upstream market are earmarked for just this downstream market. The other possibility in evaluating the following computations is to assume that q = 3 cent/kwh is the price in the general European downstream market.

For the following computations, we assume that a=9 cent/kwh, that $c = c_R^0 = 0.7 cent / kwh$, and that $c_R - c_R^0$ is distributed according to an exponential distribution with $\lambda = 1.88 kwh / cent$. From the six equations (8), (13), (17), (24), (27), and (28) we compute the six variables bx^R, bx, p_R, $\alpha, \beta, \bar{c}_R$ for the case where R is not a trader. Equivalently, we can determine the respective values for the case where R is a trader. Note that the two variants of our model need not reproduce the prices and the α which we have used to determine the demand parameter a and the distribution parameter λ. Our model tries to describe a competitive future environment and not the present state which is characterized by nearly monopolistic retail markets and by downstream markets (in Germany) with close connections between retailers and traders. In spite of this argument and although we did not expect it, Table 1 shows that the current price in the downstream market (≈ 3.0 cent/kwh) as well as that in the upstream market (≈ 2.3 cent/kwh) is reproduced for m = 3 (plus Russia) and n = 7 (the number of importing German pipelines), namely q = 3.17 cent/kwh and p_R = 2.34 cent/kwh. We conclude that the downstream market may be more competitive than we thought.

Table 1: Downstream prices q in Euro cent/kwh, Russia's upstream price p_R and security of supply 1-α for different numbers m of producers (plus Russia) and traders n. Case: Russia is not a trader.

m	**1**	**2**	**3**	**4**
n				
1	6.16	5.88	5.67	5.55
2	5.21	4.84	4.56	4.40
3	4.74	4.32	4.01	3.83
4	4.46	4.01	3.67	3.48
5	4.27	3.80	3.45	3.25
6	4.13	3.65	3.29	3.09
7	4.03	3.54	3.17	2.96
8	3.95	3.45	3.08	2.87
9	3.89	3.38	3.01	2.79
p_R	3.32	2.76	2.34	2.1
1 - α	0.993	0.977	0.955	0.928

For the future development we concentrate on numbers of producers as well as traders from 1 to 4. The current situation (in Germany as well as some other European countries) may be best described by m = 3 (plus Russia) while the number of traders is rather different (practically monopolies in France and Denmark and larger numbers in Germany and England). We think, however, that the number of traders in the regional (national) markets will become more homogeneous. Domestic production as well as Dutch deliveries will play an ever smaller role, but new competitors (Algeria, Middle East via LNG) may enter the market. In every case we found improvements with respect to downstream market prices (in periods when Gazprom delivers) as well as concerning the security of supply (Tables 2 and 3). As the downstream market price cannot exceed 9 Euro cent/kwh (in periods when Gazprom does not deliver), it is clear that the *expected* price differences are also positive. In every case, the expected consumers' surplus also increases. As, however, these values depend on the (unspecified) slope of the demand function b, we do not report the differences in a table.

Table 2: Price differences (Euro cent/kwh) q – q' with q'(q) = downstream price (in periods when Russia delivers) if Russia is (not) a trader.

m	1	2	3	4
n				
1	2.22	2.16	2.06	2.01
2	1.59	1.54	1.43	1.36
3	1.31	1.27	1.15	1.08
4	1.15	1.11	0.98	0.91

Table 3: Differences of security of supply $(1 - \alpha') - (1 - \alpha) = \alpha - \alpha'$ with $\alpha'(\alpha)$ = probability of interruption if Gazprom is (not) a trader.

m	1	2	3	4
n				
1	0.005	0.020	0.041	0.067
2	0.003	0.015	0.035	0.060
3	0.001	0.011	0.028	0.051
4	0.000	0.007	0.021	0.042

VIII. Conclusion

We proposed a model of the European gas market which takes into account that Russian deliveries could be interrupted, mainly due to quarrels with transit countries about gas prices (for their own demand) and transit fees. Our model is only a rough approximation of the gas market but we think that it is sufficient to derive qualitative results for the cases of when Gazprom is a trader and when it is not. A more sophisticated model would take into account the nature of the Take or Pay contracts which (partly) substitute vertical integration between the producers and the importing pipelines.

In principle, our model can be applied to the vertical integration of any upstream firm with insecure production. Another example from the energy sector is wind energy which could be marketed by its own trader. (The wind sector's increased costs if there is no wind may consist of buying the energy elsewhere.) The model comparison applies, however, to a future scenario with prices of CO_2-permits of about 50 Euro/t

CO_2 or more. Under such conditions wind energy need not be backed by feed-in laws or similar measures.

Agricultural production and its vertical integration can be a further example of insecure upstream supplies. Also film production may fail or take far more time than expected (which may be avoided through increased costs). Note that our model does not state that vertical integration is always advantageous in such cases. The counterexample with $q^{'} > q$ shows that conventional wisdom about the advantage of vertical integration need not apply under such circumstances. Our numerical computations, however, make us confident that it does apply in the case of the European gas market.

The conclusion from our model is that a trader "Gazprom" in the downstream market would decrease the downstream market price heavily. The security of supply as well as consumers' surplus increase. Europe can only profit if Gazprom invests in the downstream market. For this result it does not matter whether it buys existing traders ($n \rightarrow n - 1$) or builds its own trade arm (compare Tables 1 and 2/3). An additional advantage of Russian investment is that European countries are holding Russian property hostage. A reply to unlawful behaviour of Gazprom could be the expropriation of its trade arm.

The Green Paper of the European Commission (2006) on "a European strategy for sustainable, competitive and secure energy" lists some measures which should improve the security of supply. Vertical integration with the producers is not among them. We think that all the proposed measures, in particular the diversification of supply, are reasonable. But we also think that vertical integration by inviting the producers (not only Gazprom) to participate in the downstream market might be a very successful policy.

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Appendix

The derivation of (27)

For the sake of simplicity we omit the primes of the symbols, i.e. we use x instead of x', etc.

(A1) $$EG^R = \int_0^{\tilde{c}_R} \left(p_R x^R + q x_R - c_R \left(x^R + x_R\right)\right) f(c_R) dc_R$$

with (see (16) and (1))

(A2) $$x_R = \frac{a - \bar{c}_R}{2} - \frac{x^R + x_R}{2}$$

(A3) $$q = a - b(x + x^R + x_R)$$

From (7) follows $G^R(c_R = \tilde{c}_R) = 0$ and thus

(A4) $$\frac{dEG^R}{dx^R} = (1-\alpha)\left[\frac{dp_R}{dx^R}\cdot x^R + p_R + \frac{dq}{dx^R}\cdot x_R + q\cdot\frac{dx_R}{dx^R} - \overline{C}_R\left(1+\frac{dx_R}{dx^R}\right)\right]$$

Taking further into account (20) and using (A2) and (A3) we get

(A5) $$\frac{dEG^R}{dx^R} = (1-\alpha)\left[-\frac{n+1}{2n}b\cdot x^R + \frac{a+\overline{C}_R}{2} - \frac{n+2}{2n}b\left(x+x^R\right) - \frac{1}{2}bx_R\right.$$
$$\left. -\frac{1}{2}\left(a-bx-bx^R-bx_R\right) - \frac{1}{2}\overline{c}_R\right]$$
$$= (1-\alpha)\left[-\frac{n+1}{2n}b\cdot x^R - \frac{1}{n}b\left(x\ \ + x^R\right)\right]$$

Table 4: Fully owned firms and joint ventures of Gazprom in Europe.
"—" = not applicable. "n/a" = data not available. "*" = Gazprom is a shareholder via WIEE, its 50-50 joint venture with Wintershall.
Source: UCEPS (2004) and Wikipedia (2007)

Country	*Name of the company*	*Share of Gazprom, %*	*Main enterprise in the branch*	*Partner(s) of Gazprom*
Austria	Centrex Europe Energy & Gas	100	OMV	—
	GWH (Gas- und Warenhandel)	50		OMV (25.1%), Centrex (24.9%)
Bulgaria	Overgas Inc. AD	50	Bulgargaz	Overgas Holding AD (50%)
	TopEnergy	100		—
Czech Republic	Vemex	33	RWE Transgas	ZMB (33%), Austria's Centrex (33%)
Estonia	Eesti Gaas	37.02	Eesti Gaas	E.ON Ruhrgas (33.66%), Fortum Oyj (17.72%), Itera Latvija (9.85%)
Finland	Gasum Oy	25	Fortum	Fortum (31%), Finnish state (24%), E.ON Ruhrgas (20%)
	North Transgas Oy	100		—
France	FRAgas Trading House	50	GdF	GdF
Germany	Ditgaz	49	E.ON Ruhrgas (holds 6.5% of shares of Gazprom), Wintershall	n/a
	VNG (Verbundnetz Gas)	5.26		EWE (47.9), VNG Verwaltung und Beteiligung (25.79), Wintershall (15.79), EEG–Erdgas Transport (5.26)
	Gazprom Germania	100		—

	Wingas	50		Wintershall (50%)
	WIEH (Winthershall Erdgas Handelshaus)	50		Wintershall (50%)
	ZGG (Zarubezhgas-Erdgashandel)	100		—
	ZMB	100		—
Greece	Prometheus Gaz	50	DEPA	n/a
Hungary	Panrusgáz	40	MOL Gas	E.ON Ruhrgas (50%), Centrex Hungária (10%)
Italy	Volta	49	ENI (Snam Rete Gas), Edison	Edison (51%)
	Promgas	50		ENI (50%)
Latvia	Latvijas Gāze	25	Latvijas Gāze	E.ON Ruhrgas (47.15%), Itera-Latvija (25%)
Lithuania	Lietuvos Dujos	37.1	Lietuvos Dujos	E.ON Ruhrgas (38.9%), Lithu-anian State (17.7%), individuals and legal entities (6.3%)
	Stella Vitae	30		n/a
Netherlands	Peter-Gaz	51	Gasunie	n/a
	BSPC (Blue Stream Pipeline Company)	50		ENI (50%)
Poland	EuroPol Gaz	48	PGNiG	PGNiG (48%), Gas-Trading (4%)
	Gas-Trading	35		n/a
Romania	Wirom	25.5*	SNTGN Transgaz	Distrigaz Sud (49%)
	WIEE Romania	50*		n/a
Slovakia	Slovrusgas	50	SPP	SPP (50%)
Slovenia	Tagdem	85	Geoplin	n/a
Switzerland	WIEE (Wintershall Erdgas Handelshaus Zug)	50	Swissgas	Wintershall (50%)
	ZMB, Switzerland	100		—
	Nord Stream AG	51		E.ON Ruhrgas (20%), Wintershall (20%), Gasunie (9%)
United Kingdom	GM&T (Gazprom Marketing and Trading)	100	BG Group	—
	Interconnector	10		BG Group (25%), E.ON Ruhrgas (23.59%), Distrigas (16.41%), ConocoPhillips (10%), Total (10%), ENI (5%)
Yugoslavia (Serbia)	JugoRosGaz	50	NIS	NIS (27%), Progres, Progres-Gas Trading
	Progres-Gas Trading	50		n/a