COMPETITION AND SECURITY OF SUPPLY AFTER VERTICAL INTEGRATION: SHOULD RUSSIA BE KEPT OFF THE DOWNSTREAM MARKET FOR GAS?

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Abstract

We analyse the effect of vertical integration in a two-stage oligopoly where the supply of one of the upstream players is insecure because this player suffers from stochastic costs. He may decide not to deliver if costs are too high. We formulate this situation as a model of the European gas market with Russia as the unreliable player but there are also other applications. 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. We show that there are circumstances when the conventional wisdom that vertical integration is advantageous (Spengler, 1950, Abiru, 1988; Boots et al., 2004, for the gas market) is not always true. In Russia's case, however, it is.

Key words: Gas, Security of supply, Competition, Vertical Integration, Nature resources.

JEL codes: L13, L95, D84.

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I. Introduction

Currently, the European gas industry is (hopefully) transitioning to more competition. The European commission as well as 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. But can we expect competitive structures if the upstream market is a tight oligopoly with the strongest player (Gazprom) being ready to apply "rude" policies in order to enforce prices? For four days in January 2006 Russia interrupted its deliveries to the transit country Ukraine because Ukraine had taken some gas that should go to Western Europe. In January 2009 the pipeline via Ukraine was closed for several days: from 01.01.2009 Russia stopped its deliveries to Ukraine, from 05.01.2009 the quantity of gas for the European market drastically fell and consequently from 07.01.2009 all Russian gas deliveries through Ukraine were interrupted. The deliveries were started again only on 20.01.2009 after Russia and Ukraine made certain agreements. "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."[175] (Stern, 2004, p.1,2.)

On the other hand, Russia's (Gazprom's) tremendous profits, based on the oil and gas price increase in the years 2006 and 2007, and again since 2011[176], allow 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. Some in the EU regard Gazprom's downstream expansion to be a threat to Europe's energy security[177]. Those parties are trying to resist this practice (by supporting ownership unbundling[178], introducing the third country clause[179], etc.). It seems that this opposition is built rather on emotions than on rational analysis. Finon and Locatelli (2008) bemoan the view of a geopolitical power struggle with Russia with its spillovers into the economic analysis.

Therefore Gazprom's shares in the European gas industry are rather restricted (see Table 4 in the appendix). But why should Gazprom not become one of the major European pipelines, comparable to Ruhrgas (E.ON) or GdF? In this paper we argue that competition as well as security of supply can be improved in this case.

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 at the upstream market. As a producer&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. Let us assume other deliveries to be safe so

[175] Emphases by the author of this quote.
[176] Even for 2010 Gazprom reports profits of USD 35.2 billion.
[177] Not least since the Russian State holds a major stake (50% plus a stock) in Gazprom's capital. In matter, it is fuelled by concerns of over-reliance on Russian gas and of growing Russian control over distribution networks in Europe.
[178] The rules adopted in the EU's Third Energy Package of 2009 imply that a producer and supplier such as Russia cannot also, at the same time, be a Transmission System Operator (TSO) in a member state.
[179] Also known as the "anti-Gazprom clause". It says that if a non-EU energy company wishes to operate in the EU, it must demonstrate that it does not pose any threat to EU energy security.

$1-\alpha$ can be called "security of supply". For the moment Russia is dependent on transit through third countries' territories and is, among all of the producers, most threatened by terrorist attacks. Therefore we disregard the risk of non-delivery for all other producers and concentrate solely on Russia. As a matter of fact, other producers have their risks of non-delivery.

One should notice some other restrictions of our neoclassical approach. There are sets of vertical restraints that under various conditions provide the joint-profit maximum (combined manufacturer and retailer profits) so property rights will be not as important as contractual restraints (Mathewson, Winter, 1984). We also assume that retailers have no market power so Gazprom may not be interested in vertical integration because of absence of additional profit.

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".

If Russia is a trader then 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, because 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 (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, 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 sells at a lower price than its competitors do. Will this price be higher under vertical integration? If the risk of producer's cost increasing is shared between the producer and traders by means of long-term agreements then could it be that the vertical integration decreases the potential income of customers? Or could it be that the price for Russian gas in the downstream market is lower than the former price in the upstream market and thus the security of supply decreases? If security of supply increases 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 after Gazprom becomes a trader than before, then in the case of an interruption of Russian deliveries the downstream price will be larger than before. It is not even sure that the downstream market price in periods with Russian deliveries is decreased.

So, the following results of our analysis are not obvious: (i) Under some simplifying assumptions (which need not always apply), when Gazprom becomes a trader the downstream market price decreases and security of supply increases. (ii) Calibrating the model with respect to the German gas market shows that, even without simplifying assumptions, the downstream market price will probably decrease and security of supply will increase. In addition, consumers' surplus increases.

An important instrument for transitioning to more competition and breaking up old monopoly structures on the wholesale as well as on the retail level is the unbundling and regulation of gas transport. In some cases (Germany, Denmark, and other countries) gas release auctions should support the emergence of strong new competitors (Bolle and Breitmoser, 2011). 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.

In order to determine α we interpret all the above-mentioned risks as (random) additional costs for Russian deliveries. If the transit country "steals" certain amount of the transit gas, costs are apparent. If terrorist attacks 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 if the costs are above the price for 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, in the long run, that Gazprom will no longer sell in the upstream market but will distribute its gas solely via its own trading arm. The price q in the downstream market will decrease. As this price is larger than the price for 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 indices of the supply structure of a country (Stirling, 1998). Hoel and Strom (1987) derive an optimal supply structure for exogenously given probabilities of interruption.

Models of the European gas market usually give the producers and, in particular, Gazprom, a lot of market power. Golombeck et al. (1995) assume Cournot competition among producers. Sagen and Tsygankova (2006) assume Gazprom to be a monopolist 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 (2008) 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 case when Russia is not a trader is described, the fifth section is devoted to the case when Russia is 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 sixth 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 other applications of our model.

II. Gazprom in the European Downstream Market

The Introduction gave us the intuition why Russia can profit from vertical integration. So it is plausible that a number of attempts have been undertaken by Gazprom in order to obtain direct access to markets in Europe. To go deeper downstream, Gazprom has also invested in non-core business outside Russia, like gas equipment manufacturing or gas-consuming industries (such as power generation or petrochemicals), etc. Gazprom's expansion activity is supported by its tremendous profits. In 2006 it earned €27.3 billion (Neftegas.ru, 2006). The gas consumption of the European Union fell by 6% in 2009 because of the global economic crisis. Meanwhile, Europe has also been cutting its dependence on Russia by expanding other supply options, in particular cheap spot-LNG. LNG was 14% of EU's gas consumption in 2009, based on BP data, compared with less than 8% in 2004. So, in 2009, Gazprom's export revenues fell, but an increasing oil price promises new record profits. Gazprom expects an export revenue of €53 billion in 2011 – which includes €38.7 billion from gas exports outside the CIS (Bloomberg, 2011).

The large European markets (Italy, Germany, France and the UK) are of supreme priority within Russia's strategy. Gazprom has repeatedly stated its ambition to obtain a 10% direct share of the French and UK gas markets by 2010 and 20% by 2015. It has expressed similar goals about Italy and the Czech Republic (Boussena and Locatelli, 2010). Its investment and holding branch Gazprom Germania GmbH set up the 100% marketing subsidiaries in London in 1999 (GM&T Ltd[180]), in Zurich in 2003 (ZMB Schweiz), in Paris in 2006 (GM&T France SAS), and in Berlin in 2009 (GM&T Germania). When attempting to penetrate these foreign downstream markets, Gazprom, as distinct from E.ON or GdF, faces strong political opposition.

Gazprom's interest in buying the UK gas-distribution company Centrica[181] 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. In the following years a number of alternatives to Centrica acquisition attempts were undertaken. In January 2006, the press reported on Gazprom's interest in Scottish Power (with capitalisation of €15.8 billion and 5 million customers in Britain), but without any real action to be observed[182]. GM&T entered the UK end-consumer market in June 2006 – with the purchase of Pennine Natural Gas, engaged in retail gas

[180] It owns all the gas supply licenses in Britain and enables Gazprom to sell gas directly in the UK. (The same applies to the GM&T business units in France and Germany.)

[181] Centrica, as UK's largest gas supplier, has market shares of 60% in the household sector and 15% in the market for industrial and commercial customers.

[182] Instead of this, a €17 billion take-over bid by Spain's Iberdrola was agreed in November 2006.

trading to 900 final users (including a few major companies). As of July 2007, it completed the acquisition of the British-based distributor Natural Gas Shipping Services Ltd. On account of both deals, GM&T is currently supplying 8,000 customers in the UK (mainly medium-sized businesses). Gazprom's portion of direct sales was thus amounting to 2% of that market in 2007 (The Sunday Times).

Gazprom's penetration of the German downstream sector dates back to 1993 when Wingas – currently the second largest gas distributor in Germany – was established as a joint venture of Wintershall and Gazprom. Its original capital distribution was 65% (Wintershall) and 35% (Gazprom). Since 2006, each partner holds 50% with a majority of one additional share held by Wintershall. The redistribution took place following an asset swap: Wintershall received a 35% stake[183] 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. As yet, this joint venture remains Gazprom's greatest breakthrough in its whole European gas export history[184]. On account of lacking access to any other national gas-distribution network in Europe, Gazprom "lets" traders earn €2.3 billion extra annually (Ermolova, 2010). In January 2010, VNG's (a regional pipeline) stockholders agreed to Gazprom's acquisition of another 5.26% in the company (previously held by GdF). That raised Russia's share to 10.52%. For crossholdings between German and Russian gas companies see Table 4 in the appendix.

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% minus one share in the Yuzhno Russkoe field, while Gazprom receives 50% minus one share in Hungarian E.ON Foldgaz Storage and Foldgaz Trade and 25% plus one share in E.ON Hungaria (Russ Oil-Gas, 2006). A similar consideration accompanied the sale of the Hungarian gas trader Emfesz (with a 20% share in the Hungarian market) to RosGas of Switzerland, a company linked with Gazprom, in April 2009. A court in Budapest, however, annulled the regulator's approval (The Budapest Times, 2010).

In September 2006, Italian Eni and Gazprom were discussing a strategic partnership which was envisaged to involve Eni into exploration and production in Russia, while Gazprom would have been allowed to sell gas directly to end users in Italy (EBR, 2006b). These proposals have faced opposition from Italian regulators. Gazprom held unsuccessful talks to acquire two of Eni's sales subsidiaries (Snam Rete Gas and EniPower). 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).

A similar partnership agreement with GdF[185] (of December 2006) contributed to building up its retail business in France. The deals involved a yearly, starting in 2007, transfer of 3 billion m^3 to Italy for its direct operations in the Italian market and 1.5 billion m^3 for those in the French market (along with the transfer of the companies' corresponding booked transport capacities[186]). As agreed with Italy's fourth-largest gas company Gas Plus in July 2006, Gazprom‘s pipeline capacity to Italy

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[183] Only 25% of those stocks have voting rights.

[184] As a result, E.ON Ruhrgas had to accept the strategy of its major Russian supplier and intensified on its part the cooperation. It acquired in total 6.43% of Gazprom shares and, in that way, received a seat in the Board of Directors.

[185] GdF Suez since July 2008.

[186] E.g., to Italy Russian gas is transported through Austria using the TAG pipeline. Gazprom's quota in its capacity stood at 2.7 billion m^3 for 2009. From 2011 on, it planed to expand it to 4.7 billion m^3.

would be partially swapped for a share of Gazprom's own gas volume kept at Sinarca[187] – with the intent to secure the stable supply of its Italian direct clients (Downstream Today, 2008). In 2009, Gazprom's direct sales in Italy totalled 2.7 billion m^3, and in jointly France and the UK 1.8 billion m^3.

There are further successful und unsuccessful attempts of Gazprom to enter the downstream markets in Austria, the Czech Republic, Belgium, the Netherlands, the Baltics, Serbia, Romania, Slovakia, and Portugal (see the electronic appendix Table 5). In addition, Gazprom is interested in gas power plants, it invests in gas storage, LNG business, and gas spot trading. As of 2007, it was a participant on the trading floors of the UK, Belgium, the Netherlands and France[188]. In 2008, the company acquired from OMV a 50% share in the Central European Gas Hub (in Austrian Baumgarten[189]), one of the largest gas-trading platforms in Europe (Gazprom, 2011a).

At last we should mention Russia's dominant share of the transnational gas pipelines Nord Stream and South Stream which will certainly help to increase West Europe's security of supply (but are not in the strategic interest of the extant transit countries).

All this shows how large Gazprom's interest is to expand downstream and how strong the opposition is[190]. 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 in North America and China.

III. The model

Our model of the European gas market has the following properties. We have m producers P_1, …, P_m plus Gazprom (P_0=P_R). At the first stage, the producers P_j determine their capacities x^j, j = 1,…, m, and x^0=x^R =Gazprom's capacity. Then traders T_i, i = 1, …, n compete for these capacities as "price takers". If Gazprom has a trade-arm T_0=T_R, it does not compete for market capacities but will be served by extra capacities x_R which Gazprom has reserved for T_R. Therefore T_R takes into account Gasprom's expected marginal production costs. 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. It is implicit in most oligopoly models of natural resources (also gas) where the stage(s) of wholesale markets are disregarded. A "price taking" trader offers quantities in the downstream market as if the price in its supply market was fixed, i.e. while acting strategically in the downstream market they act non-strategically in the upstream market. 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

[187] A gas storage facility jointly constructed by Gazprom and Gas Plus in Italy.

[188] Those included National Balancing Point, Powernext, Nordpool, Z-Hub, TTF, PEG, European Energy Exchange and European Energy Derivatives Exchange.

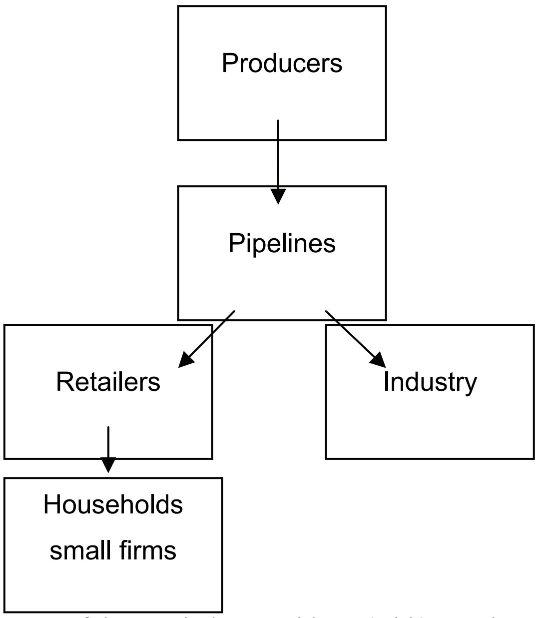
[189] Baumgarten is the final destination for key transeuropean gas export pipelines (including an eventual Nabucco). About one third of Russian gas to Europe passes through this hub.

[190] Gazprom is no exception though. Attempts of other Russia's energy utilities to buy into the European downstream result in the same opposition, often leading to longstanding delays and political scandals. "Mergers & Acquisitions" magazine even calculated that in 2006 alone the Russians were for political reasons unsuccessful in 13 large assets acquisitions abroad, totalling €35 billion (Ermolova, 2010).

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 j is obliged to supply the trader i with a certain quantity x_{ji} for which i is obliged to pay $p(x_{ji})$; it does not matter whether the supplier takes it or not. 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 (of course, in reality other producers have their risks of non-delivery).

Producers’ marginal (long term) production costs c_1, … c_m are constant. Russia, however, may bear additional costs. The reason is that there exists the possibility of a quarrel about transit fees between Gazprom and a transit country. For instance, the transit country demands a certain fee, expressed as a share of the gas transported, and it simply takes this share if negotiations fail. Russia’s reaction may be further negotiations, sanctions of some kind or, as ultima ratio, no longer feeds gas into the respective pipeline. Whether Russia adopts this ultimate measure or not will certainly depend on the respective costs of continued delivery and interruption of supply. Gazprom’s costs of delivery c_R are random variables, the value of which is determined only after all the contracts have been concluded. At 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 exists a certain probability α that deliveries are interrupted. For the sake of simplicity, this interruption is assumed to be a full interruption (as a matter of fact, the risk of producer’s cost increasing is shared between the producer and traders).



P_j, $j = 1, \dots, m$, deliver $\Sigma x^j = x$.
$P_0 = R_R$ delivers $\Sigma x_i^R = x^R$
(and x_R) with Prob $= 1 - \alpha$.

T_i, $i = 1, \dots, n$, ($T_0 = T_R$) buy and sell $\Sigma x_i = x$, $\Sigma x_i^R = x^R$, (and x_R).

inverse demand function for gas

Figure 1: The Structure of the Gas industry without (with) a trade-arm of Gazprom

Table 1:

Main variables of the model

Variable **meaning**

x^j	the quantity that supplier (producer) P_j sells, j=1, …, m
x_i	quantity of non-Russian gas that trader T_i buys, i=1, …, n
$x = \sum_{i=1}^{n} x_i$	total quantity of non-Russian gas sold to traders T_i, i=1,…,n
x_i^R	quantity of Russian gas that trader T_i buys, i=1, …, n
$x^R = \sum_{i=1}^{n} x_i^R$	total quantity of Russian gas sold to the traders T_i, i=1,…,n
x_R	quantity delivered by Gazprom to T_R
p_R	price of Russian gas in the upstream market
p	price of non-Russian gas in the upstream market
q	price of gas in the downstream market
c_R	Gazprom's marginal production costs
$c_1, \ldots c_m$	other producers' marginal (long term) production costs
$\bar{c}_R$	Russia's average costs, conditional on delivery
c	average costs of the other producers
α	probability that Russian deliveries are interrupted

In the first stage of the game the suppliers determine their quantities (capacities) x^j. In the second stage of the game, in the downstream market, there are traders $T_1, \ldots T_n$ and (possibly) T_R = Gazprom.

At first we consider the case when Gazprom is not a trader. The traders T_i supply quantities $x_i+x_i^R$ to the downstream spot[191] market which is described by a linear (inverse) demand function

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

with $x = \sum_{i=1}^{n} x_i$, $x^R = \sum_{i=1}^{n} x_i^R$. Trader i buys $x_i+x_i^R$ 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 the total number of traders is small compared to the number of producers. When producers have constant marginal costs each of these regional markets can be analysed separately.

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

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

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

[191] 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.

with x = $\sum_{j=1}^{m} x^j = \sum_{i=1}^{n} x_i$, $x^R = \sum_{i=1}^{n} x_i^R$, where x^j is the supply of producer j to the downstream market, x_i and x_i^R are demands of trader i in the upstream market, and α is a probability of Russian interruption of the gas supply. x_R is the supply of Gazprom's trade-arm (=0 if it does not exist). Only after the traders have ordered their quantities (which are bought but not yet delivered) will Gazprom decide whether to deliver. The decision in this third stage of the game is influenced by Gazprom's stochastic costs.

In the following we will determine the unique subgame perfect equilibrium of this game by working backwards from Stage 3 to Stage 1.

IV When Gazprom is not a trader

IV.1 Stage 3: Security of supply

After all contracts have been concluded, Gazprom's costs of delivery c_R are determined. Note that we assume a relatively short production period (say one week) and a decision to deliver or not during the whole period. Let us assume that production costs in a narrow sense are as expected but there are also 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

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

It will deliver gas as long as

$$c_R < p_R . \quad (5)$$

Therefore the probability of Gazprom stopping to deliver is

$$\alpha = \int_{p_R}^{\infty} f(c_R)dc_R , (6)$$

where *f* is a probability density function of c_R.

Viewed from earlier stages, Gazprom's expected profit is

$$EG^R = \int_{0}^{p_R} G^R f(c_R)dc_R \ . (7)$$

IV.2 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 p_R) either. The traders sell their gas on a spot market where the price q is 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 gas from producers.

If the traders i = 1, …,n have ordered quantities x_i of non-Russian gas and x_i^R of Russian gas which is delivered only with probability 1 - α, then the profit of trader i is

$$G_i = (1-\alpha)\left[\left(x_i + x_i^R\right)\left(a - bx - bx^R\right) - x_i p - x_i^R p_R\right] + \alpha\left[x_i\left(a - bx\right) - x_i p\right]. \quad (8)$$

Trader i’s best response is determined by:

$$\frac{\partial G_i}{\partial x_i} = (1-\alpha)\left[a - b\left(x + x^R\right) - b\left(x_i + x_i^R\right) - p\right] + \alpha\left[a - bx - bx_i - p\right] = 0, \quad (9)$$

$$\frac{\partial G_i}{\partial x_i^R} = (1-\alpha)\left[a - b\left(x + x^R\right) - b\left(x_i + x_i^R\right) - p_R\right] = 0. \quad (10)$$

Summing (10) for all i we get:

$$p_R = a - \frac{n+1}{n} b\left(x + x^R\right), \quad (11)$$

which is the inverse demand function for Russian gas in the upstream market.

Summing (9) for all i we get:

$$(1-\alpha)\left[na - nb\left(x + x^R\right) - b\left(x + x^R\right) - np\right] + \alpha\left[na - nbx - bx_i - np\right] = 0. \quad (12)$$

Solving (12) for p we get the inverse demand function for non-Russian gas

$$p = a - \frac{n+1}{n} b[x + (1-\alpha)x^R]. \quad (13)$$

Proposition 1. If Gazprom is not a trader then (11) and (13) are the inverse demand functions for Russian and non-Russian gas in the upstream market.

The difference between the demand functions (11) and (13) is due to the insecurity of Russian gas. Thus the “law of one price” for homogeneous goods does not hold in the upstream market.

IV.3. Stage 1: the upstream market

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.The producers fix quantities under the assumption that prices are described by the inverse demand functions (11) and (13). Gazprom’s profit is described by (7); the other producers’ profits are

$$G^j = x^j\left(p - c_j\right) \qquad (14)$$

Note that x is the aggregate quantity provided by the producers (except Gazprom) and that all the producers take into account their influence on α. When differentiating (14) 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. The best response of producer j requires

$$\frac{\partial G^j}{\partial x^j} = p - c_j + x^j \frac{\partial}{\partial x^j}(p - c_j) = 0, \text{ where } \frac{\partial}{\partial x^j} c_j = 0. \qquad (15)$$

From (13) we get

$$\frac{\partial p}{\partial x^j} = -\frac{n+1}{n} b + \frac{n+1}{n} b \frac{\partial \alpha}{\partial x^j} x_R \qquad (16)$$

From (6) we get

$$\frac{\partial \alpha}{\partial x^j} = -f(p_R)\frac{\partial p_R}{\partial x_j}. \qquad (17)$$

Substituting in (17) p_R from (11) we get

$$\frac{\partial \alpha}{\partial x^j} = f(p_R)\frac{n+1}{n} b. \quad (18)$$

From (15), (16) and (17) the best response of producer j is given by

$$\frac{\partial G^j}{\partial x^j} = p - c_j - \frac{n+1}{n} b(1+\beta)x^j = 0, \ (19)$$

where

$$\beta = x^R \frac{\partial \alpha}{\partial x} = \frac{n+1}{n} b x^R f\left(p_R\right). \qquad (20)$$

Summing (19) for all j results in

$$p - c - \frac{n+1}{n} b(1+\beta)\frac{x}{m} = 0, \text{ where } c = \frac{1}{m}\sum c_j. \ (21)$$

Russia's profit is given by (7) and (4), its best response to other producers' quantities requires

$$\partial EG^R / \partial x^R = \int_0^{p_R} (p_R - c_R - b(n+1)x^R / n) f\left(c_R\right) dc_R = 0, \text{ or } (22)$$

$$p_R - \bar{c}_R - \frac{n+1}{n} b x^R = 0, \qquad (23)$$

where $\bar{c}_R$ are Russia's average costs conditional on delivery,

$$\bar{c}_R = \frac{1}{1-\alpha}\int_0^{p_R} c_R f\left(c_R\right) dc_R. \ (24)$$

(11), (13), (21) and (24) provide us with four equations for the prices and quantities of

Russian and non-Russian gas.

Proposition 2: When Gazprom is not a trader, the quantities provided in the upstream market are

$$\frac{n+1}{n}bx = \frac{a-c-\left(a-\bar{c}_R\right)\frac{1-\alpha}{2}}{\frac{1+\alpha}{2}+\frac{1+\beta}{m}}. \qquad (25)$$

$$\frac{n+1}{n}bx^R = \frac{a-\bar{c}_R}{2} - \frac{n+1}{2n}bx . (26)$$

A helpful relation implied by (25) and (26) is

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

Inserting these relations in (11) and (13) shows that prices depend on m but not on n. The intrinsic reason for this independence is that n influences only the slope of the linear demand functions with which the producers are confronted.

V. When Gazprom is a trader

V.1 Stage 3: Security of supply

Let us now consider the case when Gazprom is a trader**.** Now we have to substitute x^R by x^R+x_R in (1). The trader T_R supplies the quantity x_R to the downstream spot market which is described by a linear (inverse) demand function:

$q = a - b\left(x + x^R + x_R\right)$ (28) or $q = a - bx$ if Gazprom's deliveries are interrupted.

Gazprom's profit from delivering gas is

$$G^R = \left(p_R - c_R\right)x^R + \left(q - c_R\right)x_R . \qquad (29)$$

Thus in this case Gazprom will deliver ($G^R>0$) as long as

$$c_R < \frac{p_R x^R + q x_R}{x^R + x_R} = d_R . \ (30)$$

(6) is substituted by

$$\alpha = \int_{d_R}^{\infty} f\left(c_R\right)dc_R . \ (31)$$

Gazprom's expected profit is

$$EG^R = \int_0^{d_R} G^R f\left(c_R\right)dc_R \ (32)$$

where G^R is determined by (29) and d_R is determined by (30).

V.2 Stage 2: the downstream market

In principle we have to carry out the same computations as in IV.2, namely computing the best reply functions of the traders as suppliers in the downstream market. Remember that the traders i=1,…,n take p and p_R as given unit costs. T_R takes c_R as unit cost.

The best response x_R (the quantity of Russian gas supplied by Gazprom as a trader) is determined by maximizing EG^R from (32). Taking into account the definition of d_R we get

$$\frac{\partial EG^R}{\partial x_R} = G^R(c_R = d_R) f(c_R = d_R(x_R)) \frac{\partial d_R}{\partial x_i^R} + \int_0^{d_R} \left(p_t - c_R + \frac{\partial p_t}{\partial x_R} x_R \right) f(c_R) dc_R = 0 . \quad (33)$$

Because of $G^R(c_R = d_R) = 0$ and (28) we get

$$x_R = \frac{a - \overline{c}_R}{2b} - \frac{x + x^R}{2} \quad (34)$$

where

$$\overline{c}_R = \frac{1}{1-\alpha} \int_0^{d_R} c_R f(c_R) dc_R \quad (35)$$

is the conditional expectation of c_R given that Gazprom keeps delivering.

The best response of the other traders is derived from

$$G_i = (1-\alpha)\left[\left(x_i + x_i^R\right)\left(a - bx - bx^R - bx_R\right) - x_i p - x_i^R p_R\right] + \alpha(x_i(\alpha - bx) - x_i p) \quad , (36)$$

$$\frac{\partial G_i}{\partial x_i^R} = (1-\alpha)\left[a - b\left(x + x^R + x_R\right) - p_R - bx_i^R - bx_i\right] = 0 \quad (37)$$

where, again, *i* does not assume to have influence on α. Using (34) we substitute x_R in (37) and get

$$\frac{a + \overline{c_R}}{2} - \frac{b}{2}\left(x + x^R\right) - p_R - b\left(x_i^R + x_i\right) = 0 . \quad (38)$$

Summing (38) over i we get

$$p_R = \frac{a + \overline{c_R}}{2} - \frac{n+2}{2n} b\left(x + x^R\right). \quad (39)$$

Summing $\frac{\partial G_i}{\partial x^i} = 0$ provides us with (40)

$$p = \frac{1+\alpha}{2} a + \frac{1-\alpha}{2} \overline{c}_R - \left(\frac{n+2}{2n} + \frac{\alpha}{2}\right) bx - (1-\alpha)\frac{n+2}{2n} bx^R .$$

Proposition 3: If Gazprom is a trader then (39) and (40) are the inverse demand functions for Russian and non-Russian gas in the upstream market. T_R's supply of the market is described by (34).

V.3 Stage 1: the upstream market

Proposition 4: 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 appendix.)

Corollary :

d_R=q. (41)

For the determination of the upstream market equilibrium we need to determine $\partial \bar{c}_R / \partial x$.

From (28), (34), (30) and $x^R = 0$ follows

$$d_R = q = \frac{a + \bar{c}_R}{2} - \frac{bx}{2}. \quad (42)$$

From (35) we get

$$\frac{\partial \bar{c}_R}{\partial x} = \frac{1}{1-\alpha} qf(q) \frac{\partial q}{\partial x}. \quad (43)$$

From (42) we get

$$\frac{\partial q}{\partial x} = \frac{1}{2}\frac{\partial \bar{c}_R}{\partial x} - \frac{b}{2} \quad (44)$$

Substituting (44) in (43) we get

$$\frac{\partial \bar{c}_R}{\partial x} = \frac{qf(q)b}{qf(q) - 2(1-\alpha)}. \quad (45)$$

Let us now determine the equivalent to (23), the aggregate best response in the case where Gazprom is a trader. For this purpose we compute the derivative of G^j with respect to x^j :

$$\frac{\partial G^j}{\partial x^j} = p - c_j + x^j \frac{\partial p}{\partial x^j} = 0. \quad (46)$$

Summing (46) for all j yields

$$p - c + \frac{x}{m}\frac{\partial p}{\partial x} = 0. \quad (47)$$

From (40) we get

$$\frac{\partial p}{\partial x} = \frac{1-\alpha}{2}\frac{\partial \bar{c}_R}{\partial x} - (\frac{n+2}{2n} + \frac{\alpha}{2})b. \quad (48)$$

Substituting in (48) $\frac{\partial \bar{c}_R}{\partial x}$ from (45) we get

$$\frac{\partial p}{\partial x} = -(\frac{\alpha}{2} + \frac{n+2}{2n} + \beta)b \quad (49)$$

where

$$\beta = \frac{f(q)q(1-\alpha)}{4(1-\alpha)-2f(q)q}. \quad (50)$$

From (47), (49) and (40) follows

$$bx = \frac{a - c - \frac{1-\alpha}{2}(a - \bar{c}_R)}{(\frac{n+2}{2n} + \frac{\alpha}{2})(1 + \frac{1}{m}) + \frac{\beta}{m}}, \quad (51)$$

Proposition 5: When Gazprom is not a trader, the quantities provided in the upstream market are described by (51) and (47), in connection with (35), (45), and (48).

Because of (34) with $x^R = 0$ we get the helpful relation

$$b(x + x_R) = \frac{a - \bar{c}_R}{2} + \frac{bx}{2}. \quad (52)$$

(52), (51) and (27), (26) provide us with the quantities and therefore with the prices in the downstream market (when Gazprom delivers gas). From now on we use the index (^{1}), i.e. α^1 instead of α, etc. when Gazprom is a trader. The comparison of q and q^1 as well as p_R and q^1 is difficult in general. After a calibration of our model with data from the German gas market (Section VI) 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 $c_R=q^1$. That implies

$$\alpha \approx \alpha^1, \ \bar{c}_R \approx \bar{c}^1{}_R, \ \beta \approx \beta^1 \approx 0. \quad (53)$$

Proposition 6: If (53) applies and if n > m then the downstream market price (in times when Russia delivers gas) decreases when Gazprom becomes a trader.

(Proof in the Appendix).

Proposition 6 contains an important message for the case where α is not negligible but the change of α is small. The latter condition need not always be true. In the next section we will calibrate our model and will thus be able to make rough estimations with “realistic” parameters.

VI. Calibration and evaluation of cases

Russia has been delivering gas to Western Europe for 35 years. For only one day in 2004, for four days in January 2006 and for 13 days in January 2009 all Russian gas deliveries through Ukraine were interrupted. Let us ask what the probability of an interruption for a period of, for example, two months or longer could be. On the basis of 35 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 ultimately expected to pay Western prices, the earlier the better.

In our simple model α must be reinterpreted for different period lengths. For a short period, α is the probability of a complete interruption. For a long period (say five years) it is the share of short periods when supply is interrupted. Let us view Gazprom’s situation as intermediate between the old secure regime and a completely insecure situation as, for example, pipeline transport through countries suffering from a civil war. Perhaps a slightly exaggerated guess is $\alpha = 0.05$, i.e. we expect to observe three months of interruption for a five years period.

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

$c_R = c_R^0 + \varepsilon$, (54)

$g(\varepsilon) = \lambda e^{-\lambda\varepsilon}, \lambda > 0$, (55)

with c_R^0 measuring normal production and transportation costs (comparable with c_j of the other producers) and g describing the density of ε.

We have α = Prob $(c_R^0 + \varepsilon > p_R) = 0.05$ that means that

$\int_{p_R - c_R^0}^{\infty} \lambda e^{-\lambda\varepsilon} d\varepsilon = -e^{-\lambda\varepsilon}\Big|_{p_R - c_R^0}^{\infty} = 0.05$, therefore we get (56)

$\lambda = \frac{\ln 20}{p_R - c_R^0}$. (57)

In the following we take prices from 2005 because we have reliable estimates of the wholesale gas price q (the price which local distributors pay on the basis of long term contracts). This price varies in phase with the prices p and p_R which the pipelines have to pay. At the end of 2005, Russia sold its gas at about p_R = 200 *Euro*/1000 *m*^{3}, i.e. 2.3 *Eurocent/kwh* (price at the German border), to several importing pipelines. This price has not changed very much since then (see Bundesamt für Wirtschaft und Ausfuhrkontrolle, 2011) and also the variation of yearly averages between 2006 and 2010 is small. Russia's "normal costs" c_R^0 (including transport and transit costs) is about 0.7 *€ct/kwh (Holz et al., 2008, assume 80 US Dollar/1000m*^{3}*)*. Thus (55) implies

$\lambda = \frac{\ln 20}{1.6 cent/kwh} = 1.88 kwh/cent$. (58)

There are no really reliable estimates of the gas demand. Liu (2004) finds the long run price elasticity for natural gas between -0.78 and +0.08 for OECD countries. Holz et al. (2008) 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, elasticity 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 that parameter a = $\left(1 - \frac{1}{\eta}\right) p_t$ where q =3 *€ct/kwh* is the average 2005 price in the (German) downstream market with retailers and large industrial customers (Pfaffenberger and Gabriel, 2006). Thus we get a=9 *€ct/kwh*. Note that, as long as costs are linear, we can describe 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 *€ct/kwh* is the price in the general European downstream market.

For the following computations, we assume that a=9 *€ct/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 expressions (6), (11), (24), (20), (25) and (26) we compute the six variables bx^R, bx, p_R, $\alpha, \beta, \bar{c}_R$ for the case where Gazprom is not a trader. Equivalently, from (31), (39), (35), (50), (51) and (52) we determine the respective values for the case where Gazprom is a trader (for detailed calculations see Appendix).

Table 2:

Downstream prices q in Euro €ct/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	6.15	5.86	5.66	5.53
2	5.20	4.81	4.54	4.37
3	4.73	4.29	3.98	3.79
4	4.44	3.98	3.65	3.44
5	4.25	3.77	3.43	3.21
6	4.12	3.62	3.27	3.05
7	4.02	3.51	3.15	2.92
8	3.94	3.42	3.05	2.83
9	3.88	3.35	2.98	2.75
p_R	3.31	2.72	2.31	2.05
1 - α	0.998	0.994	0.987	0.979

Table 2 shows that the price in the downstream market (≈ 3.0 €ct/kwh) as well as that in the upstream market (≈ 2.3 €ct/kwh) is reproduced for m = 3 (plus Russia) and n = 7 (the number of importing German pipelines), namely q = 3.15 €ct/kwh and p_R = 2.31 €ct/kwh. We conclude that the downstream market may be more competitive than we thought.

For the future development we concentrate on numbers of producers as well as traders from 2 to 6. The current situation (in Germany as well as some other European countries) may best of all be 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) are currently entering 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 3 and 4). As the downstream market price cannot exceed 9 Euro *€ct/kwh* (in periods when Gazprom does not deliver), it is clear that (because of α=.05) 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 differences in a table.

Table 3:

Price differences (Euro €ct/kwh) $q - q^1$ where $q^1(q)$ is the downstream price (in periods when Russia delivers) if Russia is a trader.

m	2	3	4	5	6
n					
2	1.33	1.21	1.13	1.08	1.03
3	1.05	0.94	0.86	0.81	0.76
4	0.91	0.79	0.72	0.67	0,62
5	0.82	0.71	0.64	0.59	0.54
6	0.76	0.65	0.58	0.54	0.49

Table 4:

Differences of security of supply $(1 - \alpha^1) - (1 - \alpha) = \alpha - \alpha^1$ where $\alpha^1(\alpha)$ is the probability of interruption if Gazprom is a trader.

m	2	3	4	5	6
n					
2	0.004	0.01	0.018	0.025	0.034
3	0.003	0.008	0.015	0.023	0.031
4	0.002	0.007	0.013	0.019	0.027
5	0.001	0.005	0.01	0.016	0.023
6	0	0.003	0.008	0.013	0.02

VII. 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 on 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 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. In this case the wind sector's increased costs if there is no wind may consist of buying the energy elsewhere. The model comparison applies to a future scenario with prices of CO_2-permits that are 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 another example of insecure upstream supplies. The production may fail or may be smaller than expected (which may be avoided by means of increased costs). Note that our model does not state that vertical integration is always advantageous in such cases. The counterexample (from Appendix) with $q^1 > q$ shows that the conventional wisdom that vertical integration is advantageous need not be true under circumstances with insecure supply. Our numerical computations, however, make us confident that it is in the case of the European gas market.

Russia is a country where natural resources play a special role in economy. Natural resources are one of the main factors of economic and social development. The results of the paper became even more important because of the steady growing interest in Russia to the problem how to maximize the efficiency of natural resources use (see for example Kudryavtseva (2007)[192] and Kudryavtseva (2008))[193].

The conclusion from our model is that if Gazprom becomes a trader in the downstream market it decreases the downstream market price heavily. The security of supply increases as well as consumers' surplus does. Europe can only profit from Gazprom investing in the downstream market. For this result it does not matter whether it buys existing traders (n → n – 1) or builds its own trade arm (compare Table 2 with Table 3 and Table 4). An additional advantage of Russian investment is that European countries are holding Russian property hostage, that is in the case of unlawful behaviour of Gazprom its trade arm could be expropriated.

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.

Appendix

Proof of Proposition 4:

From (32) we get $EG^R = \int_0^{d_R} \left(p_R x^R + p_t x_R - c_R\left(x^R + x_R\right)\right) f\left(c_R\right) dc_R$.

with $x_R = \frac{a - \bar{c}_R}{2b} - \frac{x^R + x}{2}$ and $p_t = a - b(x + x^R + x_R)$.

from (34) and (28). If $c_R = d_R$ then $G^R\left(c_R = d_R\right) = 0$ and therefore

$$\frac{\partial EG^R}{\partial x^R} = (1-\alpha)\left[\frac{dp_R}{dx^R} x^R + p_R + \frac{dp_t}{dx^R} x_R + p_t \frac{dx_R}{dx^R} - \overline{c_R}\left(1 + \frac{dx_R}{dx^R}\right)\right]$$

Taking further into account (39), (34) and (28) we get

$$\frac{\partial EG^R}{\partial x^R} = (1-\alpha)\left[-\frac{n+1}{2n} bx^R + \frac{a+\overline{c_R}}{2} - \frac{n+2}{2n} b\left(x + x^R\right) - \frac{1}{2} bx_R - \frac{1}{2}\left(a - bx - bx^R - bx_R\right) - \frac{1}{2}\overline{c}_R\right]$$
$$= (1-\alpha)\left[-\frac{n+1}{2n} bx^R - \frac{1}{n} b\left(x + x^R\right)\right]$$

I.e. $\frac{\partial EG^R}{\partial x^R} < 0$ and hence $x^R = 0$ in the long run. (Gazprom will not conclude new long-term contracts if it is a trader.) ■

Proof of Proposition 6:

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[192] http://elibrary.ru/item.asp?id=12839771
[193] http://elibrary.ru/item.asp?id=11533398

From (26), (27), (51), (52) and (53) follows

$$\text{(A1)} \quad \frac{\frac{n+1}{n}b\left(x+x^{R}\right)}{\frac{n+1}{n}b\left(x^{1}+x_{R}\right)} \approx \frac{a-\bar{c}_R+\dfrac{a-c-(a-c_R)(1-\alpha/2)}{(1+\alpha)/2+1/m)}}{\frac{n+1}{n}\left(a-\bar{c}_R\right)+\dfrac{a-c-\left(a-\bar{c}_R\right)(1-\alpha)/2}{\left(\frac{n+2}{2n}+\alpha\right)\frac{m+1}{m}\frac{n}{n+1}}} < 1.$$

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

Counterexample with $q^1 > q$. If we assume $\alpha = 1/2$, $c = \bar{c}_R$, $n = 5$, $m \geq 8$, then the inequality (A1) is reversed, i.e. $q^1 > q$.

But even if $q^1 < q$, 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 has become 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.

The exponential model for the case when Gazprom is not a trader:

From (55), (6), and (24) follows

$$\text{(A2)} \quad f\left(c_R\right) = \lambda e^{-\lambda(c_R - c_R{}^0)} \text{ for } c_R \geq c_R{}^0$$

$$\text{(A3)} \quad \alpha = \int_{p_R}^{\infty} f\left(c_R\right)dc_R = e^{-\lambda(p_R - c_R{}^0)}$$

$$\text{(A4)} \quad \bar{c}_R - c_R{}^0 = \frac{1}{1-\alpha}\int_{c_R{}^0}^{p_R} c_R f\left(c_R\right)dc_R = \frac{1-\alpha+\alpha\ln\alpha}{\lambda(1-\alpha)} .$$

From (11) and (A3) we get

$$\text{(A5)} \quad \beta = x^R\frac{\partial\alpha}{\partial x} = \frac{n+1}{n}bx^R f\left(p_R\right) = \alpha\lambda\frac{n+1}{n}bx^R.$$

From (11), (13), (21),(23), (25), (26), and (27) we can compute p and p_R as functions of α, β and $\bar{c}_R$.

The exponential model for the case when Gazprom is a trader:

From (31) and (41) follows

(A6) $$\alpha^1 = \int_{d_R}^{\infty} f(c_R) dc_R = e^{-\lambda(d_R - c_R{}^0)} = e^{-\lambda(q - c_R{}^0)}$$

$\bar{c}_R^1 - c_R{}^0$ is determined as in (A4), but note that α is different:

(A7) $$\bar{c}_R^1 - c_R{}^0 = \frac{1 - \alpha^1 + \alpha^1 \ln \alpha^1}{\lambda(1 - \alpha^1)}.$$

From (50) and (A2) follows

(A8) $$\beta^1 = \frac{-\alpha^1(1 - \alpha^1)\ln \alpha^1}{4(1 - \alpha^1) + 2\alpha^1 \ln \alpha^1}.$$

From (1), (34), (35), (45), (48), (51), and (52) we can compute q^1,p^1 and $p_R{}^1$ as functions of α^1, β^1 and $\bar{c}_R^1$.

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Table 5 (provided electronically): Gazprom’s fully owned firms and joint ventures to transport and market natural gas in European markets. “–“ = not applicable. “*” = Affiliated to Gazprombank where Gazprom holds 41% of shares. “**” = Owned through WIEE, the 50-50 joint venture with Wintershall. “***” = Owned through a 50% stake in Wingas. “****” = Controlled by Gazprom Neft where Gazprom holds 75% of shares.

Country	*Name of the company*	*Share of Gazprom, %*	*Main enterprise in the branch*	*Partner(s) of Gazprom*
Austria	ARosgas Holding	100	OMV	–
	Centrex Europe Energy & Gas	100*		–
	ZGG-Zarubezhgaz Neftechim Trading	100		–
	GWH (Gas- und Warenhandel)	50		OMV (25.1%), Centrex Europe Energy & Gas (24.9%*)
	Central European Gas Hub (Baumgarten)	30		OMV (30%), Centrex Europe Energy & Gas (20%*), Vienna Stock Exchange (20%)
Bulgaria	Topenergo	100	Bulgarian Energy Holding	–
	Overgas Inc.	50		DDI Holdings (50%)
	DEXIA Bulgaria	25.5**		Agropolychim (49%), Wintershall (25.5%**)
Czech Republic	Vemex	51	RWE Transgas	Centrex Europe Energy & Gas (33%*), EW East-West Consult (16%)
	Gas-Invest	37.5		Centrex Europe Energy & Gas (37.5%*), others (25%)
Estonia	Eesti Gaas	37.02	Eesti Gaas	E.ON Ruhrgas (33.66%), Fortum (17.72%), Itera Latvija (9.85%)
Finland	Gasum	25	Fortum	Fortum (31%), Finnish Government (24%), E.ON Ruhrgas (20%)
France	GM&T France SAS	100	GdF Suez	–
	FRAgaz	50		GdF Suez (50%)
Germany	Gazprom Germania	100	E.ON Ruhrgas (holds 3.5% of Gazprom shares), Wintershall	–
	GM&T Germania	100		–
	WIEH (Winthershall Gas Trading House)	50		Wintershall (50%)
	Wingas	49.98		Wintershall (50.02%)
	DitGas Trading House	49		debis International Trading
	VNG (Verbundnetz Gas)	10.52		EWE (47.9%), VNG Verwaltung und Beteiligung (25.79%), Wintershall (15.79%)
Greece	Prometheus Gaz	50	DEPA	Copelouzos Group (50%)
Hungary	Panrusgáz	40	MOL	E.ON Ruhrgas (50%), Centrex Hungária (10%*)
Italy	A2A Beta	50	Eni, Edison	A2A (70%), Iren (30%)
	Enia Energia	50		Iren (50%)
	Promgaz	50		Eni (50%)
	Volta	49		Edison (51%)
Latvia	Latvijas Gāze	34	Latvijas Gāze	E.ON Ruhrgas (47.2%), Itera Latvija (16%), others (2.8%)

Lithuania	Lietuvos Dujos	37.1	Lietuvos Dujos	E.ON Ruhrgas (38.9%), Lithuanian State Property Fund (17.7%), others (6.3%)
	Stella Vitae	30		West-Lithuanian Industrial and Financial Corp.
Netherlands	Peter-Gaz	51	Gasunie, Eneco	Heerema Oil & Gas Development (49%)
	BSPC (Blue Stream Pipeline Co)	50		Eni (50%)
	BBL (Balgzand–Bacton–Line)	9		Gasunie (51%), E.ON Ruhrgas (20%), Fluxys (20%)
Poland	EuRoPol Gaz	48	PGNiG	PGNiG (48%), Gas-Trading (4%)
	Gas-Trading	15.88		PGNiG (43.41%), Bartimpex (36.17%), Węglokoks (2.27%), WIEH (2.27%)
Romania	WIEE Romania	50**	Transgaz	Wintershall (50%**)
	WIROM Gas	25.5**		Distrigaz Sud (49%), Wintershall (25.5%**)
Serbia	YugoRosGaz	50	Srbijagas	Srbijagas (25%), Central ME Energy & Gas (25%*)
	Progres-Gas Trading	50		Progres DSO, NIS****
Slovakia	Slovrusgas	50	SPP	SPP (50%)
Slovenia	Tagdem	85	Geoplin Ljubljana	Kovinotehna (15%)
Switzerland	ZMB (Schweiz)	100	Swissgas	–
	Nord Stream	51		E.ON Ruhrgas (15.5%), Wintershall (15.5%), Gasunie (9%), GdF Suez (9%)
	South Stream	51		Eni (49%)
	Gas Project Develop-ment Central Asia	50		Centrex Europe Energy & Gas (50%*)
	RosUkrEnergo	50		Centragas Holding (50%)
	WIEE (Wintershall Gas Trading House Zug)	50		Wintershall (50%)
Turkey	Bosphorus Gaz Corp.	51	TPAO	Tur Enerji (49%)
	Turusgaz	45		BOTAŞ (35%), Gama (15.6%), others (4.4%)
United Kingdom	GM&T Ltd (Gazprom Marketing & Trading)	100	Centrica	–
	GM&T Retail (renamed from Natural Gas Shipping Services)	100		–
	Pennine Natural Gas	100		–
	HydroWingas	25***		Norsk Hydro (50%), Wintershall (25%***)
	Interconnector	10		Caisse de dépôt et placement du Québec (33.5%), Eni (16.4%), E.ON Ruhrgas (15.1%), Fluxys (15%), ConocoPhillips (10%)