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When is Mighty Gazprom Good for Russia?

Abstract:
In the late 1990s, several proposals for a structural reform that would bring competition and market prices to the Russian gas industry were intensely debated. Splitting up Russian gas monopolist Gazprom into several producing companies was a considered option. In this paper, I examine theoretically and numerically how a split-up of Gazprom would affect Russian national welfare. Results show that under the current gas market structures in Europe and Russia, the split-up of Gazprom's monopoly might not be beneficial for Russia. The market share of Russia in the European market is important in determining whether Gazprom's dominance is supported under the national welfare criteria.

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1. Introduction

State-owned gas company Gazprom[1] controls most of the Russian gas production and has the sole right to export gas to Europe. Since 1997, a structural reform that would bring competition into the Russian gas industry has been intensely debated, and a split-up of Gazprom into several smaller gas-producing companies was one of the proposed options of the reform (Locatelli, 2003). The debate ended in 2003, when Russian President Vladimir Putin publicly stated that he would not break up Gazprom (Stern, 2005). Since then, Gazprom seems to have enjoyed a strong position in both the European and Russian gas markets.

Until recently, Russian gas pricing policy has, to some extent, justified Gazprom's dominance in the Russian gas industry. Other Russian gas producers, or independent producers as they are known in Russia, are formally free to sell their gas at market prices. However, Gazprom has historically sold its gas at low regulated prices in Russia, aimed at stimulating Russia's economic growth after the collapse of the planned economy. In recent years, as the Russian economy began to recover, the Russian government gradually started to increase Gazprom's gas prices (Spanjer, 2007). Deregulation of Russian gas prices might be the next step in Russian gas price reform. In 2006 Russian opened a gas exchange, where up to 10 bcm was sold at unregulated prices. There are further plans to extend gas volumes sold at unregulated price. Price deregulation might stimulate Gazprom to abuse its market power and cause a significant rise in domestic gas prices. Therefore, the question arises as to whether Gazprom's dominance in the Russian gas industry can still be defended when Russian gas prices are deregulated.

Natural gas has great importance for Russia's wealth. It generates high export profits, provides an inexpensive energy supply to the country and remains an important instrument of Russian foreign policy. This makes the Russian government particularly cautious in making changes in the gas industry that have a potential danger of reducing the economic gains from natural gas. Importantly, in managing relations with its gas trading partners, the Russian government focuses primarily on its own gains.

In this paper, I examine the conditions under which the split-up of Gazprom is economically efficient for Russia. Assuming that Russian national welfare is a main concern of the Russian government, this paper carries out theoretical and numerical analysis to study whether the split-up of Gazprom is beneficial for Russia when the Russian domestic market is deregulated. In its concern for national

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[1] In 2005, the Russian government increased its stake in Gazprom from 38% to 51%.

welfare, it is assumed that the government ignores the effect of the breakup on foreign firms and consumers, and cares only about the domestic consumer surplus and the profit earned by national firms in domestic and export markets. In the industrial organization literature, national welfare is often used when changes in an industry, which is involved in international trade, are analyzed (e.g., Barros and Cabral (1994), Zhang and Chen (2002), Clougherty (2002)).

I consider a hypothetical long-run equilibrium for the base year of 2005 and compare the *reference case,* which describes the situation where Gazprom is not split up, with the case where Gazprom is split up and new gas-producing companies compete independently with each other in two markets for Russian gas: the domestic gas market and the European gas market. I assume Cournot competition in both the domestic and European gas markets before and after the restructuring of Gazprom. Before and after the restructuring, Gazprom's competitors in the domestic market are Russian independent gas producers, and in the European market, they are importers from other gas-producing countries.

Gazprom today is the only Russian company that can export gas to Europe. Splitting up Gazprom into several smaller competitors will affect the export structure of the Russian gas market. In the debate on Gazprom's restructuring, two main variants of the future structure of gas exports were considered. The first is the centralized sale of Russian gas to Europe through one channel. The second is competition among several Russian exporters. I concentrate my analysis on the second variant; that is, I look at the restructuring reform that allows companies detached from Gazprom to compete with each other on the European gas market. Given the ongoing liberalization of the European gas market, focus on the reform that opens competition on the Russian export side is especially important for assessment of the conditions under which Gazprom's split-up is attractive for both Russia and the EU. However, it should be stressed that I assume that after the split-up, only companies detached from Gazprom can export, while independent gas producers still cannot export and sell to the domestic consumers only. While Tsygankova (2007) analyzes how Russian national welfare is affected if independent producers are allowed to compete with Gazprom on the European market, this study concentrates on the split-up of Gazprom.

There are a number of studies that explore the quantitative relation between the Cournot-equilibrium price, the number of producing firms in the market, the profit of the producers, and national welfare. For example, Andersson and Bergman (1995) analyze numerically how a split-up of Swedish electricity-producing company Vattenfall into two separate and independently managed firms will change Swedish national welfare. The numerical model of Golombek et al. (1998) illustrates that a split-up of a single Norwegian gas exporter to the European market into two independent exporters might benefit Norway.

In the theoretical literature, there are a number of articles that look at a Cournot oligopoly where all firms can simultaneously create independent divisions (see Baye et al. (1996), Gonzalez-Maestre (2000), Corchon and Gonzalez-Maestre (2000)). However, the theoretical literature that analyzes the oligopolistic market where only one firm splits up into independent divisions, with the exception of Polasky (1992), is rare. On the other side, the split-up of a company can be considered as the opposite of a merger of several independent companies. The impact of horizontal mergers on profit and welfare is thoroughly studied in the literature. The literature on horizontal mergers provides a theoretical base for the results of this paper.

Theoretical analysis of horizontal mergers consistently suggests that in the Cournot market, the aggregate market share of the firms involved in the merger is the main determinant of merger profitability (see Salant et al. (1983), Levin (1990), Cheung (1992), Fauli-Oller (1997), Hennessy (2000)). Applying these findings to split-ups, the profit that a company involved in a split-up earns is more likely to increase after the split-up the higher is the market share of the other companies in the market not involved in the split-up. The intuition here is that the companies not involved in the split-up respond to the split-up by reducing their supply and therefore prevent the market price from falling significantly. Therefore, the market share of non-Russian gas suppliers to Europe might be an important determinant for the decision about Gazprom's restructuring.

Farrell and Shapiro (1990) analyze horizontal mergers in Cournot oligopoly and provide a sufficient condition for profitable mergers to increase welfare in a closed economy. For the case of split-ups, Farrell and Shapiro's result would require that in order for the split-up to be welfare enhancing, the market share of nonsplitting rivals has to be relatively small. Supply of non-Gazprom production to the domestic Russian market is small. Therefore, if the export profits that Russia earns on the European gas market are small, it can be expected that restructuring of Gazprom will increase Russian national welfare.

As split-ups are given far less attention in the theoretical literature than horizontal mergers, I find it to be a useful exercise to set up a theoretical model that focuses on the split-up of a company that is an oligopolistic producer in both the domestic and export markets. In the theoretical literature on mergers and divisionalization, companies in a market are often assumed to have the same marginal costs. This is a strong simplification, especially for the gas market. Costs of different gas producers normally differ because they supply gas from gas fields that vary in size, depth of gas deposits and transportation distance to consumers. Then, in my theoretical analyses, I weaken this assumption, allowing differences in costs between splitting and nonsplitting companies.

The paper is organized as follows. Section 2 develops a theoretical model that is used to examine how profit and welfare are affected if a firm in an oligopolistic industry is split up. Section 3 presents some central data required for the numerical calibration. Section 4 explores the impact of splitting up Gazprom. Section 5 numerically examines the dependence between Gazprom's markets shares and changes in Russian national welfare because of the restructuring reform. Section 6 examines the sensitivity of the numerical result to demand elasticity parameters. Finally, Section 7 concludes the discussion.

2. Theoretical Model

The focus of the theoretical analysis below is the effect of split-ups on the national welfare of an economy, where the firm involved in the split-up competes Cournot-style in both the domestic and export markets. The national welfare of such an economy consists of two components: domestic and foreign. The domestic component is the change in domestic welfare, which is the sum of consumer surplus and profits earned on the domestic market. The foreign component is the change in the national profits earned on the foreign market.

It is mathematically cumbersome to analyze theoretically the effect of a split-up on national welfare for general demand and cost functions. Therefore, for simplicity, in the theoretical model, I assume linear demand and constant marginal costs. The effects that a split-up has on the domestic component and on the foreign component are independent when the splitting firm has constant marginal costs. I analyze separately the split-up's effect on profit and welfare in a closed economy. At the end of this section, I examine the effects of split-ups on welfare and profit together, and analyze conditions under which the split-up of a firm that both sells domestically and exports can enhance national welfare.

2.1 Basic model

Consider a Cournot industry where all firms sell their homogeneous output at the market price, P. The inverse demand function is $P(Y) \equiv a - bY$, where Y is total industry output. In a set of $n+1$ firms, one firm is reformed. After the reform, production of this firm is split up, and m new independent firms are created. There are $n+m$ firms after the reform. For convenience, I will refer to the subset of firms involved in the split-up as *splitters* and to the subset of firms not involved in the split-up as *nonsplitters*.

Let Y^S denote the splitters' aggregate production. Before the reform, Y^S is the supply of the splitting firm, and after the reform, it is the sum of supplies of the m firms established after the split-up. Y^{NS}

denotes the nonsplitters' aggregate output, which is the sum of supplies from the n firms that are not involved in the split-up.

The cost advantages often give incentives for smaller firms to operate under a larger company. On the other hand, larger companies are typically complex organizations, and additional resources are required to coordinate their production. The larger companies often have fewer incentives to minimize their costs. In this analysis, however, I disregard any cost effects because of the split-up. For simplicity, I assume that all firms have constant marginal costs. Let C^S be the marginal cost of the splitting firm. I assume that the marginal cost of each new firm established after the split-up remains C^S. Let all nonsplitters have the same marginal cost C^{NS}.

In Cournot equilibrium, prereform aggregate supplies of splitters and nonsplitters are characterized by the following conditions:

(1)
$$-bY_1^S + a - b\left(Y_1^S + Y_1^{NS}\right) - C^S = 0,$$

(2)
$$-b\frac{Y_1^{NS}}{n} + a - b\left(Y_1^S + Y_1^{NS}\right) - C^{NS} = 0.$$

The subscript "1" in (1) and (2) denotes the equilibrium outputs that firms choose before the reform. Equation (1) is the first-order condition for the splitting firm. Equation (2) is the sum of the first-order conditions for all nonsplitters divided by the number of nonsplitters n, where the first-order condition of nonsplitter j is:

(3)
$$-by_j + a - b\left(Y^S + Y^{NS}\right) - C^{NS} = 0,$$

where $Y^{NS} = \sum_{j=1\ldots n} y_j$.

The conditions for aggregate supply from splitters and nonsplitters after the restructuring reform are:

(4)
$$-b\frac{Y_2^S}{m} + a - b\left(Y_2^S + Y_2^{NS}\right) - C^S = 0,$$

(5)
$$-b\frac{Y_2^{NS}}{n} + a - b\left(Y_2^S + Y_2^{NS}\right) - C^{NS} = 0.$$

The subscript "2" in (4) and (5) denotes the equilibrium outputs that firms choose after the reform. Equation (4) is the sum of the first-order conditions for each new firm established after the split-up

and divided by the number of these firms *m*. Equation (5) is the sum of the first-order conditions for all nonsplitters divided by the number of nonsplitters *n*.

In the Cournot market, the splitters' aggregate production as well as the total industry production will expand after the restructuring reform. This and other important comparative-statics properties, which are useful for this analysis, are formulated in *Proposition 1* (proved in Appendix).

Proposition 1

*If in a Cournot market a larger firm splits up into **m** smaller independent firms, then:*

(i) aggregate output of the splitters will increase, i.e., $Y_2^S \geq Y_1^S$;

(ii) aggregate output of the nonsplitters will decrease, but by less, i.e., $Y_1^{NS} \geq Y_2^{NS}$ and $Y_2 \geq Y_1$;

*(iii) splitters' prereform output decreases and nonsplitters' prereform output increases as the number of nonsplitters **n** increases, i.e., $\dfrac{\partial Y_1^S}{\partial n} < 0$ and $\dfrac{\partial Y_1^{NS}}{\partial n} > 0$;*

*(iv) splitters' post reform output increases as the number of new independent firms **m** increases, i.e., $\dfrac{\partial Y_2^S}{\partial m} > 0$.*

Proposition 1 (i) and (*ii*) simply specify the changes in equilibrium outputs after the split-up in a Cournot setting. The increase in equilibrium output of splitters implies a decrease in the equilibrium output of nonsplitters and, therefore, a respective change in market shares of splitters and nonsplitters. Therefore, *Proposition 1 (iii)* indicates how allocation of markets shares in a Cournot market is tied to the numbers of nonsplitters. The larger the number of nonsplitters in the market, the smaller is the market share of the splitters. Finally, *Proposition 1 (iv)* indicates that the larger the number of new companies established after the split-up reform, the more affected is the initial equilibrium.

2.2 Effect of split-up on profit

The following proposition (see proof in Appendix) establishes conditions under which a split-up can increase or decrease splitters' profit.

Proposition 2

*Assume a Cournot oligopoly with **n+1** firms, with a linear demand function, and firms have constant marginal costs. One firm is considering splitting into **m** independent firms. S_1^S is the prereform market share of the firm. Then:*

(i)   if $n+1 > \sqrt{m}$ and $S_1^S < \dfrac{\sqrt{m}}{m - \sqrt{m} + 1}$, then the split-up will increase the splitters' profits;

(ii) if $n+1 > \sqrt{m}$ and $S_1^S \geq \dfrac{\sqrt{m}}{m - \sqrt{m} + 1}$, then the split-up will decrease the splitters' profits;

(iii) if $n+1 \leq \sqrt{m}$, then the split-up will not increase the splitters' profits.

Proposition 2 shows that the prereform market share of the splitting firm is an important indication of whether the split-up is profit enhancing or not. Given that $n+1 > \sqrt{m}$, if the market share of the splitting firm is relatively low, then the split-up is profitable; conversely, for a large market share, the split-up will generate losses. On the other hand, *Proposition 2 (iii)* says that given $n+1 \leq \sqrt{m}$, a split-up is unprofitable irrespective of the market share of the splitting firm. However, according to *Proposition 1 (iii)*, the number of nonsplitters *n* affects the market share of the splitters. The smaller is *n,* the larger is the splitters' market share. Indeed, $n+1 \leq \sqrt{m}$ requires quite a small number of nonsplitters or a very large number of firms established after the split-up. For example, when the splitting firm is divided into *m = 4* firms, *n* has to be zero in order for the inequality above to hold. If the splitting firm is a monopolist and $n = 0$, the market share of the splitters S_1^S is equal to one, and the splitters' profits are always lower after the split-up.

Proposition 2 shows that *m* is also an important indicator of the profitability of the split-up. As *m* increases, $\dfrac{\sqrt{m}}{m - \sqrt{m} + 1}$ decreases. Therefore, the larger is the number of newly established firms *m,* the smaller the market share S_1^S of the splitting firm must be in order for the split-up to be profit enhancing. Therefore, downsizing of a split-up reform, which is unprofitable for splitters, might become profitable.

The discussion above suggests that a high prereform market share of splitters will generate profit losses for splitters from the split-up, while a low prereform market share of splitters will generate profit gains. This result occurs because of the equilibrium response of firms outside of the split up. Indeed, as is well known, the profit earned by a monopolist is always higher than the joint profit of several companies competing in this market because of the split-up of a monopoly. However, the situation can change if the company that is split up is not a single supplier in the market. That is, there are both splitters and nonsplitters. If nonsplitters do not change their supply after the split-up, then clearly the profit of the splitters will decrease. However, in the equilibrium, in response to an increase in supply from the splitter, the nonsplitters should reduce their production. The market price will be

higher than in the situation where nonsplitters do not respond. Therefore, the profit of the splitters will be at least as high as in the situation where the nonsplitters do not respond. In the equilibrium, the large market share of the nonsplitters results in a large reduction in supply from nonsplitters when the splitters are split up. Thus, when the market share of splitters is low, the split-up will have a positive effect on the profit of the splitters.

2.3 Effect of the split-up on welfare

The following proposition (see proof in Appendix) establishes the sufficient conditions for the split-up to be welfare increasing and welfare decreasing.

Proposition 3

*Assume a Cournot oligopoly with **n+1** firms, with a linear demand function, and firms have constant marginal costs. One firm is considering splitting up into **m** independent firms. S_1^S is the prereform market share of the firm.*

(i) If $S_1^S > \dfrac{1}{n+1}$, then the split-up increases welfare. The larger is m, the greater is the increase in welfare.

(ii) If $S_1^S < \dfrac{1}{n+2}$, then the split-up decreases welfare. The larger is m, the greater is the decrease in welfare.

As is well known, increased competition will increase welfare. However, this is not always true when the market share of the splitting firm is small. *Proposition 3* says that the splitting company has to be more efficient than nonsplitters for the split-up to increase welfare. When the splitting company is quite inefficient, this is reflected in its very low market share. Then the split-up of a low-efficiency company results in some efficient production being substituted by inefficient production. Such reallocation of output can adversely affect welfare.

2.4 Effect of split-up on national welfare

In Sections 2.2 and 2.3, I assumed a closed economy and analyzed the effect of a split-up on profit and welfare. Now consider an economy where splitters can export to a foreign market. Otherwise, the economy is closed to import from abroad, and nonsplitters cannot export. Then, the national welfare, W^N, consists of domestic welfare, W^D, plus splitters' export profit, $\pi^{S\,export}$. The changes in national welfare because of the split-up can then be written as:

$$\Delta W^N = \Delta W^D + \Delta \pi^{S\,\text{export}}.$$

Two effects determine the sign of the split-up effect on national welfare: the effect on domestic welfare and the effect on export profit. The split-up will not enhance national welfare when at least one of the effects is negative and outweighs another. If the split-up increases domestic welfare but at the same time has a strong negative effect on export profits, then the split-up might not be beneficial for the national economy.

The prereform market shares of the splitting firm in each market can be important information for predicting whether the proposed restructuring will be positive for the economy. *Proposition 2* suggests that for a low prereform share of the splitting company in the foreign market, the split-up will have a positive effect on the export profit earned by the economy. On the other hand, according to *Proposition 3*, the small market share of the splitter in the domestic market can have a negative effect on domestic welfare.

Table 1: Impact of market share size on national welfare

	Domestic market Effect on ΔW^D	Foreign market Effect on $\Delta \pi^{S\,\text{export}}$
Small market share	—	+
Large market share	+	—

Table 1 illustrates how the combination of market shares that the splitting company has in two markets might contribute to changes in national welfare after the split-up. In the table, a negative sign indicates a negative effect, and a positive sign indicates a positive effect on the respective component of national welfare. As Table 1 shows, a large domestic market share and a small foreign market share is the only combination of market shares that will generate with certainty an increase in national welfare after the split-up. Conversely, if the splitting firm dominates in the foreign market and does not control much of the domestic market, then a split-up will not produce any gains for the economy. The effect on national welfare in the cases where the splitting firm dominates both the domestic and foreign markets, or has small shares in both markets, is unclear. In these cases, a trade-off between domestic welfare and export profit will determine whether the split-up is welfare enhancing.

3. Numerical Model

The theoretical model above formally discusses conditions under which a split-up of a company that is a big supplier on both the domestic and export markets might increase national welfare. Although the model provides key insights for the basic mechanisms, the results are for general to suggest anything about the welfare effects on an actual split up. This motivates the numerical model presented in this section. In the numerical model, Gazprom allocates its production between two markets: the domestic Russian gas market and the European gas market. The model assumes an oligopolistic market structure in both Russia and Europe, and the equilibrium concept is Cournot in both markets. The starting point of the numerical model is a *reference case*, which describes the situation where Gazprom is not restructured. The *reference case* and the calibrations are based on assumptions similar to those in Tsygankova (2007) and are explained in more detail in the subsections below.

3.1 Two gas markets

Generally speaking, Russian natural gas is consumed in two markets: the domestic Russian gas market and the European gas market. In 2005, Russia supplied natural gas to practically all countries in Europe that were net importers of natural gas, including not only current EU countries but also countries in the Commonwealth Independent States (CIS). While Gazprom sells its gas at market prices to Western European countries, prices for Russian gas in the CIS and some Eastern European countries are still set lower by bilateral agreements. However, EU enlargement and the Russian–Ukrainian conflict on gas prices that raged in January 2006 indicate a movement towards market pricing throughout all of Europe in the long run. Therefore, the focus of the model is restricted to consumption in two regions: Europe and Russia.

3.2 Demand

For the calibration of natural gas demand in Europe and Russia, I use 2005 data for gas prices and consumption levels (see BP (2006)). There is, in general, little consensus in the literature about the price and income elasticities in energy markets, and estimates of elasticities for Russia are almost nonexistent. In the survey by Al-Sahlawi (1989) on price and income elasticities of natural gas demand, long-run price elasticities range from –0.56 to –4.6. Because of the lack of definitive evidence, I have chosen a value for the price elasticity of natural gas demand in Europe of –0.7. This is in line with other studies that model the European gas market (e.g., Golombek et al., 1995).

The only known estimates of elasticities for Russia are found in the econometric study by Solodnikova (2003). She finds no significant link between natural gas consumption in Russia and the price of gas. The result can be partly explained by low natural gas tariffs relative to other energy sources. As natural gas remains the cheapest energy source in Russia, a price change may not have a notable effect

on consumer behavior. In addition, the Russian energy infrastructure was built during the Soviet planned-economy era and allowed few substitution possibilities between energy alternatives; therefore, consumers still often have to rely on one energy source. Nevertheless, some studies use a price elasticity of around –0.5 for natural gas demand in Russia (see, e.g., Holtsmark and Mæstad (2002) and Tarr and Thomson (2004)). Assuming that future domestic market reforms will bring on more substitution with other energy sources, so that consumer response to gas price variations will be larger than zero, I choose a price demand elasticity in Russia of –0.4, which lies between the results of Solodnikova and the latter studies.

3.3 Gas producers

In 2005, besides Gazprom, the supply of natural gas to Europe consisted partly of imports from five companies in other major gas-producing countries (two Norwegian companies, Statoil and Norsk Hydro[2]; the Dutch Gasunie; the Algerian Sonatrach; and the Nigerian National Petroleum Corporation) and partly of indigenous European gas production. In the model, Gazprom and the five foreign companies choose their quantities to supply to Europe under Cournot competition. Indigenous European gas production, which was 172 bcm in 2005 (BP, 2006), is assumed to be exogenous to the model. The exogeneity assumption is a simplification but can be justified on the grounds that in order to mitigate their strong dependence on importing natural gas, most European countries with their own gas production capabilities produce at their production capacities regardless of the gas price.

In the Russian domestic market, Gazprom competes with Russian independent producers. By the end of 2005, after several acquisitions and mergers in the Russian petroleum sector, four oil companies (Surgutneftegaz, Rosneft, TNK-BP and Lukoil) and two small gas companies (Novatek and Itera) were responsible for practically all non-Gazprom gas production in Russia. In the empirical model, these six independent gas producers, Gazprom and a single supplier from Turkmenistan independently compete with each other à la Cournot. Gazprom currently buys Turkmen gas under long-term contracts and resells it to Russian and CIS consumers. However, if the Russian gas market is deregulated, as is assumed in the model, imported gas from Turkmenistan has to be sold directly to the market in order to add to competition.

3.4 Production and transportation costs

The estimates of costs for Russian and non-Russian gas producers are mainly based on the data by OME (2001), which provide estimates of average production costs and transportation costs of natural gas to Europe by major gas-producing area for the period 2010–2020. Natural gas delivery to a

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[2] In October 2007 Statoil and NorskHydro merged and the new company StatoilHydro was established.

consumption market depends on the extraction conditions in particular producing areas as well as on the remoteness of production from the market. In addition, the production capacities of the fields under operation are limited. Combining information on the production capacity of the gas fields under operation in the base year 2005 and OME estimates of production costs, I use the piecewise production cost function for each gas producer in the model.

For estimates of Russian gas transportation costs I use OME's data that report unit transportation costs from production regions in Russia to the Russian border with Ukraine. The transportation costs depend on the length of the transportation route. As Russian consumers are located closer to production regions than European consumers, the gas transportation costs to Russian consumers are adjusted by the average distance to the domestic market. Therefore, transportation costs differ between regions of production (Nadym Pur Taz, Orenburg, Astrahan and Yamal) and between domestic and export markets. The transportation costs to Europe are also increased by a transit tariff that Russia has to pay in order to pipe gas through Ukraine. The total transportation costs is estimated at US$17,84 per $1000m^3$.[3]

4. Breaking up Gazprom's Monopoly

If restructuring reform in the Russian gas industry occurs and Gazprom's production and exports are split up into several companies, the market outcomes will change. In order to answer the question of whether the breaking up of Gazprom will benefit Russia , I now focus on a Nash–Cournot equilibrium where Gazprom's regional producing subsidiaries noncooperatively compete with each other in both the domestic and export markets.

Currently Gazprom's gas production is mainly concentrated in the monopolist's six subsidiaries: Astrakhangazprom, Nadymgazprom, Orenburggazprom, Noyabrskgazodobycha, Urengoygazprom, Yamburggazodobycha (Stern, 2005). The division into producing subsidiaries, which have been built around the giant gas fields discovered in the 1960s–70s, is mainly regionally based. The idea of creating competition in the Russian gas industry was high on the agenda during 1997–2003. Reorganizing Gazprom's production subsidiaries into independent producing companies was the natural way to break up the monopoly (MEDT, 2003). If the production separation of Gazprom ever takes place, it remains to be seen how Gazprom's assets will be allocated. To assess the long-run effects of Gazprom's production unbundling from the current production structure, we first consider

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[3] In January 2006, the tariff for transit of Russian gas through Ukraine became US$1,6 per $1000m^3$ per 100 km. The distance from the Russian–Ukrainian border to Uzhgorod, a town in Ukraine located in the west near the border with Slovakia, is 1115 km (OME, 2001). Therefore the total transportation costs through Ukraine can be estimated at US$17,84 per1000 m^3.

splitting into these six subsidiaries. In Section 5, alternative ways of dividing Gazprom are also discussed.

Table 2. Breaking up the natural gas export monopoly in Russia

	Reference case		Gazprom is split up by subsidiaries	
Price in Europe for natural gas ($/1000 m^3)	*193*		*149*	
Total supply to European market (bcm)	650		824	
which is divided between:				
Gazprom	221	(34%)*	404	(49%)
non-Russian producers	429	(66%)	420	(51%)
Price in Russia for natural gas ($/1000 m^3)	*133*		*80*	
Total supply to Russian market (bcm)	243		297	
which is divided between:				
by Gazprom (percent)	63	(26%)	148.5	(50%)
by Independent gas producer (percent)	180	(74%)	148.5	(50%)

Note:* In parenthesis markets shares are reported.

Table 2 shows that after the restructuring reform occurs, Russian gas supply is increased in both the domestic and export markets. Increased competition will force independent producers to reduce their production. On the other hand, the joint supply to the domestic market from Gazprom's former companies more than doubles in the model. Similar changes occur in the European gas market. As supply from non-Russian producers is reduced, the overall supply to Europe increases because of an almost doubling of supply from Gazprom's companies.

The *reference case* and the split-up case model the situation when gas prices in Russia are unregulated. The results in Table 2 point out that Gazprom's presence in the Russian gas market can be significantly reduced if Russian gas prices are deregulated. Indeed, in the *reference case*, Gazprom's domestic market share is 26%, while Gazprom's observed market share in 2005 was about 76% (Gazprom, 2006). This is because in the deregulated market, domestic prices are considerably higher than prices in 2005, which are regulated. Therefore, independent producers get additional incentives to develop their gas resources. In addition, in the deregulated market, Gazprom is no longer forced to deliver large volumes of gas at low prices. Gazprom can then behave as a profit maximizer and will considerably reduce its domestic supply compared with the actual situation in 2005. On the other hand, the results in Table 2 show that gas price deregulation in Russian will not significantly affect Gazprom's position in Europe. In Europe, Gazprom's market share in the *reference case* and

that actually observed in 2005 are practically the same: 34% versus 35% (the latter is calculated from BP (2006) and Gazprom (2006)).

Table 3 summarizes how Russian producers' profit, Russian consumers' surplus and Russian national welfare are affected by the restructuring reform.

Table 3. **Division of Gazprom: Changes in Russian producers' profit, Russian consumers' surplus and Russian national welfare**

	Gazprom's export profit	Gazprom's domestic profit	Independents' profit	Consumer surplus	National welfare
Change in $b	–2.73	–2.51	–9.84	13.92	–1.17

The restructuring of Gazprom and increased competition in the domestic market will decrease the domestic price from $133/1000 m^3 to $80/1000 m^3, and as a result, consumer surplus will increase by $13.92 billion. However, the increase in consumer surplus will not cover the losses in profit for Russian producers. The reduction in the profit of independent producers is obvious. As the supply from Gazprom's subsidiaries increases, the independent producers' response is withdrawal of some of their production from the domestic market. Thus, in the new equilibrium, independent producers sell a lower volume of gas at a lower price, and their profit is reduced. The effect of Gazprom's restructuring on the overall profit of Gazprom is also negative in both markets.

It should be noted that besides the price effect, there is also a cost effect that contributes to Gazprom's reduced profit because of the split-up. Before the split-up, Gazprom can rationalize gas production between its subsidiaries and therefore minimize costs. After the split-up, each subsidiary produces independently and cannot rationalize production. The calculation of the model shows that Gazprom's average cost of production per 1000 m^3 of natural gas increases from $43 to $46 because of the split-up.

National welfare is defined as the surplus of Russian consumers plus the surplus of Russian producers. According to Table 3, Gazprom's split-up decreases Russian national welfare as the losses in producers' surplus outweigh the gains in consumers' surplus. Thus, numerical results indicate that given the national welfare criteria the split-up of Gazprom is unattractive.

It is important to note that the conclusion about the unattractiveness of Gazprom's restructuring is based on the assumption that the government weights the surplus of all market participants equally when it measures national welfare. However, if the government decision is affected by the number of lobbying groups, then the government will put more weight on the surplus of market participants who represent groups with stronger lobbying power. Recent years witnessed the significant influence of

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Gazprom on the decision making of the Russian government. According to Table 3, Gazprom's profit is reduced in both domestic and export markets when the company is split up. Given the strong political influence of Gazprom, the numerical results reflect the fact that the government might refrain from splitting up Gazprom despite the high consumer gains that the restructuring reform can bring. Nevertheless, political influence is probably not a satisfactory argument if one wants to evaluate whether Gazprom's position in the Russia gas industry can be economically justified. Then the assessment criterion that simply sums up the gains and losses that the reform entails seems to be fair.

5. Other Scenarios

Table 3 shows that under market structure in Europe and Russia in 2005, Gazprom's restructuring reform decreases Russian national welfare. As discussions in Section 2 point out, the market shares that Gazprom controls in both the Russian and European gas markets are important indicators of the expediency of the restructuring reform. In this section, I illustrate numerically how Gazprom's restructuring reform affects Russian national welfare given changes in Gazprom's market shares.

5.1 Gazprom's market share in Europe

Gazprom's market share in Europe is determined by supplies to Europe from both Gazprom and non-Russian producers. Figure 2 below shows how Gazprom's market share in the European gas market affects the change in national welfare, Russian export profit and domestic welfare because of Gazprom's restructuring reform. Several runs of the numerical model, where production capacities for non-Russian gas exporters are changed in each run, simulate alteration in Gazprom's market share in Europe. In order to distinguish the export market share's impact on Russian national welfare, here I concentrate on the scenarios where only non-Russian production capacity varies, not Gazprom's.

Thus, Figure 2 imitates continuity of the scenarios for different production capacities of Gazprom's rivals on the European gas market. In Figure 2, scenarios where Gazprom has a lower market share in Europe reflect higher production capacities of non-Russian producers. According to Figure 2, Gazprom needs to control at least 33% of the European gas market to ensure that its split-up is not supported under the national welfare criteria. In the *reference case*, Gazprom's market share in Europe is 34%. The increase of non-Russian gas in the European market is necessary in order for Gazprom's restructuring reform to increase Russian national welfare.

Figure1: Welfare effects from Gazprom's split up for different Gazprom's market shares

Gazprom's pre-reform market share in European gas market
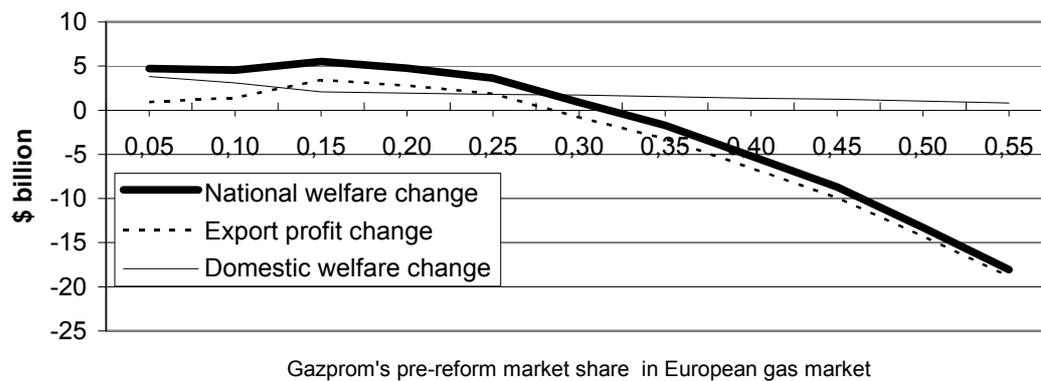
National welfare is the sum of domestic welfare and export profit. As Figure 2 shows, domestic gains from Gazprom's split-up are positive, but they diminish as Gazprom's position in Europe strengthens. This is because a higher market share in Europe means larger exports for Gazprom and therefore less supply to the domestic market. Gazprom's market power in the domestic market is then reduced, and the positive domestic gains from restructuring are mitigated.

Changes in export profits because of restructuring reform are positive when Gazprom has small market shares in Europe, and they are negative when Gazprom's market share is large. When Gazprom has almost no market power in Europe, increases in Russian exports because of reform have little impact on price in Europe. Therefore, an increase in exports drives Russian export profits up. In Figure 2, if Gazprom controls no more than 15% of the European market, reform generates even larger export profits as Gazprom's market share increases. This is because the larger is the market share of Gazprom, the stronger is Gazprom's export growth because of reform, and at the same time, the price response to Gazprom's restructuring is low when Gazprom's market share in Europe is low. When Gazprom controls more than 15%, export gains from the reform start to fall. This is because the price response to greater Russian exports gets stronger.

Given the allocation of gas assets in Russia in the base year 2005, Figure 1 depicts the dependence of Russian national welfare on the European gas supply of Gazprom's rivals. However, doubtless conditions in the Russian gas industry will differ from the base year when, if ever, serious evaluation of the Gazprom restructuring takes place. As the theoretical results point out, it is the combination of Gazprom's market share in both domestic and export markets that determines the overall effect of restructuring reform on national welfare. Therefore, if Gazprom's market power in Europe falls

because of growth in LNG trade, the simultaneous increase in supply from independent producers might still make Gazprom's restructuring unprofitable.

Figure 2 plots the dependence of national welfare on Gazprom's export market share for two different scenarios: lower and higher Gazprom market shares in the domestic gas market. Both scenarios reflect current trends in the development of the Russian gas market.

The first scenario is where Gazprom's domestic share is increased. In this scenario, Gazprom offsets declining own production by acquiring gas assets from independent producers Novatek and Itera. Indeed, in recent years, Gazprom gradually started to acquire control over the independent producers' gas production assets. In 2006, Gazprom bought 20% of Novatek and acquired control over Itera's main producing fields.

On the other hand, in the second scenario, Gazprom's domestic share is reduced. This scenario reflects the ambitions of oil companies to increase their gas production. Both Rosneft and Lukoil stated on several occasions that they have potential to increase their gas production if they receive full access to transportation networks.

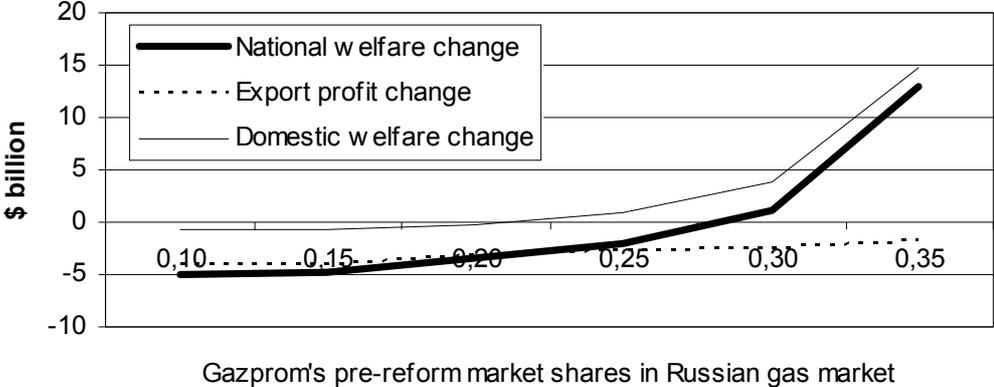Figure 2:Change in national welfare for different domestic Scenarios
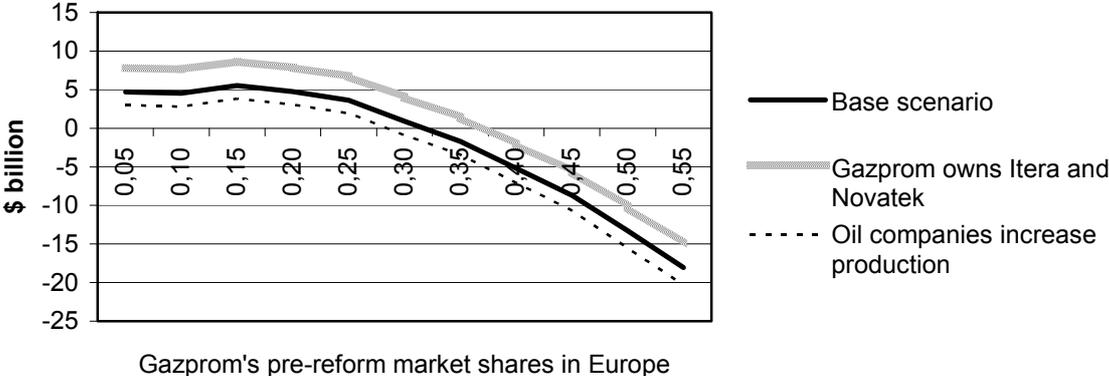
Obviously Gazprom's market shares increase if independent producers are acquired by Gazprom. Then the split-up of the enlarged Gazprom will generate additional gains in the Russian domestic market. In this case, Gazprom has to control a larger share of the European market in order to justify its dominance in both markets. A smaller share for Gazprom in the domestic market has the opposite effect on the change in national welfare. The gains from Gazprom's split-up will be lower, and Europe has to attract more gas from other suppliers if they want Gazprom to be split up.

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Figure 2 illustrates that Gazprom has to allow competition in the domestic market if it wants to defend the efficiency of its current structure. The greater the competition Gazprom faces in the export market, the more important for Gazprom is the presence of independent producers in the Russian market. If the impact of reform on national welfare is a criterion that determines whether Gazprom will maintain its integrity in the future, Gazprom's efforts to prevent export from independent producers can be explained. Indeed, the opening of gas export markets for other Russian gas suppliers will withdraw some of the non-Gazprom supply from the domestic market to export markets. As a result, Gazprom's domestic market share increases while the market share in Europe decreases. Both these changes will contribute to larger gains if Gazprom is split up, and will make Gazprom's reform more attractive.

5.2 Gazprom's market share in Russia

Figure 3 below illustrates the dependence of changes in Russian national welfare on Gazprom's domestic market share. Several runs of the numerical model, where production capacities for Russian independent gas producers differ in each run, simulate changes in Gazprom's market share in Russia. Figure 3 assumes continuity of the scenarios for different production capacities of Russian independent gas suppliers.

Figure3: Welfare effect of Gazprom's split up for different Gazprom's market share in Russia

Gazprom's pre-reform market shares in Russian gas market

Change in national welfare generated by Gazprom's restructuring is growing as production by independent producers decreases, and therefore Gazprom's domestic market share grows. However, according to simulations in Figure 4, Gazprom has to control at least 28% of the domestic market in order for the split-up reform to be welfare enhancing. The negative effect of reform on Russian export profit reflects the fact that national welfare decreases for a low market share for Gazprom in the domestic market. For a higher market share in the domestic market, the reform will generate increases in Russian national welfare.

Figure 3 depicts the effect on Russian national welfare of Gazprom's split-up, and changes in Gazprom's market share in the Russian market given the European market structure in the base year 2005. The rapid development of LNG technology and annual growth of gas supply from new exporters is evidence that the structure of the European gas market is changing. In Figure 4, I add plots for two scenarios. In the first scenario, Gazprom's market share in Europe is reduced. This scenario reflects expected growth of LNG in Europe and assumes the immediate entrance of several new gas exporters such as Qatar, Iran, Egypt and Libya. The merger of two Norwegian gas exporters, NorskHydro and Statoil, in October 2007, reflects the second scenario. The merger of Norwegian petroleum companies might increase Gazprom's market share in Europe.

Figure 4: Change in national welfare for different European scenarios
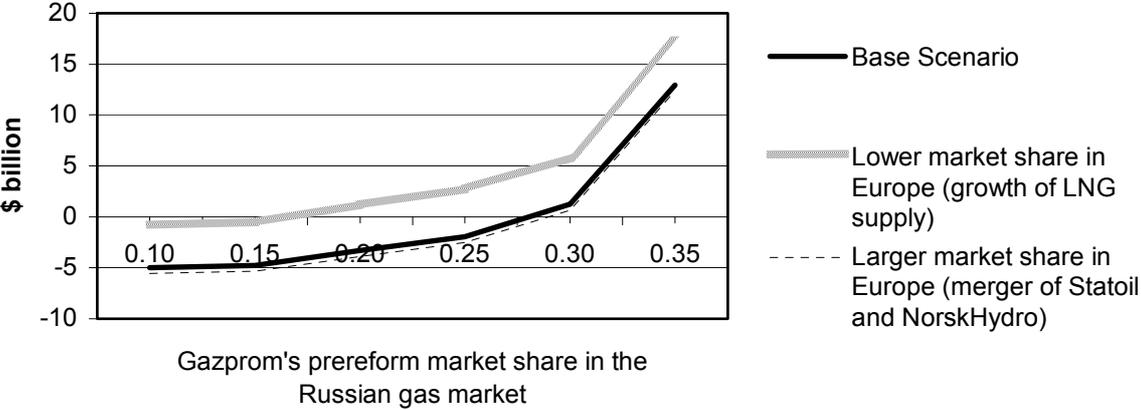
The entrance of LNG suppliers into Europe will increase the Russian gains from Gazprom's restructuring. If all LNG projects that are currently proposed are able to commence production, the attractiveness of Gazprom's restructuring is virtually unquestionable. Only if Gazprom controls less than 17% of the domestic market might the Russian economy face a decrease in national welfare, but the decrease is rather insignificant.

As Figure 4 shows, the impact of a merger between Statoil and NorskHydro on Russian national welfare is small. The low share, 12%, of Norwegian gas in the European gas market means that the merger does not significantly affect the European gas market. Nevertheless, the merger of Norwegian gas producers gives Gazprom additional arguments for defending a restructure, because the merger will decrease the national welfare.

5.3 Alternative split-up of Gazprom

A split-up of Gazprom into subsidiaries was the reform option that received the most attention when gas restructuring reform was discussed in early 2000s. Nevertheless, if Gazprom's restructuring ever happens, the division into subsidiaries is not the only straightforward way to restructure Gazprom. Table 4 shows that the split-up of Gazprom into two companies instead of six will actually increase Russian welfare. Alternatively, if property rights for each Russian gas field belong to different private firms, national welfare will be even lower compared with a split-up into subsidiaries.

Table 4: Effects of the Gazprom's restructuring for different split-up alternatives

	Gazprom is split up by subsidiaries		Gazprom is split up into two companies		Gazprom is split up by fields	
Price in Europe on natural gas ($/1000 m³)	***149***		***169***		***145***	
Total supply to European market (bcm)	824		734		846	
which is divided between:						
Gazprom	404	(49%)*	308	(42%)	448	(53%)
non-Russian producers	420	(51%)	426	(58%)	398	(47%)
Price in Russia on natural gas ($/1000 m³)	***80***		***104***		***75***	
Total supply to Russian market (bcm)	297		268		306	
which is divided between:						
Gazprom	148.5	(50%)	94	(35%)	178	(58%)
non-Russian producers	148.5	(50%)	174	(65%)	128	(42%)
Export profit change (in $ billion)	–2.73		–0.41		–3.36	
Domestic welfare change ($ billion)	1.56		1.19		1.46	
National welfare change (in $ billion)	***–1.17***		***0.78***		***–1.90***	

Note:* In parenthesis markets shares are reported.

Table 4 shows that when Gazprom is split up into two companies instead of six, domestic gains from the restructuring reform are higher than reductions in export profit, and the overall effect of such a split-up is positive. A split-up of such a giant company as Gazprom into two independent companies means that each new company will still retain substantial market power in supply markets. The fall in price in both markets is not as large as if Gazprom were divided into subsidiaries, and therefore reductions in export profit are quite moderate. On the contrary, more drastic restructuring reform that splits Gazprom on the field base implies a strong fall in export prices and therefore larger reductions in Russian gas export profit. As a result, Gazprom's split-up on the field base lowers Russian national welfare more than if Gazprom were split up into subsidiaries.

Figure 5: Different restructuring scenarios

Gazprom's prereform market share in the European gas market
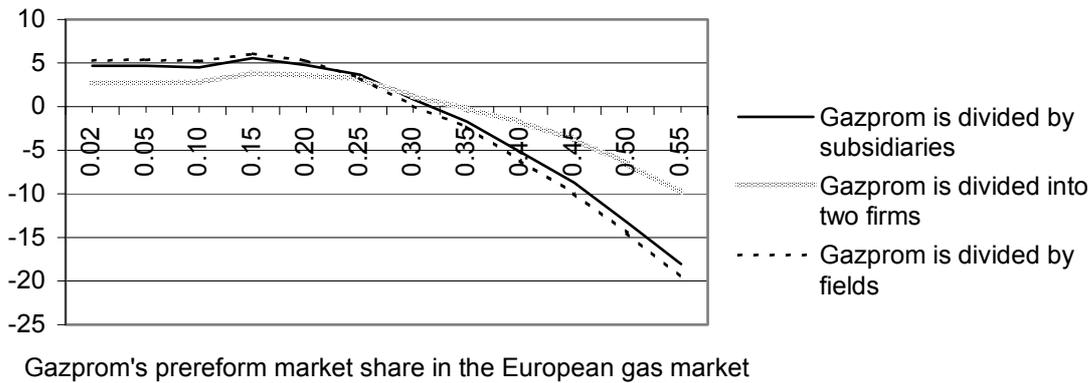
Both Table 4 and Figure 5 illustrate that the scope of the reform is important. In Figure 5, the changes in national welfare for three different reforms are plotted against Gazprom's market shares in Europe. Figure 5 shows that if Gazprom's market share in Europe is low, then a reform that splits up Gazprom into several companies generates more gains than a reform where Gazprom is divided into only two companies. However, when Gazprom's market share in Europe is large, moderate reform might generate larger gains. If restructuring brings decreases in national welfare, these decreases will be smaller than under strong reform.

6. Results' Sensitivity to Demand Price Elasticities

It is important to stress that conclusions about the negative effect of Gazprom's restructuring on Russian national welfare is based on the parameters chosen for the numerical model. The price elasticities of natural gas demand in Europe and in Russia are chosen to be –0.7 and –0.4 respectively. However, the uncertainty about the exact value of the elasticities can undermine the quantitative conclusions of the numerical model. Although calculation of the sensitivity of the results to different elasticities does not remove uncertainty, it can indicate how numerical results are dependent on the elasticity parameters.

Figure 6 shows how a split-up of Gazprom affects Russian national welfare when the elasticity parameters vary within the range –0.3 to –2 for the *base scenario*. The solid line in Figure 6 illustrates how Russian national welfare depends on the European price elasticity of demand. The dotted line in Figure 6 illustrates how Russian national welfare depends on the Russian price elasticity of demand.

Figure 6: Changes in national welfare for different values of the elasticity parameters

Change in Russian natioanal welfare (in $ billions)

Value of elasticity parameter

‑ ‑ ‑ Russian price elasticity of demand

—— European price elasticity of demand
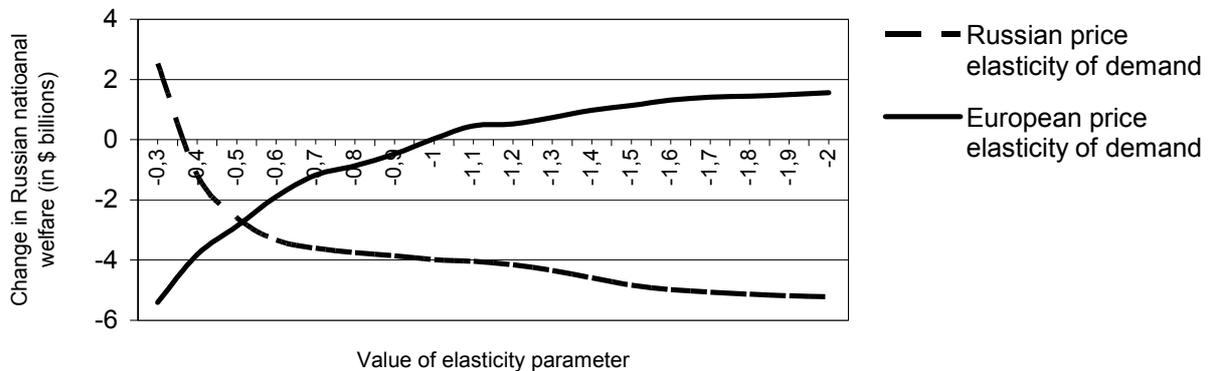
According to Figure 6, increases in the European price elasticity affect Russian national welfare positively, while increases in the Russian price elasticity affect Russian national welfare negatively. A split-up of Gazprom results in increased supply to both European and Russian markets. However, the more elastic a market, the smaller the price fall because of a supply increase in the market. The higher the elasticity of European demand, the lower the Russian export reductions. Therefore, the overall effect of the restructuring reform on national welfare might be positive given a more elastic European gas market. However, for a more elastic Russian domestic market, restructuring reform generates less growth in consumer surplus because the price fall is moderate in response to a supply increase. Then the more elastic the Russian gas market, the more negative the overall effect of the restructuring reform on national welfare.

Although the quantitative conclusion about the effect of Gazprom's restructuring on national welfare is primarily determined by elasticity parameters, under- or overestimating the elasticities in both markets will not necessarily change the qualitative conclusion about the unattractiveness of the Gazprom restructuring.

7. Conclusion

The aim of this paper is to explore the conditions that will support Gazprom's restructuring reform, as well as to study how splitting up Gazprom into several companies might affect the Russian and European gas markets. The paper argues analytically and by using numerical simulation that although the splitting up of Gazprom's production will benefit European and Russian consumers, such reform will not necessarily increase Russian national welfare. Gazprom's position in the European market and the trade-off between consumer's surplus and producer's profit influences the attractiveness of the

reform. In the absence of exports, the removal of Gazprom's dominant position in the Russian deregulated gas market would be beneficial for Russia. In the current situation, when Russia is the largest supplier of natural gas to the European market, the reductions in Russian export profit might outweigh the positive effects of reform in the domestic market.

Comparing different scenarios, the paper suggests that the market shares that Gazprom has in both the Russian domestic and European markets are important factors that determine whether Gazprom's restructuring will be beneficial for Russia. The small market share of Gazprom in Europe and the large market share of Gazprom in the domestic market is a combination that plausibly results in Russian national welfare increasing because of the restructuring of Gazprom.

The results of the paper have several important implications. First, for Gazprom, which opposes its restructuring reform, the presence of independent gas producers is important, especially if the development of the LNG market puts pressure on Gazprom in Europe. Second, increased competition from non-Russian gas suppliers in Europe might affect the restructuring of Gazprom and competition in the Russian gas market. Third, if Gazprom continues its acquisition of the gas assets of independent producers, which is occurring now in the Russian gas industry, then more aggressive behavior by Gazprom in the European gas market can be expected. Finally, the size of Gazprom's restructuring reform is an important factor that determines the attractiveness of the reform under the national welfare criteria.

It is important to stress that the results in this paper are based on a number of assumptions, especially deregulation of the Russian gas market and Cournot competition among producers in both the Russian and European gas markets. Therefore, this study cannot be used to predict future development of the supply side in the European gas market, which is characterized by long-term contracts, or the supply in the Russian gas market, which is characterized by strong government price regulation.

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Proof of Proposition 1

i)

Rearranging (1) and (2) yields:

$$(A1) \qquad P'\left(Y_1^S + Y_1^{NS}\right)Y_1^S + P\left(Y_1^S + Y_1^{NS}\right) = P'\left(Y_2^S + Y_2^{NS}\right)\frac{Y_2^S}{m} + P\left(Y_2^S + Y_2^{NS}\right).$$

(A1) equalizes splitters' marginal revenue before and after the split-up.

Assume that $Y_1^S > Y_2^S$.

According to the regularity condition $P''Y^S + P' + P' < 0$, the prereform marginal revenue of splitters $P'(Y^S + Y^{NS})Y^S + P(Y^S + Y^{NS})$ decreases with Y^S. It follows that the total marginal revenue of splitters decreases as Y^S decreases.

Then:

$$P'\left(Y_1^S + Y_1^{NS}\right)Y_1^S + P\left(Y_1^S + Y_1^{NS}\right) < P'\left(Y_2^S + Y_2^{NS}\right)Y_2^S + P\left(Y_2^S + Y_2^{NS}\right) < P'\left(Y_2^S + Y_2^{NS}\right)\frac{Y_2^S}{m} + P\left(Y_2^S + Y_2^{NS}\right).$$

The inequality above contradicts (A1).

ii)

A split-up increases the splitter's output. From (5), output Y^{NS} is unambiguously determined by output Y^S. Therefore, in order to prove that $Y_1^{NS} \geq Y_2^{NS}$ and $Y_2 \geq Y_1$, it is enough to show that

$$-1 < \frac{\partial Y^{NS}}{\partial Y^S} < 0.$$

Differentiating (2) with respect to Y^S yields:

$$(A2) \qquad \frac{\partial Y^{NS}}{\partial Y^S} = -\frac{n}{n+1}.$$

Therefore, $-1 < \dfrac{\partial Y^{NS}}{\partial Y^S} < 0$ and the aggregate output of nonsplitters decreases when the output of splitters increases. However, the decrease in nonsplitters' output is smaller than the increase in

splitters' production. Differentiating aggregate industry output $Y = Y^S + Y^{NS}(Y^S)$ with respect to Y^S, it easily follows that $0 < \dfrac{\partial Y}{\partial Y^S} < 1$.

(A3) $\qquad \dfrac{\partial Y}{\partial Y^S} = \dfrac{1}{n+1}$

iii)

Differentiating (1) and (2) with respect to *n* yields:

(A4) $\qquad \dfrac{\partial Y_1^S}{\partial n} = -\dfrac{Y_1^{NS}}{n(2+n)} < 0$,

(A5) $\qquad \dfrac{\partial Y_1^{NS}}{\partial n} = \dfrac{2Y_1^{NS}}{n(2+n)} > 0$.

iv)

Differentiating (4) and (5) with respect to *m* yields:

(A6) $\qquad \dfrac{\partial Y_2^S}{\partial m}\left(P''\dfrac{Y_2^S}{m} + P' + \dfrac{P'}{m} \right) + \dfrac{\partial Y_2^{NS}}{\partial m}\left(P''\dfrac{Y_2^S}{m} + P' \right) - \dfrac{P'Y_2^S}{m^2} = 0$,

(A7) $\qquad \dfrac{\partial Y_2^S}{\partial m}\left(P''\dfrac{Y_2^{NS}}{n} + P \right) + \dfrac{\partial Y_2^{NS}}{\partial m}\left(P''\dfrac{Y_2^{NS}}{n} + P' + \dfrac{P'}{n} \right) = 0$.

Solving system (A6)–(A7), it is straightforward to determine that an increase in *m* will affect the postreform splitters' output:

$$\dfrac{\partial Y_2^S}{\partial m}\left((1-\alpha)\left(P''\dfrac{Y_2^S}{m} + P' \right) + \dfrac{P'}{m} \right) = \dfrac{P'Y_2^S}{m^2},$$

where $0 < \alpha < 1$, $\alpha \equiv \dfrac{P''\dfrac{Y_2^{NS}}{n} + P'}{P''\dfrac{Y_2^{NS}}{n} + P' + \dfrac{P'}{n}}$.

According to the regularity condition, $P''\dfrac{Y_2^S}{m} + P' < 0$, and therefore $\dfrac{\partial Y_2^S}{\partial m} > 0$.

For the linear demand function $P(Y) = a - b\left(Y^S + Y^{NS} \right)$, we have:

$$\frac{\partial Y_2^S}{\partial m} = \frac{Y_2^S(n+1)}{m(1+n+m)} > 0 \,.$$

Proof of Proposition 2

Let $\pi_1^S = \left(a - b\left(Y_1^S + Y_1^{NS}\right)\right)Y_1^S - C^S Y_1^S$ and $\pi_2^{NS} = \left(a - b\left(Y_2^S + Y_2^{NS}\right)\right)Y_2^S - C^S Y_2^S$ be the joint profit of splitters before and after the reform respectively. Then the split-up increases splitters' profit if $\pi_2^S - \pi_1^S > 0$.

Rearranging (1) yields:

(A8) $a - C^S = 2bY_1^S + bY_1^{NS}$.

Given (A8), the splitters' prereform profit π_1^S can be further calculated as:

(A9) $\pi_1^S = b\left(Y_1^S\right)^2$.

It is easy to show that the postreform supply of splitters, Y_2^S, and nonsplitters, Y_2^{NS}, and consequently splitters' postreform profit π_2^{NS}, can be directly calculated from the prereform supplies Y_1^S and Y_1^{NS}. However, before doing so, I want to stress that all supplies in the model have to be nonnegative. According to *Proposition 1*, after the split-up, supplies between splitters and nonsplitters are relocated: the splitters' supply increases and the nonsplitters' decreases. Then if cost differences imply that prereform supply of the nonsplitters is much lower than of the splitters, the split-up might result in the crowding out of the nonsplitters from the market; that is, postreform nonsplitters' supply is zero, $Y_2^{NS} = 0$.

Combining (1) and (4), which set conditions for the aggregate supply of splitters before and after the split-up respectively, yields:

(A10) $-bY_1^S - b\left(Y_1^S + Y_1^{NS}\right) = -b\dfrac{Y_2^S}{m} - b\left(Y_2^S + Y_2^{NS}\right)$.

Combining (2) and (5), which set conditions for aggregate supply of nonsplitters before and after the split-up respectively, yields:

(A11) $-b\dfrac{Y_1^{NS}}{n} - b\left(Y_1^S + Y_1^{NS}\right) = -b\dfrac{Y_2^{NS}}{n} - b\left(Y_2^S + Y_2^{NS}\right)$.

Then from (A10) and (A11), it is possible to express postreform supplies using prereform supplies:

(A12) $\qquad Y_2^{NS} = Y_1^{NS} - \dfrac{Y_1^S(m-1)n}{m+n+1}$,

(A13) $\qquad Y_2^S = \dfrac{Y_1^S(2+n)m}{m+n+1}$.

According to (A12), the output of nonsplitters after the reform will be negative if $Y_1^{NS} < \dfrac{Y_1^S(m-1)n}{m+n+1}$.

Because supply cannot be negative, $Y_1^{NS} \leq \dfrac{Y_1^S(m-1)n}{m+n+1}$ means that nonsplitters produce nothing and

leave the market after the reform. The inequality above can be equivalently expressed in the prereform market shares:

(A14) $\qquad S_1^{NS} \leq \dfrac{S_1^S(m-1)n}{m+n+1}$,

where $S_1^S \equiv \dfrac{Y_1^S}{Y_1}$ and $S_1^{NS} \equiv \dfrac{Y_1^{NS}}{Y_1}$ are the prereform market share of the splitters.

Given that $S_1^{NS} = 1 - S_1^S$, rearranging (A14) gives a condition under which no nonsplitters are left in the market after the reform:

$$S_1^S \geq \dfrac{m+n+1}{m+mn+1} .$$

Furthermore, calculating profit π_2^S, I will distinguish between two cases: the first case, when Y_2^{NS} is positive and the second case, when $Y_2^{NS} = 0$. I will calculate the splitters' profit difference $\pi_2^S - \pi_1^S$ for each case.

<u>Case 1</u>: $Y_2^{NS} > 0$ (or equivalently $S_1^S < \dfrac{m+n+1}{m+mn+1}$).

In this case, Y_2^{NS} is defined by (A12), and Y_2^S is defined by (A13). Substituting (A8), (A12) and

(A13) into the expression $\pi_2^S = \left(a - b\left(Y_2^S + Y_2^{NS}\right)\right)Y_2^S - C^S Y_2^S$, it follows that:

(A15) $\qquad \pi_2^S = bm\left(\dfrac{Y_1^S(2+n)}{m+n+1}\right)^2 .$

From (A15) and (A9), it is easy to calculate the difference between π_2^S and π_1^S:

$$\pi_2^S - \pi_1^S = b\left(Y_1^S\right)^2 \left(\frac{m(2+n)^2}{(m+n+1)^2} - 1 \right).$$

The split-up will increase splitters' profit if $\dfrac{m(2+n)^2}{(m+n+1)^2} > 1$ or equivalently if $\sqrt{m}(2+n) > m+1+n$.

Simplifying the last inequality, we obtain $n+1 > \sqrt{m}$.

Then I can conclude that a split-up will increase the splitters' profit if $S_1^S < \dfrac{m+n+1}{m+mn+1}$ and if

$n+1 > \sqrt{m}$.

Case 2: $Y_2^{NS} = 0$ (or equivalently $S_1^S \geq \dfrac{m+n+1}{m+mn+1}$).

Given that $Y_2^{NS} = 0$, the splitters' supply Y_2^S can be calculated from (4) and (A8):

(A16) $Y_2^S = \dfrac{m\left(2Y_1^S + Y_1^{NS}\right)}{m-1}$.

Substituting (A16) and (A8) into expression $\pi_2^S = \left(a - bY_2^S\right)Y_2^S - C^S Y_2^S$, it follows that:

(A17) $\pi_2^S = \dfrac{bm\left(2Y_1^S + Y_1^{NS}\right)^2}{(m+1)^2}$.

From (A13) and (A9), it is easy to calculate the difference between π_2^S and π_1^S:

$$\pi_2^S - \pi_1^S = Y_1^{NS}\sqrt{m} - Y_1^S\left(m - 2\sqrt{m} + 1\right).$$

The split-up will increase splitters' profit if $Y_1^{NS}\sqrt{m} > Y_1^S\left(m - 2\sqrt{m} + 1\right)$. Writing this inequality in terms of the splitters' prereform market share yields:

$$S_1^S < \frac{\sqrt{m}}{m - \sqrt{m} + 1}.$$

Then I can conclude that a split-up will increase the splitters' profit if $S_1^S \geq \dfrac{m+n+1}{m+mn+1}$ and if

$$S_1^S < \frac{\sqrt{m}}{m - \sqrt{m} + 1}.$$

It can be shown that if $n+1=\sqrt{m}$, then $\dfrac{m+n+1}{m+mn+1}=\dfrac{\sqrt{m}}{m-\sqrt{m}+1}$. Therefore, if $n+1>\sqrt{m}$, then

$\dfrac{m+n+1}{m+mn+1}<\dfrac{\sqrt{m}}{m-\sqrt{m}+1}$, and if $n+1\le\sqrt{m}$, then $\dfrac{m+n+1}{m+mn+1}\ge\dfrac{\sqrt{m}}{m-\sqrt{m}+1}$.

Summing up the conclusions from both cases, it follows that:

i)   if $n+1>\sqrt{m}$ and $S_1^S<\dfrac{\sqrt{m}}{m-\sqrt{m}+1}$, then the split-up will increase splitters profit;

ii)   if $n+1>\sqrt{m}$ and $S_1^S<\dfrac{\sqrt{m}}{m-\sqrt{m}+1}$, then the split-up will increase splitters profit; and

iii)   if $n+1\le\sqrt{m}$, then the split-up will not increase splitters' profit.

Proof of Proposition 3

In a closed economy, welfare W consists of consumer surplus CS, profit of splitters and profit of nonsplitters.

$$W=CS+\pi_S+\pi_{NS},$$

where $CS=\displaystyle\int_0^Y P(x)dx-P(Y)Y=\int_0^Y(a-bx)dx-(a-bY)Y$.

Thus, welfare can be written as:

(A18) $W=\displaystyle\int_0^{Y^S+Y^{NS}(Y^S)}(a-bx)dx-C^S Y^S-C^{NS}Y^{NS}$.

Similarly to the proof of *Proposition 2*, I will distinguish here between two cases: *Case 1*, when nonsplitters remain in the market after the split-up, that is, $Y_2^{NS}>0$ and defined from (A12), and *Case 2*, when nonsplitters leave the market after the split-up, that is, $Y_2^{NS}=0$.

Case 1: $Y_2^{NS}>0$ *(or equivalently $S_1^S<\dfrac{m+n+1}{m+mn+1}$).*

A direct way to find conditions under which a split-up is welfare increasing is to calculate the difference between postreform welfare W_2 and prereform welfare W_1. However, for the case with $Y_2^{NS}>0$, direct calculation of the difference W_2-W_1 turned out to be very slow and cumbersome. It

turned out that a more elegant way is to write the change in welfare $W_2 - W_1$ as an integral of small changes from Y_1^S to Y_2^S:

$$W_2 - W_1 = \int_{Y_1^S}^{Y_2^S} \frac{\partial W}{\partial Y^S} dY^S.$$

The change in welfare W because of an infinitesimally small split-up can be calculated as:

(A19)
$$\frac{\partial W}{\partial Y^S} = a - bY + (a - bY)\frac{\partial Y^{NS}}{\partial Y^S} - C^S - C^{NS}\frac{\partial Y^{NS}}{\partial Y^S} + C^{NS} - C^{NS}$$
$$= (a - bY - C^{NS})\left(1 + \frac{\partial Y^{NS}}{\partial Y^S}\right) + C^{NS} - C^S = b\frac{Y^{NS}}{n(n+1)} + b\left(Y_1^S - \frac{Y_1^{NS}}{n}\right).$$

The third equality in (A19) is because of (1), (2) and (A2).

(A19) indicates that if splitters are more efficient than nonsplitters, that is, $C^S < C^{NS}$ or equivalently $Y_1^S > \frac{Y_1^{NS}}{n}$, then the split-up will increase welfare. The inequality $Y_1^S > \frac{Y_1^{NS}}{n}$ can be rewritten as:

$$S_1^S > \frac{1}{n+1}.$$

The welfare change $W_2 - W_1$ is an integral sum of $\frac{\partial W}{\partial Y^S}$ for all Y^S from Y_1^S to Y_2^S. Nonsplitters decrease output as splitters' output increases. Thus, in $W_2 - W_1$, each next component is smaller than the previous one. Then, if the first component in $W_2 - W_1$ is negative, the whole integral sum is negative. The first component in $W_2 - W_1$ is:

$$\frac{\partial W}{\partial Y_S}\bigg|_{Y^S = Y_1^S} = b\left(Y_1^S - \frac{Y_1^{NS}}{n+1}\right).$$

If $Y_1^S < \frac{Y_1^{NS}}{n+1}$, then the first component is negative. The inequality $Y_1^S < \frac{Y_1^{NS}}{n+1}$ can be rewritten as $S_1^S < \frac{1}{n+2}$. Therefore, if $S_1^S < \frac{1}{n+2}$, then the first component in $W_2 - W_1$ is negative and the entire change in welfare because of the split-up will be negative.

According to *Proposition 1(iv)*, the greater the number of newly established firms *m,* the larger a *s*plitter's output expansion. Then, the larger is *m,* greater the number of components of which the

integral sum $W_2 - W_1$ consists. Therefore, for $S_1^S > \dfrac{1}{n+1}$, the increase in welfare generated by a split-up increases with m. On the contrary, for $S_1^S < \dfrac{1}{n+2}$, the decrease in welfare generated by a split-up increases with m.

Case 2: $Y_2^{NS} = 0$ (or equivalently $S_1^S \geq \dfrac{m+n+1}{m+mn+1}$).

In this case, I directly calculate W_1, W_2 and the difference $W_2 - W_1$.

$$W_1 = \int_0^{Y_1^S + Y_1^{NS}(Y_1^S)} (a - bx)\,dx - C^S Y_1^S - C^{NS} Y_1^{NS} = a\left(Y_1^S + Y_1^{NS}\right) - b\frac{\left(Y_1^S + Y_1^{NS}\right)^2}{2} - C^S Y_1^S - C^{NS} Y_1^{NS}$$

$$(A20) \quad = \left(a - C^S\right)Y_1^S + \left(a - C^{NS}\right)Y_1^{NS} - b\frac{\left(Y_1^S + Y_1^{NS}\right)^2}{2}$$

$$= b\left(2Y_1^S + Y_1^{NS}\right)Y_1^S + b\left(Y_1^S + Y_1^{NS}\left(\frac{n+1}{n}\right)\right)Y_1^{NS} - b\frac{\left(Y_1^S + Y_1^{NS}\right)^2}{2}.$$

The fourth equation in (A20) is derived from (1) and (2).

Calculation of W_2 is similar to calculation of W_1, with the only difference being that $Y_2^{NS} = 0$:

$$(A21) \qquad W_2 = b\left(2Y_1^S + Y_1^{NS}\right)Y_2^S - b\frac{\left(Y_2^S\right)^2}{2}.$$

Substituting (A16) into (A21) and simplifying, I can further express postreform welfare W_2 in terms of prereform supplies:

$$(A22) \qquad W_2 = \frac{bm(m+2)\left(2Y_1^S + Y_1^{NS}\right)^2}{2(m+1)^2}.$$

From (A22) and (A20), it is straightforward to calculate the difference between W_2 and W_1:

$$(A23) \qquad W_2 - W_1 = \left(Y_1^S\right)^2\left(4\beta - \frac{3}{2}\right) + Y_1^S Y_1^{NS}\left(4\beta - 1\right) + \left(Y_1^S\right)^2\left(\beta - \frac{2+n}{2n}\right),$$

where $\beta = \dfrac{m(m+2)}{2(m+1)^2}$.

Dividing (A23) by $Y_1^S + Y_1^{NS}$ and rewriting in terms of the splitters' preform market share yields:

(A24) $\qquad \dfrac{W_2 - W_1}{Y_1^S + Y_1^{NS}} = \left(S_1^S\right)^2 \left(\beta - \dfrac{n+1}{n}\right) + S_1^S \left(2\beta + \dfrac{2}{n}\right) + \left(\beta - \dfrac{2+n}{2n}\right).$

A split-up will increase welfare if the right-hand side of (A24) is positive. It easy to calculate that

$\beta - \dfrac{n+1}{n} < 0, \ 2\beta + \dfrac{2}{n} > 0$ and $\beta - \dfrac{2+n}{2n} < 0$. Then the right-hand side of (A24) is a quadratic function

that resembles $\cap$ and is positive for all S_1^S, satisfying $x_1 < S_1^S < x_2$, while x_1 and x_2 are roots of the

quadratic equation:

(A25) $\qquad x^2 \left(\beta - \dfrac{n+1}{n}\right) + x\left(2\beta + \dfrac{2}{n}\right) + \left(\beta - \dfrac{2+n}{2n}\right) = 0.$

Market share S_S^I cannot exceed one, that is, $S_1^S \leq 1$. On the other hand, this case concerns only the

splitters' market shares that satisfy $\dfrac{m+n+1}{m+mn+1} \leq S_1^S$. Then if I can show that $x_1 < \dfrac{m+n+1}{m+mn+1}$ and

$x_2 > 1$, then it is straightforward to conclude that a split-up will increase the splitters' profit for all

$\dfrac{m+n+1}{m+n+mn} \leq S_1^S \leq 1$.

In (A25), set $x = 1$, then the left-hand side of (A25) is calculated as $4\beta - \dfrac{3}{2} = \dfrac{m^2 + 2m - 3}{2(m+1)^2} \geq 0$. This

allows the conclusion that $x_2 > 1$. Similarly, setting $x = \dfrac{m+n+1}{m+mn+1}$ in (A25), after some algebra, it is

possible to calculate that the left-hand side of (A25) is positive. This allows the conclusion that

$x_1 < \dfrac{m+n+1}{m+mn+1}.$

Therefore, it follows that for all $\dfrac{m+n+1}{m+n+mn} \leq S_1^S \leq 1$, a split-up will increase the splitters' profit.