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An exploration of a strategic competition model for the European Union natural gas market

Zaifu Yang[a,b,*], Rong Zhang[c], Zongyi Zhang[d]

[a] Southwestern University of Finance and Economics, China
[b] University of York, UK
[c] College of Economics and Business Administration, Chongqing University, Chongqing400030, China
[d] Southwestern University of Finance and Economics, Chengdu610074, China

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ABSTRACT

Following Jansen et al. (2012), we examine an unconventional Cournot model of the European Union natural gas market with three major suppliers: Russian Gazprom, Norwegian Statoil, and Algerian Sonatrach. To reflect Russia's other strategic consideration besides profit, we incorporate a relative market share into Gazprom's objective function. We prove that when Gazprom pursues the control of market share along with profit, it will be good news for consumers but bad news for its pure profit maximising rivals. We further show that by seeking a proper market share, Gazprom can achieve the same profit of a Stackelberg leader in a simultaneous move model as in the standard sequential move leader–follower model. Compared with Jansen et al.'s, our approach makes both the analysis considerably simpler and more transparent, and the model more applicable.

1. Introduction

Natural gas market has becoming increasingly important as its worldwide consumption has risen significantly since IEA's record in early 1970s (IEA, 2010), because natural gas has considerably lower carbon dioxide emission than coal and oil, and therefore is more conducive to environmental protection. This market usually displays regional characteristics over a given period of time due to transportation like pipelines and geographical constraints. Currently, the global natural gas market can be roughly divided into three major regional markets: North American, European, and Asian markets. In the current paper we focus our analysis on the European Union (EU) market. In this market, there are three major natural gas suppliers: Russian Gazprom, Norwegian Statoil, and Algerian Sonatrach. Unlike other markets, this market exhibits some unusual complex geopolitical features along with oligopolistic behaviour. The EU gas market is currently dominated by the three players and will remain so for many years to come and its import is expected to expand to the level of 70% in 2030 (Lise and Hobbs, 2008).

As it is well recognised in the literature, in contrast to other players in the market which compete purely for commercial interest, Russia and its state monopolist Gazprom are not only pursuing profit but also seeking market power, presumably in the hope that this will enhance Russia's economic and geopolitical influence on Europe;[1] see e.g., Stern (2006), Finon and Locatelli (2008), Bilgin (2009), Boon von Ochssée (2010), Goldman (2010), Pirani et al. (2010), Smeenk (2010), Yegorov and Wirl (2011), and Jansen et al. (2012). Russia is presently the biggest natural gas provider to the

* Corresponding author.
E-mail addresses: zaifu.yang@york.ac.uk (Z. Yang), zhangrong@cqu.edu.cn (R. Zhang), zhangzy@vip.sina.com (Z. Zhang).

[1] The current Ukraine crisis has made the issue even more outstanding and also more urgent for policy makers on European energy security.

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EU, accounting for more than 40 percentage of EU's natural gas import. Although unconventional gas development may potentially affect the current natural gas suppliers, uncertainty about such development is high (McGlade et al., 2013) and the EU will still depend on Russia's gas for a long period of time.

Due to imperfect competition, natural gas markets are typically formulated as Cournot, Bertrand or Stackelberg models (see e.g., Hobbs et al., 2000; Pang and Sun, 2006) in which the goal or objective of every commercial enterprise (i.e., player) is to maximise its profit, nothing else. In the current paper we propose a new Cournot model for the European Union natural gas market that can reflect Gazprom's other strategic interest besides profit against two traditional profit maximisers: Norwegian Statoil and Algerian Sonatrach. Formally, to capture Russia's comprehensive strategic goal, we incorporate a relative market share into Gazprom's objective function besides profit. We demonstrate that when Gazprom pursues the control of market share along with profit, it will be good news for the EU's consumers but bad news for its rivals, as Gazprom's behaviour pushes total output up and brings prices down. Our analysis further shows that by seeking a proper market share, Gazprom can achieve the same profit of a Stackelberg leader in a simultaneous move oligopoly model as in the classical sequential move leader–follower oligopoly model, and that no matter how Gazprom might manoeuvre its influence on the market, its profit can never exceed that of the Stackelberg leader. This provides a useful complement to the standard theory of industrial organisation (see Tirole, 1988; Belleflamme and Peitz, 2010) that a firm can attain the profit of a Stackelberg leader only in a sequential move environment where this firm makes its decision before all other firms (i.e., followers). Our result reconfirms what Jansen et al. (2012, p. 283) have observed: "The corresponding profits for Russia appear to be the profits of a Stackelberg leader in a classical leader–follower model."

Our paper is most closely related to and was inspired by Jansen et al. (2012). In a striking analysis, Jansen et al. introduce a modified Cournot model that elegantly takes Russia's geopolitical motive into account by using the standard market share together with profits as Gazprom's objective. Their use of standard market share complicates their analysis, because this involves a highly nonlinear equation which is difficult to solve. Consequently, it has tended to make their analysis less transparent and obscure a good understanding of the substance. Our new approach makes their model more applicable[2], simplifying their analysis and enriching their insights. In another related article, Chyong and Hobbs (2014) study a strategic Eurasian natural gas market model in which Russia as producer exports its natural gas through transit countries Ukraine and Belarus to other European states. They explore economic and strategic implications for European energy security regarding Russian Gazprom's investment in the South Stream pipeline project under several scenarios. Their model is quite different from Jansen et al. (2012) and ours. We also refer to Boucher and Smeers (1985a,b) for an early related study on the European natural gas market.

The rest of the paper goes as follows. Section 2 briefly reviews a classical Cournot oligopoly model which will be used to compare with the new model. Section 3 introduces the new model and presents the main results. Section 4 provides a comparative statics analysis. Section 5 explores some policy implications and concludes the paper.

2. The classical Cournot model

Following closely Jansen et al. (2012), we formulate the EU natural gas market as a Cournot model, as this market is dominated by homogeneous bulk goods. Russian Gazprom, Norwegian Statoil, and Algerian Sonatrach are the major gas suppliers, i.e., players. For ease of exposition, the symbols R, N and A will be used to represent Russia, Norway, and Algeria, respectively. Assume that marginal costs c_i are positive constants, and the inverse market demand function is given as

$$p(Q) = a - bQ,$$

where $Q = q_A + q_N + q_R$ and $a, b > 0$. Here a is the maximum price that any consumer is willing to pay, and b reflects the price elasticity. Production outputs q_i, $i = R, N, A$, represent respectively the decision variables for Russia, Norway, and Algeria. The objective functions of three players are $\Pi_i(q_A, q_N, q_R) = (p - c_i)q_i$, $i = R, N, A$, with the marginal production costs satisfying $c_R > max\{c_A, c_N\}$, which is slightly more general than what Jansen et al. (2012, p. 281) have used. Given the outputs of its opponents, each player i tries to maximise its profit

$$\max_{q_i} \Pi_i = (p - c_i)q_i = [a - b(q_R + q_N + q_A) - c_i]q_i.$$

Assume that the condition of interior solution is satisfied, i.e., $a - 3c_R + c_N + c_A > 0$.[3] By the first order condition, we obtain the equilibrium output q_i^c for each player i, total output Q^c, and equilibrium price p^c:[4]

$$q_R^c = \frac{1}{4b}(a - 3c_R + c_N + c_A),\ q_N^c = \frac{1}{4b}(a + c_R - 3c_N + c_A),$$
$$q_A^c = \frac{1}{4b}(a + c_R + c_N - 3c_A), Q^c = \frac{1}{4b}(3a - c_R - c_N - c_A),$$
$$\text{and}\ \ p^c = \frac{1}{4}(a + c_R + c_N + c_A).$$

In equilibrium, each player's profit Π_i^c and the consumer surplus CS^c are

$$\Pi_R^c = \frac{1}{16b}(a - 3c_R + c_N + c_A)^2 = b(q_R^c)^2,$$

$$\Pi_N^c = \frac{1}{16b}(a + c_R - 3c_N + c_A)^2 = b(q_N^c)^2,$$

$$\Pi_A^c = \frac{1}{16b}(a + c_R + c_N - 3c_A)^2 = b(q_A^c)^2,$$

$$CS^c = \frac{1}{32b}(3a - c_R - c_N - c_A)^2.$$

Let $\Pi^c = \Pi_A^c + \Pi_N^c + \Pi_R^c$ denote the total profits of all the suppliers and $W^c = \Pi^c + CS^c$ the social welfare. So far we have analysed the classical case in which all three players are profit maximisers. Our focus, however, will be the situation where Russia gas company Gazprom is not merely a profit maximiser.

We should point out that throughout the paper without loss of generality we concentrate on the model with three players, which is a fairly realistic description of the current EU gas market. The analysis can be easily extended to any finite number of players.[5]

[2] In our analysis Jansen et al.'s condition (d) of Proposition 1, p. 282, is not needed and thus dropped.

[3] Notice that $a - 3c_R + c_N + c_A > 0$ implies $a - 3c_N + c_R + c_A > 0$ and $a - 3c_A + c_R + c_N > 0$.

[4] In order to compare with the following new version of Cournot competition where a non-profit objective is involved, the superscript c is used here to represent the equilibrium solution of the traditional Cournot competition where all players use merely profit maximisation as their objectives.

[5] We refer to Hobbs et al. (2000) and Pang and Sun (2006) for extensive studies on general Cournot–Nash equilibrium models.