The Impact of Securing Alternative Energy Sources on Russian-European Natural Gas Pricing

Nathalie Hinchey
Graduate Student
Center for Energy Studies
James A. Baker III Institute for Public Policy
Rice University
6100 Main Street
Houston, Texas
77005
USA
nh17@rice.edu

Abstract

This paper examines the effects of procuring alternative sources of natural gas on Russian pricing in Europe. With the increasing presence of LNG import capability in European ports, this topic is growing in importance, especially for European policy makers. Theoretical results, stemming from an asymmetric Nash Bargaining model, suggest that Russian prices decrease as dependency on Russian gas decreases. The empirical results, obtained from the estimation of a correlated random effects model, corroborate this stipulation by finding a negative relationship between Russian pricing and average dependency on Russian supplied gas. These findings explain the recent phenomenon experienced in the Baltic Region where the presence of an LNG import terminal in Lithuania has secured access to non-Russian suppliers of gas and decreased prices from Gazprom.

Keywords: Natural Gas Pricing, Asymmetric Nash Bargaining, Game Theory, Outside Options

1 Introduction

One of the pivotal concerns in most modern political agendas is the reliable procurement of energy supply at reasonable prices. Natural gas is a premium fuel and is highly valued in most developed countries. In Europe in particular, natural gas is an important source of energy but its procurement is vulnerable to Russia's market dominance. This study seeks to quantify the impacts of securing alternative sources of natural gas on pricing between Russia and its European clients. I find evidence that as Russia is forced to compete more, it charges less; specifically, using an asymmetric Nash bargaining model for theoretical justification, I estimate an empirical model and find that decreasing reliance on Russian sources leads to a diminution in Russian natural gas prices.

In the last few decades, Russia has been the dominant supplier in the European natural gas markets (EIA, 2016b). It possesses the largest proven reserves in the world, and exploration continues, particularly in the promising Arctic regions. Norway, Europe's second most influential gas supplier, has the sixteenth largest proven natural gas reserves worldwide (EIA, 2016b) and provides competition to Russia in Western European countries. The majority of European countries have long term contracts with Gazprom. These contracts range in duration from 10 to 25 years and dictate the price and quantity of natural gas (Gazprom, 2016). Surprisingly, most former Soviet Republics pay prices significantly higher than European Union countries. Ukraine, for example, paid approximately 55% more, on average, for their Russian supplied gas than the United Kingdom in 2013. See Figure 1 for the average prices by country paid to Gazprom in 2013 (RFERL, 2016).

The growing presence of liquefied natural gas (LNG) [1] in Europe is pro-

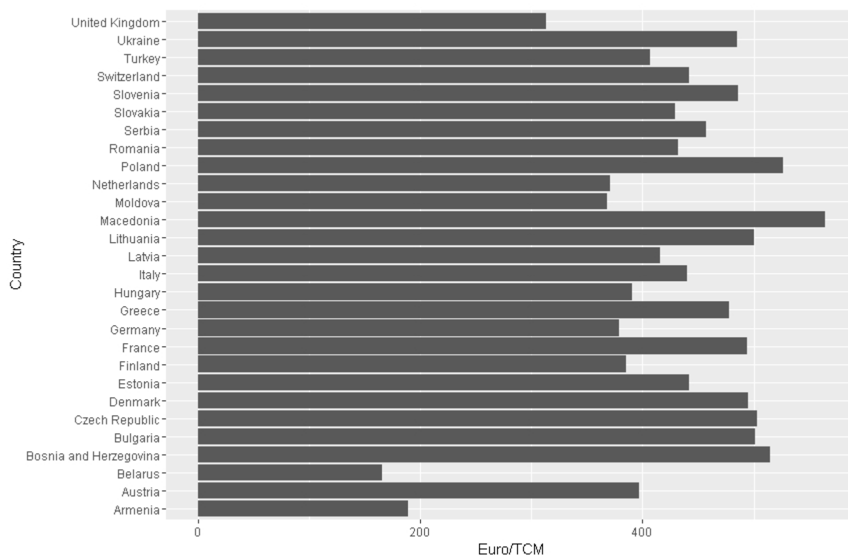
[1] The concept of liquefied natural gas (LNG) was developed in the late seventies. The basic premise of LNG is to liquefy natural gas cryogenically to approximately 1/600th of its gaseous volume at -260 degrees Fahrenheit, (-162.2 degrees Celsius), after the extraction of oxygen, water and carbon dioxide, as well as most sulfates (Office of Fossil Energy, 2016), and

viding opportunities for countries previously dependent on Russian natural gas to diversify their supply. This new paradigm has had impressive consequences for those who have seized such opportunities. In October 2014, Lithuania essentially effected its second declaration of independence from Russia in modern times. The tiny, former Soviet state had invested 128 million US dollars to assert its independence from its sole provider of natural gas, Gazprom; Russia's natural gas monopolist with close political ties to the Kremlin (Seputyte, 2014). With the realization of the appropriately named FSRU Independence, a Liquefied Natural Gas Import terminal, situated at Klaipeda, Lithuania, the country was able to secure, for the first time in its history, an alternative energy source for natural gas. That same year, Lithuania negotiated a 23% price decrease for natural gas from Russia through 2015 (Seputyte, 2014), in line with lower prices charged to it by Scandinavian countries lacking pipeline access to the Baltic states.

The dramatic differences in cross country negotiated prices, illustrated in Figure 1, as well as the drastic decrease in Lithuania's post investment price, provide the motivation to explore exactly how these price discrepancies are to be explained. The goal of this paper will be to quantify the impact of access to alternative sources of natural gas on Russian contract pricing. A theoretical, illustrative asymmetric Nash Bargaining model will be developed to provide economic intuition for heretofore observed natural gas price discrepancies in Europe. The estimated model, inspired by its illustrative counterpart, will account for access to alternative sources of natural gas and will find that the price paid to Russia decreases as the ratio of supplies from non-Russian to Russian sources increases. Essentially, the empirical evidence suggests that the increasing presence of LNG in the European markets will drive contracted,

to transport that gas by way of specially constructed tanker ships. This process also requires a liquefaction plant and a regasification plant.

Figure 1: 2013 Average Gas Prices Paid to Gazprom by Country



Source: RFERL (2016)

Russian natural gas prices down.

2 Geographical and Physical Constraints

Geographical and physical constraints severely limit the range of possible outcomes when trading natural gas. Unlike oil, which is reasonably easy to transport in its natural or refined states, natural gas requires substantial investments to be transported via pipeline or in the form of LNG. The traditional medium for the transportation of natural gas are pipelines, which necessitate primarily a contiguous land based and accessed supply source. Russia possesses the advantage of a web of existing pipelines supplying customers in Western Europe. The fact that Gazprom is the monopolist exporter of Russian natural gas, with Russia representing the only available supplier in quantities demanded by clients (Eurostat, 2016a), puts this company in a position to heavily influence prices. In recent years, North America was essentially an "island" in the natural gas world with very little trade in LNG. As a result, North American supply and demand had no bearing on output and price in Europe; with LNG exports from the US beginning in 2016[2], European countries now have more options to import LNG at competitive prices.

The most reliable and cheapest way to transport natural gas is currently through pipelines. Pipelines, for many reasons, are essentially restricted to crossing land, and are capital intensive, relationship-specific investments. For this reason, suppliers of natural gas generally tend to demand long term supply contracts to secure income guarantees necessary to finance investment in pipelines; consumers, on the other hand, are generally amenable to such contracts for energy security and the ability to enhance long term financial planning. The LNG industry also requires extensive capital investments and tends to be governed by long term contracts, albeit this trend seems to be on the decline (Hartley, 2015). The problem then inevitably becomes one of bargaining and how the gains are distributed among the parties. Due to its massive reserves, Russia and Gazprom have traditionally maintained a dominant position in the negotiation stage and have been able to extract most of the rents. The existing bargaining landscape can only change by way of a fundamental power shift between bargainer and bargainee, as evidenced by the Lithuanian case.

The relevance of LNG is in its ability to provide fresh options to importers and exporters of natural gas. Russia currently counterparties 34% of all natural gas sales in Europe (EIA, 2016b). Prior to Lithuania's investment, eight EU countries were solely supplied by Russia, as these countries lacked the infrastructure to access other reserves or suppliers. With the advent of LNG technology,

[2] There were exports from Alaska in prior years. By the "US" we mean the contiguous 48 States excluding Alaska and Hawaii and by "North America" we effectively mean the 48 states plus Canada.

these countries have the potential to access natural gas from many new energy exporters, such as Qatar and the US. As evidenced by the bold Lithuanian experiment, this investment clearly has had an impact on negotiated prices.

3 Literature Review

To date, natural gas markets have primarily been analyzed using calibrated equilibrium models. For example, Hartley et al. (2004) develop a dynamic, spatial equilibrium model (the Rice University World Gas Trade Model) for natural gas markets in a global setting, using geological data in a competitive environment. Hartley and Medlock III (2009) explore Russia's ability to influence world gas prices in the long run using the Rice University World Gas Trade Model and find that increasing competition from alternative suppliers of natural gas limits Russia's ability to affect the gas markets. The results of the study herein are congruent with the findings of Hartley and Medlock III (2009)

Gabriel et al. (2005) create a mixed-complementarities based dynamic equilibrium model with strategic behavior in the natural gas markets. This study proves the existence and uniqueness of a Nash-Cournot equilibrium in the complementarity problem subject to rather benign assumptions. Gabriel et al. (2005), Egging and Gabriel (2006), and Egging et al. (2010) extend Gabriel et al. (2005) for the North American, European and World markets respectively. Egging et al. (2010) find that Europe will expand its pipeline capacity to increase imports of natural gas. Understanding the impact of increased access to natural gas in Europe is then clearly of importance. Egging and Gabriel (2006) find that plentiful storage and pipeline capacity are beneficial for consumers. They analyze the potential for harm from increased market power from producers.

It should be noted that all of the models presented herein employ a Cournot framework rather than a Bertrand approach. This is intuitively appealing since most natural gas contracts specify quantity to be delivered as the prime focus. Further, assuming a Bertrand game framework would imply that the strategic firms price at marginal cost (Bertrand, 1883), meaning they face the same outcome they would if they were in a competitive setting, which would appear inconsistent with the outcome in Lithuania, for example.

Egging et al. (2009) examine the possible effects on the world natural gas market of a cartel Gas Exporting Countries Forum (GECF). In their dynamic model, both regasifiers and traders act strategically according to a Nash-Cournot specification while all other agents behave in a perfectly competitive manner. Egging et al. (2009) find that a gas cartel would increase price and decrease quantity supplied. Europe would be particularly affected by the formation of a gas cartel. Gabriel et al. (2012) extend the model presented in Egging et al. (2009) to allow for a theoretically consistent representation of cartels and find very similar results.

Moryadee et al. (2014) analyze the effects of increased American LNG exports on various natural gas markets. The authors make some adjustments to the World Gas Model used in Gabriel et al. (2012) and find that increased US LNG exports decrease European gas prices.

Holz et al. (2008) present a two-stage, perfect information game theoretic model to approximate the European natural gas market. Their focus is on the strategic behavior of both the downstream and upstream components of the market. They find that LNG suppliers will gain market share in the European gas markets.

Dorigoni et al. (2010) also use a game theoretic approach to model the European natural gas market. They develop a two-period model to evaluate whether the increased presence of LNG exporters would increase competition in the European natural gas market. The authors find that the presence of LNG contributes to competition in the European markets, despite the inherently greater cost of the fuel.

All of the literature examined emphasizes the presence of market power in the European gas markets and the potential of LNG to increase competition. Neumann and von Hirschhausen (2004) even find that the presence of LNG import facilities affects the nature of supply contracts with Russia.

While most of the above papers use game theoretic approaches, none employ a Nash Bargaining model to analyze the effect of increasing access to alternative sources of natural gas. There appears to be no or negligible analytics which attempt to estimate aspects of the natural gas markets, as opposed to calibrating values. The intent and purpose of this paper is to estimate the effect on European gas prices of increased access to alternative sources of natural gas. The results of this paper are consistent with the results of the models described above.

4 Illustrative Model

To provide economic intuition, an illustrative model will be presented to describe the behavior of the players in an asymmetric Nash Bargaining game. Ultimately, this model theorizes that the variation in Russian gas prices across countries stems from the ability of those countries to procure natural gas from independent sources such as domestic gas reserves or LNG imports.

We first assume that all investment in LNG import capabilities and domestic gas reserves is completed prior to the negotiation phase of the problem. All of these sources require costly investment, whether it be through the development of national resources or the acquisition of LNG import terminals. If these investments were not made prior to negotiations, they would not provide credible negotiating threats and inducements. Further, it must be acknowledged that none of the European countries who purchase natural gas from Russia can currently meet their domestic demand without Russian imports. In a report by Dickel et al. (2014), it was determined that Europe will require, at a minimum, imports of 100 bcm/year from Russia well into 2030, notwithstanding increasing efforts to diversify energy supply. So while some countries have outside options, they are all still vulnerable and dependent on Russian gas supply. In the model, this will mean that if countries walk away from negotiations with Gazprom, they will not be able to fulfill domestic demand and consumers will experience higher prices.

Until now, negotiations have been described as occurring between individual countries. In reality, individual corporate entities negotiate with Gazprom; there is in fact a series of bilateral negotiations taking place between firms and Gazprom. Despite this, the problem will be modelled at the country level. This restriction is due to data limitations which will be discussed in the next section. All of the results herein can be extended to a firm level analysis and so this assumption is rather benign.

Some authors have suggested that prices can be explained by political rather than economic factors - namely by a country's cooperation with Russian policy. The argument herein purports that such a correlation is incidental rather than essential to explaining the outcome. Gazprom is first and foremost a profit maximizing company, notwithstanding well founded questions about its integrity and internal decision making. Many countries that cooperate with Russia, such as Macedonia, the highest paying country in the sample, do not experience any price subsidization from the natural gas giant. Russia is extremely dependent on natural gas revenues and will not relinquish additional profits, if it need not. For this reason, political decisions will be abstracted from in the illustrative model. Political affiliations, will, however, be accounted for by the exogenously given bargaining power of a country.

Consider each country in Figure 1 as an individual player who negotiates with Russia separately. Each game will therefore consist of two players who bargain over price in a deterministic world with complete information. Assume that contracts are negotiated on long term bases, it being well known that in actual negotiations prices and quantities are agreed upon in single contracts for up to 25 years. The bargaining process can then be treated as a static problem. European countries come to the table with an exogenously specified amount of natural gas to purchase, as well as the ratio of imports from Russia and non-Russian countries, to negotiate price. Assume there is no risk of default on past contracts. In reality, these contracts are internationally arbitrated and are almost always enforced (Export, 2016).

Due to its massive supply and proven reserves of natural gas, Russia is treated as having an unlimited supply. This is a reasonable assumption based on forecasts of Russian gas supply for the next 50 years (EIA, 2016a). Utility is expressed in terms of profits and breakdown points are profits from no trade.

To illustrate this premise, define the set of players as Russia and the European country who purchases Russian natural gas, denoted by i $\in \{1, ..., n\}$. Let P_i^I and P_i^L describe the price of non-Russian imported gas and the price of domestically produced natural gas for country i respectively. Let P_i^R be the price of Russian imported gas[3] for country i net of transportation costs. The set of actions comprise any price, P_i^R, between each bargaining pair, in the set of positive, real numbers. Denote by P_i^D the price received for natural gas in the European country's domestic market and denote by P_i^{Do} the price received for natural gas in the domestic market net of Russian Imports. Allow Q_i to denote

[3]This price is indexed to the price of crude as most Gazprom contracts use crude price indexation.

total, exogenously given consumption for country i where $Q_i = Q_i^L + Q_i^I + Q_i^R$ such that Q_i^L is domestically produced natural gas in country i, Q_i^I is imported natural gas from alternative countries in country i and Q_i^R is imported natural gas from Russia for country i. Assume that Russia has a constant marginal cost of extraction, C, and let $\tau_i(USSR)$ represent the exogenously given bargaining power of the European country.[4] We allow $\tau_i(USSR)$ to be a function of former USSR state status. In essence, $\tau_i(USSR)$ allows for types of consumers to be considered. Finally, let $t_i^j(Dj_i, Q_i^j)$ for $j \in \{R, L, I\}$ denote the cost of transportation of natural gas from Russia, country i and non-Russian export countries to country i respectively, which is a function of country i's distance from the exporter, denoted by Dj_i, and the volume of its imports.

The payoff function for Russia is its profit function:

$$\Pi_i^R = P_i^R \times Q_i^R - C \times Q_i^R \tag{1}$$

and the payoff function for its counterpart is described as:

$$\begin{aligned} \Pi_i^D = {} & P_i^D \times Q_i - P_i^I \times Q_i^I - P_i^R \times Q_i^R - P_i^L \times Q_i^L - t_i^R(DR_i, Q_i^R) \\ & - t_i^I(DI_i, Q_i^I) - t_i^L(DL_i, Q_i^L) \end{aligned} \tag{2}$$

where Π_i^D denotes the profit of the European country when importing from Russia and

$$\Pi_i^{Do} = P_i^{Do} \times (Q_i^I + Q_i^L) - P_i^I \times Q_i^I - P_i^L \times Q_i^L - t_i^I(DI_i, Q_i^I) - t_i^L(DL_i, Q_i^L) \tag{3}$$

is the profit when negotiations break down. In the event of a breakdown in negotiations, Russia has no outside options, since its supply is unlimited

[4] We can view $\tau_i(USSR)$ as incorporating country specific effects, such as the willingness to cooperate with the Kremlin.

and the negotiations have no impact on contracts with other trading partners. For the importing country, however, a breakdown in negotiations would result in a cessation of Russian imports. For countries solely dependent on Russian imports, this result could be devastating. Such countries would most likely need to import emergency supplies from neighboring countries at exorbitant rates. A country with alternative access to natural gas would most likely endure higher prices in that season to account for limited supply net of Russian imports. Consequently, both parties have strong incentives to successfully negotiate terms for pricing.

In the traditional asymmetric Nash bargaining setting, the optimal contracted price will be determined by solving the following problem:

$$P_i^{R*} = \max_{P_i^R \in \mathbb{R}_+} (\Pi_i^D - \Pi_i^{Do})^{\tau_i(USSR)} \times (\Pi_i^R)^{1-\tau_i(USSR)} \tag{4}$$

Plugging (1),(2) and (3) into (4) we obtain:

$$\begin{aligned} P_i^{R*} = \max_{P_i^R \in \mathbb{R}_+} & \left(P_i^D \times Q_i - P_i^R \times Q_i^R - P_i^{Do} \times (Q_i^I + Q_i^L) - t_i^R(DR_i, Q_i^R) \right)^{\tau_i(USSR)} \\ & \times \left(P_i^R \times Q_i^R - C \times Q^R \right)^{(1-\tau_i(USSR))} \end{aligned} \tag{5}$$

From which we obtain the optimal P_i^R*,

$$\begin{aligned} P_i^{R*} &= \tau_i(USSR) \times C + [1 - \tau_i(USSR)] \\ &\times \left[(P_i^D - P_i^{Do}) \times \left(\frac{Q_i^I + Q_i^L}{Q_i^R} \right) + P_i^D - \frac{t_i^R(DR_i, Q_i^R)}{Q^R} \right] \end{aligned} \tag{6}$$

Thus, the negotiated price depends on domestic prices, extraction and transportation costs, and most importantly for this study, the ratio of non-Russian to Russian sourced gas. Essentially, the proportion of Russian imports with respect to all imports is a main determinant of negotiated prices. This result suggests that the absolute value of imports, while still important in determining prices, does not provide sufficient explanatory power. The comparative static from equation (7) below provides an interesting result of the model.

$$\frac{\partial P_i^R}{\partial (Q_i^I + Q_i^L)} = (1 - \tau_i(USSR))(P_i^D - P_i^{Do})\frac{1}{Q_i^R} < 0 \tag{7}$$

As a country increases its procurement of non-Russian gas, its negotiated price with Russia should decrease. This result is in line with the Lithuanian experience, which provides further confidence in the model. The estimated model, presented in Section 6, will incorporate this feature. In fact, the empirical evidence finds a negative relationship between price and average relative imports, confirming the theoretical predictions.

5 Data

This section will present and describe the data used in estimation. European prices paid for Russian natural gas were obtained from the Eurostat International Trade database (Eurostat, 2016b) for the years 2009-2014 for 11 European countries. Eurostat provides information on average import values from various trading partners as well as total quantities imported. These values reflect the prices paid, including transportation and insurance costs, at the border. Prices are obtained by manipulating value and quantity information. Prices are in Euros and do not include taxes and levies; this is advantageous for it obviates the need to parse out the benefit received by government agencies versus the purchaser of natural gas. Further, since these prices represent contracted border prices and not consumer prices, the effects of the Ukrainian gas crises should not distort the results.

Natural gas imports include both dry natural gas and liquefied natural gas, all of which are measured in 100 Kg units. Trade partners for natural gas exporters include Norway (the main provider of alternative natural gas in Europe), Qatar (an LNG market leader), Algeria and Russia. These countries were selected due to their significant presence in the European natural gas markets as exporters. Domestic production levels, obtained as yearly observations, and heating degree days for each country in the sample were obtained from the Eurostat database as well. Distances between countries were calculated as the distance, in kilometers, between capital cities. The choice of creating a metric based off of capital cities was influenced by the fact that most capitals tend to have higher population densities which would increase local demand for natural gas imports.

6 Estimated Model and Results

Using results from the illustrative model, the price paid to Gazprom should be a function of the ratio of non-Russian to Russian supplied gas. For this reason, a term for relative procurements from non-Russian to Russian sources is included in the estimated model. In the illustrative model, types were allowed for in the bargaining process, which were reflected in the bargaining power of country i for former USSR states and non-USSR states. When considering Russian pricing, historical and political associations with the latter should almost certainly affect negotiations. In particular, one should anticipate a former USSR country to expect favorable pricing from Russia, *ceteris paribus.* This could stem from cultural similarities, infrastructure supported and maintained by Russian authorities, and amities. Thus, an indicator term for the presence of former

USSR countries is included to allow for the type of country, where in this case two types are considered.

Since border prices include transportation costs, the latter should provide explanatory power. As is assumed in the illustrative model, transportation costs will be modeled as a function of distance from country i to Moscow and the total quantity of Russian gas imports. In particular,

$$t_i^R(DR_i, Q_i^R) = DR_i + DR_i \times Q_i^R \tag{8}$$

This specification reflects the fact that pipeline transmission contracts are formulated by volume and distance measures.

Furthermore, since the vast majority of the contracts in the sample period were indexed to crude oil prices (a trend that is finding resistance as of late), a term for Brent crude prices should be included as well. This relates well to the illustrative model since bargaining is performed over a normalized price, the normalization being with respect to crude oil prices. These observations have motivated the following specification of the estimated model:

$$P_{i,t}^R = \beta_0 + \beta_1 \frac{Q_{i,t}^O}{Q_{i,t}^R} + \beta_2 Brent_t + \beta_3 1\{USSR\}_i + \beta_4 DR_i + \beta_5 DR_i \times Q_i^R + \epsilon_{i,t} \tag{9}$$

where $i \in N$, such that N is the set of European countries in the sample. $Q_{i,t}^O$ represents all non-Russian supplied gas, including non-Russian gas imports and domestic production, in country i at time t. DR_i represents the distance from country i to Moscow: the location of Gazprom headquarters. $Q_{i,t}^R$ represents the quantity of Russian imported natural gas for country i at time t, $Brent_t$ represents the yearly average Brent crude price in year t and $1\{USSR\}_i$ is an indicator which takes on a value of 1 if country i was formerly a USSR state and 0 otherwise. The specification of the estimated model is defined so as to incorporate the fact that panel data was used in estimation. As is common with panel data, the error term is specified in the following manner:

$$\epsilon_{i,t} = c_i + v_{i,t} \tag{10}$$

where c_i is a country specific effect and $v_{i,t}$ represents the traditional, white noise error term. The c_i term captures country specific effects which persist through time in the data and which are not explicitly modeled or observable in the data set. One can choose to view the c_i as representing the country's representative negotiator's bargaining skills. These will definitely influence natural gas prices and yet they are almost impossible to observe. It could also represent a country's willingness to forgo energy consumption in the event of exorbitant prices as well as its flexibility in terms of substituting towards other energy sources.

The model includes time invariant parameters which cannot be estimated with the usual fixed effects (FE) approach. These parameters, most notably the effect of being a former Soviet state, are of interest in this study and will provide compelling conclusions. Further, since we are looking at long term contracts, the average Russian dependency is crucial in explaining contract prices and this term would be lost in a fixed effects approach. In fact, the only reason we include a per period relative imports term is to capture the fact that the observed border prices include spot prices. The correlated random effects (CRE) estimation method proposed by Mundlak (1978) is an alternative estimation technique which allows for the inclusion of time invariant parameters. The CRE approach models the correlation between the regressors and fixed effects whereas the FE approach does not specify a distribution for the latter. Essentially, the country specific effect, c_i, in a CRE context, is modeled as:

$$c_i = \psi + \xi \overline{\frac{Q^O}{Q^R}}_i + a_i \tag{11}$$

where $E(a_i|x_i) = 0$, such that x_i is the set of all regressors in c_i.

Fortunately, the estimates from the time varying parameters are robust to violations of the true relationship between the regressors and the country fixed effects using the CRE method.

Prior to discussing estimation strategy, it should be noted that the relative dependency term and the total value of Russian imports are endogenous variables. Since this model is akin to a simultaneous equations model, it is imperative to find proper instruments for the relative and absolute demand of Russian natural gas. Two instruments proposed for this purpose are the heating degree days and the distance from Oslo. Heating degree days constitute the number of degrees by which the temperature is below 18 degrees Celsius (64.4 degrees Fahrenheit). Colder days will naturally have higher heating degree days. Since natural gas is primarily used for heating in Europe, heating degree days should provide an acceptable proxy for the demand of natural gas. We should expect countries with higher heating degree days to have higher demand for natural gas. Moreover, to capture the idea and the importance of outside options for the supply of natural gas, the distance from country i to Oslo, Norway is provided as an instrument. One would expect a country to have a lesser dependency on Russian supplied gas the closer it is located to competing producers of the latter. Norway is chosen as the main competitor since it is Europe's second greatest supplier of natural gas. These instruments are time varying in the case of the heating degrees days variable and time invariant for the case of the distance to Oslo variable.

Given the correlated random effects specification, we assume the correlation between the unobserved effects and the regressors has been modeled and accounted for. Thus, estimation of the model is performed using a pooled instrumental variables method using clustered errors on countries. The robust estimates are presented below in Table 1.

Table 1: Results

	Russian Price
$\frac{Q^O}{Q^R}$	6.069
	(1.65)
Mean($\frac{Q^O}{Q^R}$)	-18.11****
	(-4.80)
Brent	0.266*
	(2.06)
Soviet	-138.0****
	(-14.07)
$Q^R\times$ Distance from Russia	-1.32e-11
	(-1.11)
Distance from Russia	0.00563*
	(2.14)
Constant	128.2****
	(5.85)
N	57
R^2	0.823

t statistics in parentheses

* $p < 0.1$ ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$

Interestingly, there is a statistically significant, negative coefficient on the average over time, by country, of the main variable of interest. These results imply that as a country decreases its average dependency on Russian supplied natural gas, it experiences a decrease in Russian natural gas prices. This bodes well with the idea that as a country increases its outside options it should negotiate more favorable terms with its counterparty. Further, the sign of the average relative supply term is consistent with results from the illustrative model. Curiously, the empirical results suggest that it is the average dependency over the time span, and not the current year dependency, which explains the price variation. Upon reflection, this is a rather intuitive result. Contracts are negotiated over long time spans. A change in the dependency of Russian supplied gas in one year is unlikely to affect Russian pricing if that change is not consistent. Negotiators would take the average dependency and behavior of a country much more seriously than a one or two year change in consumption patterns when determining prices. If a country persistently has access to other sources of natural gas, it would likely exhibit a greater amount of leverage and bargaining power.

Another feature of note is that the distance of country i from Russia only minimally increases Russian pricing. This result is rather surprising since transportation costs are accounted for in the data. This result should be explored further in future analyses; a consideration of networks and their impact on transportation costs would likely enrich the study and possibly provide different results. Nonetheless, the direction of its sign is in line with expectations from the model.

As expected, having been a former USSR country does provide discounts for natural gas prices. However, heavy reliance on Russian gas can dominate the discount from having been a former USSR state, which explains the higher prices faced in many former USSR states, most of whom are completely dependent on

Russian gas. This result also highlights the potential for former USSR states to significantly benefit by a decrease in natural gas prices, should they invest in LNG technology.

Since most contracts are priced relative to crude indices, the significant, positive Brent coefficient is not surprising. As of late, many contracts have resisted crude price indexation; this relationship may not be persistent when considering Russian natural gas pricing in Europe.

One interesting observation is that LNG prices tend to exceed dry natural gas prices. Notwithstanding this, increasing consumption of LNG has been shown empirically, in this study, to decrease prices paid to Russia for dry gas. Importers then have to consider the benefits from investing in regasification terminals to obtain an averaged price of higher cost LNG with lower priced Russian gas, as opposed to a higher price for Russian gas, with no investment costs. The results of this paper should assist in investment decision analysis, having obtained a quantification of the effect of outside options on contracted prices.

7 Examining the Baltic Region

Employing the results of the estimated model, we can reconsider Lithuania's decision to invest in the FSRU Independence and the resulting consequences for Estonia and Latvia. At the time of writing, the average price Lithuania paid to Gazprom in 2016 for natural gas was 18.72 Euros/100 kg.[5] The estimated model does a remarkable job at predicting an average price of 18.79 Euros/100kg in Lithuania for the year 2016.[6] From 2014 to 2016, Lithuanian importers experienced a 61% price decrease from Gazprom. Latvia, by comparison, experienced

[5]This average was calculated using prices from January 2016 to September 2016, the most recent data available at the time of writing, and so most likely underestimates the true average price for 2016

[6]Using statistically significant estimates and average dependency for 2014-2016.

a 39% price decrease, which, according to the empirical model, is explained by the substantial drop in Brent crude prices. Latvia has not yet imported Lithuanian natural gas, despite future plans to do so, and so provides an interesting point of reference for analyzing the effects of diversification of supply. Latvia currently pays 24.39 Euros/100kg of natural gas to Gazprom. The empirical model suggest that if Latvia were to import 20% of its current natural gas demand from the Lithuanian FSRU Independence, it would experience a further 11% price decrease, to 21.59 Euros/100kg. At current consumption levels, this would result in a savings of 17,732,485 Euros.[7] These savings are considerable and not unrealistic as Lithuania currently sells natural gas to Estonia at a lower average price than Gazprom.

The Estonian experience, on the other hand, provides support for the empirical results of the paper: increasing diversification of supply will reduce Gazprom prices. In 2015, Estonia began to import natural gas from both Lithuania and Russia. For the first time in its history, Estonia secured supply from a non-Russian source. In 2016, Estonia imported 12% of its natural gas from Lithuanian sources for an average price of 20.70 Euros/100kg. By way of contrast, it paid an average price of 24.49 Euros/100 kg to Gazprom. This lead to an average import price of 24.03 Euros/100kg, a substantial decrease from its 2014 price of 41.79 Euros/100kg and even its 2015 price of 38.38 Euros/100 kg. The empirical model stipulates that if Estonia were to increase its imports from Lithuania to 20% of total imports, it would be charged 20.77 Euros/100kg by Gazprom. Clearly, there are more gains to be made from diversification and these are likely to occur in the coming years.

The enormous discounts provided from diversification provide support for further investments in the procurement of alternative sources of natural gas. Notwithstanding the higher price of LNG, the rents received from Gazprom are

[7] Assuming Lithuania uses Gazprom prices as a ceiling on Lithuanian prices.

sufficiently high that the price benefits received from higher bargaining power would warrant the investment costs of such an endeavor. The model in this paper has suggested that further price decreases are possible if dependence on Russia is reduced.

8 Conclusion and Policy Implications

Pricing and delivery of natural gas is a concern that particularly interests and affects all those living in temperate and frigid climates, and those interested in the impact of global warming. In Europe, where energy security from Russia is an open and sustained concern, this matter is of pivotal importance. Modeling the bargaining procedure between these countries and estimating the correlations between Russian pricing and access to alternative options has to date been an unexplored exercise which is valuable both at the theoretical and the policy level. With the advent of LNG technology, this issue is more pressing than ever. The results of this paper provide enormous support for continued investment in LNG technology. Empirically, it was shown that as a country invests more in procuring alternative sources of natural gas, it faces lower prices from Gazprom. LNG is providing a new platform with which countries can claim higher portions of the gains from trade. Lithuania was a prime example of this phenomenon and the data emphasizes that this effect should be anticipated to occur in any European country which secures increased, consistent access to alternative sources of natural gas. The potential for reduced pricing is present in Europe and investors need to weigh the benefits of lower prices against the costs of securing LNG import terminals and contracts with alternative suppliers. Interesting streams for future research would include modeling the bargaining process as a network, as opposed to a series of bilateral processes. In fact, countries like Estonia are benefiting from Lithuania's FSRU Independence terminal by being able to purchase alternative natural gas sources from Lithuania, as well as from Russia. This paper has provided evidence that further research should be devoted to understanding the pricing relationship between Gazprom and its European customers.

References

Bertrand, J. (1883). *Review of Walras's Théorie Mathematique de la Richesse Sociale and Cournot's Recherches sur les Principes Mathématiques de la Théorie des Richesses in Cournot Oligopoly: Characterization and Applications. Edited by A. F. Daughety.* Cambridge University Press.(1988).

Dickel, R., E. Hassanzadeh, J. Henderson, A. Honoré, L. El-Katiri, S. Pirani, H. Rogers, J. Stern, and K. Yafimava (2014). Reducing European Dependence on Russian Gas. *OIES Paper NG92*.

Dorigoni, S., C. Graziano, and F. Pontoni (2010). Can LNG Increase Competitiveness in the Natural Gas Market? *Energy Policy 38*(12), 7653–7664.

Egging, R., F. Holz, and S. A. Gabriel (2010). The World Gas Model: A Multi-Period Mixed Complementarity Model for the Global Natural Gas Market. *Energy 35*(10), 4016–4029.

Egging, R., F. Holz, C. Von Hirschhausen, and S. A. Gabriel (2009). Representing Gaspec with the World Gas Model. *The Energy Journal*, 97–117.

Egging, R. G. and S. A. Gabriel (2006). Examining Market Power in the European Natural Gas Market. *Energy Policy 34*(17), 2762–2778.

EIA (2016a). International Energy Outlook 2016. https://www.eia.gov/forecasts/ieo/nat_gas.cfm [Accessed: October,2016].

EIA (2016b). Russia. http://www.eia.gov/beta/international/analysis.cfm?iso=RUS [Accessed: April 20,2016].

Eurostat (2016a). Energy Production and Imports. http://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_production_and_imports [Accessed: April 10, 2016].

Eurostat (2016b). Eurostat International Trade Database. http://ec.europa.eu/eurostat/data/database [Dataset][Accessed July 2016].

Export, G. (2016). Arbitration Factsheet. www.gazpromexport.ru/content/file/110801_arbitration_factsheet.pdf [Accessed: April 1,2016].

Gabriel, S. A., S. Kiet, and J. Zhuang (2005). A Mixed Complementarity-Based Equilibrium Model of Natural Gas Markets. *Operations Research 53*(5), 799–818.

Gabriel, S. A., K. E. Rosendahl, R. Egging, H. G. Avetisyan, and S. Siddiqui (2012). Cartelization in Gas Markets: Studying the Potential for a "Gas OPEC". *Energy Economics 34*(1), 137–152.

Gabriel, S. A., J. Zhuang, and S. Kiet (2005). A Large-Scale Linear Complementarity Model of the North American Natural Gas Market. *Energy economics 27*(4), 639–665.

Gazprom (2016). Europe. http://www.gazprom.com/about/marketing/europe/ [Accessed: April 20,2016].

Hartley, P., K. Medlock III, and J. Nesbitt (2004). Rice University World Gas Trade Model. *James A. Baker Institute of Public Policy. Rice University*.

Hartley, P. R. (2015). The Future of Long-Term LNG Contracts. *Energy Journal 36*(3).

Hartley, P. R. and K. B. Medlock III (2009). Potential Futures for Russian Natural Gas Exports. *The Energy Journal*, 73–95.

Holz, F., C. Von Hirschhausen, and C. Kemfert (2008). A Strategic Model of European Gas Supply (GASMOD). *Energy Economics 30*(3), 766–788.

Moryadee, S., S. A. Gabriel, and H. G. Avetisyan (2014). Investigating the Potential Effects of US LNG Exports on Global Natural Gas Markets. *Energy Strategy Reviews 2*(3), 273–288.

Mundlak, Y. (1978). On the Pooling of Time Series and Cross Section Data. *Econometrica: Journal of the Econometric Society*, 69–85.

Neumann, A. and C. von Hirschhausen (2004). Less Long-Term Gas to Europe? A Quantitative Analysis of European Long-Term Gas Supply Contracts. *Zeitschrift für Energiewirtschaft 28*(3), 175–182.

RFERL (2016). Gazprom's Grip: Russia's Leverage over Europe. http://www.rferl.org/contentinfographics/gazprom-russia-gas-leverage-europe/25441983.html [Accessed: April 20,2016].

Seputyte, M. (2014). Lithuania Grabs LNG in Effort to Curb Russian Dominance.