DOES EU’S ENERGY DEPENDENCE ON RUSSIA INCREASE PRICE VOLATILITY FOR CONSUMERS?

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By

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ABSTRACT

Europe’s dependence on natural gas imports from Russia has raised questions about energy risk and the vulnerability of the European countries, especially after the supply cuts in 2006, 2008, 2009, and 2012. The implementation of the Third Energy Package to finally unify European energy markets by linking the states located on the periphery to the well connected gas hubs in Northern Europe has been slow due to a lack of political will across Europe. This has enabled Russian Gazprom to retain its position as a major player in European markets and hinder any European effort to diversify the energy portfolio of the region. Using residential natural gas and electricity price data from 2000 through 2014, this paper analyzes the impact of EU’s import reliance on natural gas from Russia and the supply disruptions on the volatility of natural gas and electricity prices through a fixed effects regression model. Results indicate that while the size of Russian natural gas imports does not significantly affect natural gas and electricity price volatility in EU countries, security supply measures such as natural gas stocks matter, especially for Southeast European countries that consistently pay more according to the results. The paper concludes by discussing the importance of formulating policies that not only aim to reduce overall EU dependence but minimize Southeastern Europe’s vulnerabilities. Policy suggestions include increasing cross-border interconnectors and storage capacity as well as increasing LNG import capacity by building regasification terminals in periphery countries like Greece, Bulgaria, Romania and Slovenia.
The research and writing of this thesis is dedicated to everyone who helped along the way, especially my thesis advisor, Dr. Andrew Wise.

Many thanks,
Zeynep Yekeler
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I. **Introduction**

The objective of this thesis is to evaluate how Europe’s natural gas dependence on Russia for its imports affects the volatility of natural gas and electricity prices of each country, adjusting for natural gas crises. Using residential natural gas and electricity price data from 2000 through 2014, I will attempt to estimate the impact of import reliance and supply disruptions on European countries, namely Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom. I hypothesize that southeast European countries, namely Bulgaria, Cyprus, Greece, Malta, Romania, Slovak Republic, and Slovenia that are less interconnected by gas pipelines and thus have fewer supply options are more vulnerable to price volatility in the case of supply disruptions.

Falling petroleum and natural gas reserves in the North Sea, the uneconomical potential for coal production, and the EU ‘cap and trade’ system resulted in a shift away from oil and coal towards the cheaper and environmentally friendly alternative of natural gas in the early 1990s. Between 1990 and 2013, natural gas consumption grew from 375.75 billion cubic meters (bcm) to 464.24 bcm,\(^1\) while production fell to 157.14 bcm, thus increasing European reliance on imports, especially from Russia given its largest proven supply of natural gas reserves and transportation and distribution networks. The energy dependence rate of EU-28 countries has grown from 52 percent to 65.3 percent\(^2\) in

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\(^1\) Eurostat Gross Inland Energy Data from Data section.

\(^2\) Eurostat Energy Balances Data from Data section.
the past decade and this is attributed to the Russian imports that constitute 40 percent of total trade movements.\(^3\)

Europe’s dependence on Russia to meet its increasing energy demand has increased market vulnerability to supply disruptions, especially in less diversified, less connected and low storage capacity states using natural gas for electricity generation. The largest Russian natural gas company Gazprom’s cut of supplies to Belarus and Ukraine over pricing disputes in 2005 to 2006, 2009 and 2014 have shown that Russian energy policy and diplomatic relations with former Soviet Union countries, through which the majority of existing operational pipelines run, can result in a serious energy crisis in Europe.

Although EU countries have passed legislative packages to ensure secure, competitive and sustainable supply of energy under the Europe 2020 strategic plan, European countries still do not have a genuinely integrated single energy market. The lack of a unified, single market in natural gas that functions according to supply-demand principles has perpetuated Russian monopoly on European natural gas import supply, hence hindering the goal of diversifying EU’s electricity generation portfolio. The Third Energy Package of 2009, a regulatory reform in Europe, which included ownership unbundling of the generation, transmission and distribution of energy to weaken the market power of transmission network operators, has been slow in implementation due to the lack of political will. Cooperation between Gazprom and European energy companies (including EON-Ruhrgas, BASF, Eni, Gaz de France, DONG Energy, Bulgargaz), differing energy interests of EU states and Russia’s manipulation of environmental

\(^3\) BP 2015 Statistical Review.
movements to hinder development of local gas production and transit infrastructure has helped Russian interests.\textsuperscript{4}

The thesis proceeds as follows. In Section II, I will provide background information on European natural gas markets and review primary literature that looks at the European energy security challenges in light of increasing natural gas imports. Section III will establish the conceptual model. In Section IV, I will outline the data used in this thesis. In Section V, I will explain the empirical model estimate. In Section VI, I detail the results of my estimation. In the last section, I will conclude and discuss relevant policy recommendations.

\textsuperscript{4}Shaffer, B. (2014).
II. Background and Literature Review

A. Background

This section provides background on EU natural gas policy, the rise of natural gas use in Europe, state of Europe’s energy market, and how Russia maintains its power as the major supplier of natural gas to Europe, especially in the southern and southeastern European countries.

With the exception of the 2008 to 2013 period, when a global economic crisis combined with low coal and CO₂ prices and mild winters decreased the demand, natural gas use in Europe has been steadily increasing at an average annual rate of 1.8 percent since the early 1990’s. The increase in the natural gas market share is attributed to several factors including; (i) Europe’s need to diversify away from oil and coal; (ii) implementation of the EU Emission Trading Scheme; (iii) a preference for low-carbon combined cycle gas turbine (CCGT) plants in electricity generation; (iv) the need for a thermoelectric back-up source to meet shortfalls of the growing renewable energy industry in peak or off-season times; (v) the increasing availability of LNG liquefaction plants and regasification terminals; and (vi) the growing natural gas transportation and distribution networks that can conveniently supply the regional demand in electricity generation, industry, residential heating and transportation.

Lower CO₂, sulfur and mercury emissions in the processing and burning of natural gas compared to other fossil fuels have also helped natural gas gain a somewhat environmentally friendly reputation and displace other fossil fuels to an extent. The majority of the gas demand in Europe is met by Russia, the second largest gas producer.

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5 My own calculation using the EIA Natural Gas consumption data from EIA.
in the world. Between 2000 and 2014, OECD Europe imports of natural gas grew at a 1.23 percent annual average rate from 119 bcm to 141 bcm. While the International Energy Agency’s 2015 World Energy Outlook predicts that OECD Europe imports from Russia will contract by 10 bcm (or more depending on the policy scenario) by 2040, the projections show that European dependence on Russian gas imports will remain high as it can be seen from trends in Graph 1 and Graph 2 in the Appendix.

In this regard, however, it is important to distinguish between dependence and vulnerability. Many OECD European countries are dependent on Russia. However, as Percebois points out, a country should not be considered vulnerable if it imports majority of its energy at sustainable costs, and has a diverse portfolio of supply and a domestic decision center for energy policy, as demonstrated in Graph 6 in the Appendix.

Nonetheless, Europe’s dependence on natural gas imports from Russia has raised questions about energy risk and the vulnerability of the member countries, especially after the supply shortfalls in January 2006, December 2008 to January 2009, and 2012 during the winter gas consumption peaks. In addition, the supply cuts and ensuing tensions between Ukraine and Russia in 2005 to 2006 have raised a question about Russia’s use of its “gas weapon,” and prompted charges that the major Russian producer Gazprom uses tariffs and contracts to advance the government’s geopolitical motives and undermine European energy security.

Three main aspects of Russian energy policy increase energy vulnerability in the EU states:

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7 IEA World Energy Outlook 2015 (p.221).
8 Percebois (2007).
1. Rising Russian domestic consumption and falling Russian gas production

In Russia, the combination of generous oil and gas subsidies, growing domestic demand, the growth of energy intensive industries (chemicals and petrochemicals, iron and steel, cement and aluminum) and export commitments to European and Asian countries necessitate a continuing increase in domestic gas production. However, many have voiced concern that domestic production might not be sufficient to keep up with the growth in domestic demand, estimated at 562 bcm in 2020 and 608 bcm in 2030.\(^9\)

In addition, a highly politicized Russian gas market catering to highly inefficient users as a result of the dual pricing system leaves Gazprom without the domestic profits that it needs to invest in the declining major fields (Yamburg, Urengoy and Medvezh’ye in Yamal, Western Siberia) that make up 60 percent of its total production.\(^10\) The dual pricing system requires Gazprom to first meet domestic demand at subsidized prices and then sell the rest to the European market at predetermined (contract) prices. Victor, et al., estimate that production in these three major fields will decrease by five percent annually between 2008 and 2020, and fall to 140 bcm by 2020.\(^11\) Development of the Shtokman field in the South Barents Basin, which is estimated to hold 3.8 trillion cubic meters of gas that would meet the demand from Europe, was shelved amid increasing costs, falling EU demand and the American shale gas boom in 2012.

According to Solanko and Sutela,\(^12\) Gazprom’s solution, of increasing Central Asian gas imports to a quarter of its exports to make up for its lagging investment, could

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fail given the competition among other buyers, price pressures, and availability restrictions, as demonstrated by the price dispute between Gazprom and Turkmengaz, the national gas company of Turkmenistan.\textsuperscript{13}

Soderbergh, Jakobsson, and Aleklett (2010) note that production in giant gas fields owned and operated by smaller Russian oil and gas companies Lukoil, Surgutneftegaz, TNK-BP and Rosneft that could serve EU’s increasing import demand could face uncertainties due to the channeling of money to their large oil projects and the reluctance to increase gas production capacity in a market that Gazprom controls through its ownership of the transmission system.\textsuperscript{14} Gazprom’s power in the market has in fact forced these producers to flare up so much of their associated gas (as much as 24 percent of production)\textsuperscript{15} that the Russian government passed laws to reduce flare levels.

2. Russian shift to Asian markets

Falling prices, shrinking demand, and deteriorating access to the EU market (as a result of EU’s gas market liberalization and terms of ownership unbundling) have worsened Russian perception of the security of EU demand.\textsuperscript{16} Consequently, Russia has begun to find trading partners less beholden to Europe and shifted its oil and gas strategy eastward to supply Asian and Pacific Rim markets with the gas production from Eastern Siberia and the Far East regions, reducing the future available gas supply for European and former Soviet Republics markets. The Russian Far East’s limited gas transport network and proximity to China has encouraged Russia to move towards the lucrative

\textsuperscript{13} \url{http://thediplomat.com/2015/07/russia-takes-turkmenistan-to-court-over-the-price-of-gas/}, visited [November 10\textsuperscript{th}, 2015].
\textsuperscript{14} Soderbergh, Jakobsson, Aleklett (2010) p.7829.
\textsuperscript{16} Shadrina (2014) p.56.
North East Asian market where large LNG importers Japan and South Korea, and the rapidly growing Chinese energy market demand significant import volumes at above-market prices. Shadrina reports that the Asia Pacific shares of total exports from Eastern Siberia and Russia’s Far East could rise from 11 to 12 percent between 2013 and 2015 to 19 to 20 percent between 2021 and 2030.18

3. Existing long-term oil-indexed contracts that result in rigid and unfair pricing

When natural gas use was growing in the 1980s and 1990s, markets were regional and necessitated the formation of long-term alliances through long-term contracts. Gas was seen as a substitute for oil, so its price was linked to the oil price where the “seller assumes the price risk, connected with oil price dynamics, whereas the buyer assumes the volume risk through the so called ‘take or pay’ clause, which sets a minimum volume of natural gas to be retired each year.”19 As the transportation of natural gas became safer and cheaper with the advances in LNG terminals, the gas market became more globalized, and it made less sense for EU countries to enter oil-linked contracts. Instead, the idea of gas trading hubs, where gas would be exchanged between owners in a transparent market driven by supply and demand fundamentals became more popular. Higher levels of gas trade meant that the prices would move closer to the clearing price and prevent unfair pricing.

Although the EU’s Third Energy Legislation Package in 2009 took steps in liberalizing the electricity and gas markets by allowing third party access and requiring ownership unbundling (separation of generation and sale operations from transmission network ownership), members have been slow to implement the package fully. As a

17 Ibid., p.58.
18 Shadrina (2014).
result, with consumers having access to different providers at different prices, this has kept European prices high and made imports cheaper. However, increases in the flow of LNG have made hub pricing more popular and hub-priced gas volume has increased from 15 percent of the total volume in 2005 to 50 percent in 2013. The Columbia Center on Global Energy Policy research concluded that the increase in U.S. LNG exports to Europe had an impact on Russian natural gas export revenue by pressuring Gazprom to renegotiate contracts and reduce prices to decrease the significant spread between oil-indexed and spot natural gas prices in Europe. See Graph 7 in the Appendix for details on the spread between hub prices and contracts and the renegotiated contracts between European companies and Gazprom.

Although Gazprom has renegotiated several contracts to include hybrid pricing formulas and agreed to sell more gas at spot prices via the Nord Stream II pipeline between Russia and Germany, signaling a shift to hub pricing in some of its dealings with European gas companies, LNG exports from U.S. are too small to free EU from Russian gas dependence or increase its bargaining position significantly. Increased hub trading, LNG exports and contract renegotiations have largely benefited the Northwest and Central Europe by increasing gas on gas competition from 28 percent to 88 percent and from zero to 50 percent between 2005 and 2014 respectively, while Southeast European gas competition only increased by 4 percent in the same period.

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20 Vladimir Urutchev (2014).
23 Ibid., p.3
B. Literature Review

This section reviews the literature on European energy security and the implications of Russian energy policy in Europe’s natural gas supply. Academic discussion regarding the energy vulnerability of Europe and energy relations between the EU and Russia has focused on four main questions:

• Does the level of supply dependence translate to energy vulnerability for the European countries?

• Can Russia use its market power as a weapon in the international geopolitical game?

• Which countries are the most vulnerable to supply disruptions?

• What can European countries do to reduce their energy vulnerability? How can they diversify energy supplies?

1. European supply dependence

Weisser groups the risks involved in supply dependence in four categories: source dependence, transit dependence, facility dependence, and structural risks in addition to major sources of risk such as natural disaster, political blackmail and terrorism. He predicts that OECD Europe’s source dependence will increase from 36 percent to 69 percent between 2002 and 2030, and notes that the concentration of pipelines, especially in the eastern countries of the EU, also creates transit dependence. In addition, he argues, gas supply logistics that stem from monopoly regimes create facility dependence, and combined with the previous two factors, could increase structural risks and create supply disruptions that affect national accounts beyond the direct cost market participants.

Urutchev notes that despite all efforts, European dependence on Russian gas increased to a record level in 2013 due to the EU’s failure to build pipelines to other

suppliers. He argues that the dependence will continue since the planned pipeline projects South Stream and Nabucco have failed and the Trans Adriatic Pipeline is far from completion.\textsuperscript{26}

Reymond points out that the construction of combined-cycle power plants made European electricity producers dependent on natural gas and lowered the elasticity of demand. He calculates that the in 2005 Hirschmann–Herfindhal Index was 2877, which lies in the range where there is a medium degree of concentration for gas imports to the EU.\textsuperscript{27}

2. The Russian gas weapon

Cameron makes the case that Russia has skillfully used energy as a political weapon, especially on the former Soviet Republics with which it has historical, business and cultural ties. He argues that Gazprom uses its market power to offer gas at discounted rates to influence political and economic direction of Russia’s neighbors.\textsuperscript{28} Riley confirms the fact that Russia maintains its sphere of influence by adding sweeteners to the deals of certain states, by offering the old terms of $50 per thousand cubic meters, or increasing its attempt at energy acquisitions by taking over strategic energy assets directly or via shadow companies.\textsuperscript{29}

On the other hand, Goldthau argues that Russia does not have much leverage over European customers because a credible supply cut threat would mean large revenue cuts for Gazprom. He concludes that the gas disputes with former Soviet Republic countries following price hikes in 2007 are the result of Gazprom’s attempts to equalize prices with

\textsuperscript{26} Urutchev (2014).
\textsuperscript{27} Reymond (2007) p.4174-4175.
\textsuperscript{28} Cameron (2009) p.6.
\textsuperscript{29} Riley, A. (2014, May 20).
Western European clients rather than the result of a geopolitical game and that threats to energy security really lie in lagging upstream investments and Russia’s inefficient use of gas.\(^{30}\) Spanjer adds that while uneasiness with large import dependence is understandable, given Gazprom’s reliance on European revenues, diversification of European supplies from Qatar, Algeria or Iran should ease fears of a political weapon.\(^{31}\)

Gonchar, Martyniuk and Prystayko conclude that the December 2008 to January 2009 Russia-Ukraine tensions and the ensuing two-week supply cut that has since been seen as Russia’s use of its gas weapon really had to do with Gazprom passing the winter consumption peak, while hiding its gas deficit problem behind transit issues with Ukraine but later turned this event into a means to attain its political goals.\(^{32}\)

Kolb adds to the discussion by pointing out that Russia has exercised control over the former Soviet republics Turkmenistan, Kazakhstan, Azerbaijan, Georgia, Armenia, Tajikistan, Kyrgyzstan, and Uzbekistan by using its Soviet-era pipeline system to link the Caucasus and Caspian providers and European consumers of energy,\(^{33}\) and thus has charged European consumers triple or quadruple times the regular price by reselling cheap Central Asian gas in the underdeveloped EU natural gas market.\(^{34}\) Russian policy to define the Caspian as a ‘unique inland water basin’ has impeded cooperation between Azerbaijan, Kazakhstan, and Turkmenistan.\(^{35}\)

It should also be noted that the cancellation of the Nabucco pipeline project, which would transport Azeri gas from the Caspian starting from Turkey to Austria, has

\(^{30}\) Goldthau (2007).
\(^{31}\) Spanjer (2006).
\(^{33}\) Kolb (2011)
\(^{34}\) Bryza, M. (2014, May 20).
\(^{35}\) Bilgin (2009).
helped Russia retain its high market share in the vulnerable transit countries (Bulgaria, Romania and Hungary).

3. Energy vulnerability of European countries

Coq and Paltseva’s study measuring the short-term risk to the security of energy supply in the EU finds that Bulgaria, Czech Republic, Hungary, Latvia, Lithuania, Romania and Slovak Republic are high-risk countries that lack a diversified external gas supply and have low substitutability among oil, gas, and coal in the case of sudden supply disruptions.\textsuperscript{36} Locatelli points that the Shannon-Wiener index, a measure of diversity of importers, shows that Poland, Hungary, Romania and Lithuania are among the highly vulnerable states due their heavy reliance on Russian imports.\textsuperscript{37} Shaffer explains that the vulnerability of southern and southeastern Europe is caused by the fact that the Europe does not have a well-connected pipeline network and, therefore, states located on the periphery have to rely on a single source, Russia, and its prices.\textsuperscript{38}

Christie argues that an indicator should measure the vulnerability by linking gas supplier failures to economic losses instead of arbitrary non-linear transformations like the Herfindahl-Hirschman or the Shannon-Wiener index examples in the literature.\textsuperscript{39} Christie recommends using volumes of expected natural gas shortfall given a certain confidence level which can be used to model expected economic losses given a country’s fuel intensity of GDP.

My contribution adds to the existing literature by assessing the degree of European natural gas vulnerability depending on the economic effects of price variability.

\textsuperscript{36} Coq, C., & Paltseva, E. (2009).
\textsuperscript{37} Locatelli, C. (2013).
\textsuperscript{38} Shaffer, B. (2014).
\textsuperscript{39} Christie, E. (2009).
and supply disruptions. I will look the time period of 2003 to 2014, which has not yet been assessed in the academic literature. Examining more recent data will also allow me to assess whether Russian-Ukraine tensions have had an impact on the energy relations between Russia and peripheral European countries that depend on the natural gas transit from pipelines crossing Ukraine.

Next, I describe the theoretical framework that guides my empirical analysis.
III. **Theoretical Framework**

In order to examine whether high levels of Russian natural gas import dependence results in adverse economic effects of price variability, I develop the theoretical models below. These models will illustrate the factors that determine natural gas and electricity prices.

(1) Residential Natural Gas Price = f (Dependence, Market Conditions, Heating Degree Days, Geopolitical conditions, e)

(2) Residential Electricity Price = f (Dependence, Market Conditions, Geopolitical conditions, Natural Gas Consumption, e)

Where Dependence factors are Energy Self Sufficiency Index and total natural gas imports coming from Russia.

The logic behind the first model is that the natural gas prices are a function of natural gas market conditions, number of heating degree days, and geopolitical conditions affecting EU countries’ gas supplies. I am interested in looking at how the dependence measure affects the natural gas prices. I expect that as the natural gas imports coming from Russia increases in the total share of natural gas imports, the price volatility will also increase due to supply vulnerability. Countries with higher energy self-sufficiency (various supply options) are expected to have greater bargaining power and contract gas at lower prices.

The logic behind the second model is that the residential electricity price is a function of similar market conditions and geopolitical conditions that affect natural gas prices. The correlation coefficient between percent change in natural gas residential price and percent change in electricity residential price was 0.39, showing that there is some
positive correlation between the two. I expect that the dependence variable will have a similar effect on electricity prices. This could be due to higher natural gas prices and higher energy import bills that result from the high energy dependence of the country, which would prompt power generation companies to hike prices.

In the next section, I describe the data I use.
IV. Data and Descriptive Statistics

I use data from three main sources; the OECD iLibrary database, the EU European Commission Eurostat database and World Bank database. This produces a panel dataset with the variables Natural gas production, natural gas imports, natural gas consumption, natural gas price, total natural gas imports from Russia, total energy consumption, total energy production electricity generation, electricity consumption, industrial production index, annual GDP, real GDP growth, net FDI inflows, net exports, government expenditure and government revenue for each year between 2000 and 2014 for the European countries mentioned. Data for heating degree days, and energy related variables are collected from the International Energy Agency (IEA) database on Energy Balances, Natural Gas and Electricity through the OECD iLibrary website, while macroeconomic data on exports, government expenditure, government revenue are collected from the European Union’s Eurostat database. Population and GDP data are collected from the World Bank database.

One issue with the collection of the data has been the availability of data for European countries that are not part of the OECD, specifically Bulgaria, Croatia, Cyprus, Latvia, Lithuania, Malta, and Romania. I have been able to find data for these excluded countries from the Eurostat website for the macroeconomic indicators, but natural gas industrial prices, coal and petroleum prices are missing from the Eurostat website.

My attempts to convert oil, coal, natural gas, and electricity prices from national currencies to USD using exchange rates from January 1st of each year have been unsuccessful. The results were not meaningful and this could be the result of the tons of oil equivalent/ national currency unit that was used in the original dataset. This prompted
me to generate year to year percentage change versions of each price variable to get rid of units and look at how the control variables affected the volatility in natural gas and electricity prices.

I believe that I have used best available and reliable data sources. The following table presents descriptive statistics for my data.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Observations</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government Expenditure</td>
<td>289</td>
<td>45.08</td>
<td>6.57</td>
<td>32.1</td>
<td>65.5</td>
</tr>
<tr>
<td>Government Revenue</td>
<td>289</td>
<td>42.64</td>
<td>6.95</td>
<td>32.1</td>
<td>58.6</td>
</tr>
<tr>
<td>Exports</td>
<td>347</td>
<td>58.50</td>
<td>34.01</td>
<td>18.5</td>
<td>203.3</td>
</tr>
<tr>
<td>FDI inflows</td>
<td>311</td>
<td>5.35</td>
<td>7.93</td>
<td>0.005</td>
<td>74.752</td>
</tr>
<tr>
<td>Electricity Output</td>
<td>444</td>
<td>121.21</td>
<td>154.87</td>
<td>0.42</td>
<td>634.38</td>
</tr>
<tr>
<td>Electricity Consumption</td>
<td>444</td>
<td>113.89</td>
<td>142.95</td>
<td>1.68</td>
<td>594.71</td>
</tr>
<tr>
<td>Industrial Index</td>
<td>360</td>
<td>98.93</td>
<td>14.18</td>
<td>53.9</td>
<td>128.7</td>
</tr>
<tr>
<td>Oil Imports</td>
<td>444</td>
<td>16.49</td>
<td>38.66</td>
<td>-157.41</td>
<td>132.36</td>
</tr>
<tr>
<td>Energy Self-Sufficiency Index</td>
<td>444</td>
<td>0.70</td>
<td>1.34</td>
<td>0</td>
<td>9.43</td>
</tr>
<tr>
<td>Natural Gas for Main Activity Producer</td>
<td>257</td>
<td>3732.94</td>
<td>6365.5</td>
<td>0</td>
<td>29602</td>
</tr>
<tr>
<td>Natural Gas Consumed by Industry and</td>
<td>264</td>
<td>13963.31</td>
<td>18694.95</td>
<td>245</td>
<td>68744</td>
</tr>
<tr>
<td>Natural Gas for Main Heat Plants</td>
<td>264</td>
<td>272.49</td>
<td>611.79</td>
<td>0</td>
<td>3972</td>
</tr>
<tr>
<td>Natural Gas for Combined Heat and Power</td>
<td>257</td>
<td>2049.17</td>
<td>3577.25</td>
<td>0</td>
<td>15519</td>
</tr>
<tr>
<td>Natural Gas for Residential Consumption</td>
<td>264</td>
<td>5852.78</td>
<td>9048.52</td>
<td>2</td>
<td>35940</td>
</tr>
<tr>
<td>Natural Gas for Industrial Consumption</td>
<td>264</td>
<td>4520.05</td>
<td>5860.61</td>
<td>122</td>
<td>24857</td>
</tr>
<tr>
<td>Natural Gas Opening Stock</td>
<td>288</td>
<td>2002.61</td>
<td>3578.36</td>
<td>0</td>
<td>18864</td>
</tr>
<tr>
<td>Unemployment (%)</td>
<td>337</td>
<td>8.36</td>
<td>4.33</td>
<td>2.251434</td>
<td>27.46715</td>
</tr>
<tr>
<td>Natural Gas Imports from Russia</td>
<td>360</td>
<td>5509.78</td>
<td>8647.99</td>
<td>0</td>
<td>39977</td>
</tr>
<tr>
<td>Natural Gas Closing</td>
<td>288</td>
<td>2056.21</td>
<td>3601.16</td>
<td>0</td>
<td>18864</td>
</tr>
</tbody>
</table>
I next present the empirical model I estimate, and my expectations for the results.
V. **Empirical model**

I estimate the following equations, both with OLS and fixed effects, for a total of four regressions. I then do the same after dropping HDD for equation 3 to maximize the number of observations. Thus, I present a total of 5 regressions.

(3) Natural Gas Price (percentage change) = $\beta_0 + \beta_1 \text{Population} + \beta_2 \text{Energy Self-Sufficiency Index} + \beta_3 \text{Natural Gas Imports from Russia} + \beta_4 \text{GDP percentage change} + \beta_5 \text{Russia-Ukraine-Belarus Crisis} + \beta_6 \text{Southeast Europe} + \beta_7 \text{Heating Degree Days} + \beta_8 \text{Industrial Index} + \mu$

(4) Residential Electricity Price (percentage change) = $\beta_0 + \beta_1 \text{Electricity Output} + \beta_2 \text{Residential Natural Gas Consumption} + \beta_3 \text{Industrial Natural Gas Consumption} + \beta_4 \text{Industrial Index} + \beta_5 \text{GDP percentage change} + \beta_6 \text{Natural Gas Imports from Russia} + \beta_7 \text{Natural Gas Opening Stock} + \beta_8 \text{Population} + \beta_9 \text{Southeast Europe} + \mu$

**Dependent Variable Descriptions**

Natural Gas Residential Price (percentage change): Year-on-year percentage change in residential natural gas price.

Residential Electricity Price (percentage change): Year-on-year percentage change in household electricity price.

**Independent Variable Descriptions**

Population: Population of residents in the country in millions.

Energy Self-Sufficiency Index: Ranges from 0 to 1, 0 shows total dependence on energy exports while 1 shows total self-sufficiency meaning all energy needs are met by internal energy sources.

Natural Gas Imports from Russia: Total annual volume of natural gas imported from Russia, in million cubic meters.

GDP percentage change: Year-on-year percentage change in Annual Gross Domestic Product.

Russia_Ukraine_Belarus_Crisis: Dummy variable that equals 1 for years 2005, 2006, 2009 and 2014 due to Russian natural gas supply cut to Ukraine or Belarus that year, and 0 otherwise.

Southeast Europe: Equals 1 if the country is Bulgaria, Cyprus, Greece, Malta, Romania, Slovak Republic, or Slovenia, and 0 otherwise.
**HDD (Heating Degree Days):** The total number of days in a year when average daily temperature is below 18 °C (heating threshold).

**Industrial Index:** Total annual industrial production, compared to the base year of 2010, between 0 and 100.

**Electricity Output:** Total annual electricity generation from all sources of energy for the observation, in TWh.

**Residential Natural Gas Consumption:** Annual amount of natural gas consumed by households, in million cubic meters.

**Industrial Natural Gas Consumption:** Annual amount of natural gas consumed by the industry, in million cubic meters.

**Natural Gas Opening Stock:** Total volume of gas stored from the previous year in the country available for the market, in million cubic meters.

**Government Expenditure:** Total annual government expenditures as a percent of GDP.

**Government Revenue:** Total annual government revenues as a percent of GDP.

**FDI Inflow:** Total annual foreign direct investment measured in millions of USD.

**Exports:** Annual exports of goods and services as a percent of GDP.

**Unemployment:** Percent of the labor force that is unemployed

**Electricity Consumption:** Total annual electricity consumption for the observation, in TWh.

**Electricity Industry Price:** Average retail electricity price for industrial consumption, (nat. cur./toe NCV).

**Electricity Industry Price (percentage change):** Year-on-year percentage change in industrial electricity price.

**Electricity Residential Price:** Average retail electricity price for household consumption, (nat. cur./toe NCV).

**Natural Gas for Main Activity Producer Electricity Plants:** Annual amount of natural gas consumed by Main Activity Producer Electricity Plants, in million cubic meters.
**Natural Gas for Main Heat Plants:** Annual amount of natural gas consumed by Heat Plants, in million cubic meters.

**Natural Gas for Combined Heat and Power Plants:** Annual amount of natural gas consumed by Combined Heat and Power Plants (CHP), in million cubic meters.

**Natural Gas Electricity Generation Price:** Average retail natural gas price for electricity generation purposes, denominated in national currency (nat. cur./toe NCV).

**Natural Gas Industry Price:** Average retail natural gas price for industrial consumption, (nat. cur./toe NCV).

**Natural Gas Residential Price:** Average retail natural gas price for household consumption, (nat. cur./toe NCV).

**Coal Electricity Generation Price:** Average retail steam coal price for electricity generation purposes (nat. cur./toe NCV).

**Oil Price:** Average retail price of regular unleaded petroleum for residential users (nat. cur./toe NCV).

\[ \text{Natural Gas Residential Price (percentage change) and Electricity Residential Price (percentage change) will be the main dependent variables in my models.} \]

Population, energy self-sufficiency index, natural gas imports from Russia, percent change in GDP, Russia-Ukraine-Belarus Crisis, Southeast Europe, Heating Degree Days, and Industrial Index are control variables that will account for the factors that affect the natural gas markets. The issue with including only the European set of energy market conditions is that I will only look at European demand and exclude variables affecting Russian gas supply due to the lack of data. I will use a reduced form equation to rather than a general equilibrium equation.

\[ \text{Electricity output, residential natural gas consumption, industrial natural gas consumption, industrial index, percent change in GDP, natural gas imports from Russia, natural gas opening stock, population, Southeast Europe are control variables that will be used to isolate the effect of natural gas imports from Russia on residential electricity} \]
prices. I have excluded HDD from all but Models 1 and 2 this model to due the lack of data between 2009 and 2014.

Given my hypothesis that higher natural gas imports from Russia and hence dependence, result in higher volatility in natural gas and electricity prices, I expect to find the following results.

**Population**

Countries with higher populations have higher total energy import bills, which can result in higher natural gas and electricity bills, making the country more vulnerable to the price volatility.

**Energy Self-Sufficiency Index**

It is not possible to determine whether higher energy self-sufficiency will have a positive or negative effect on natural gas and electricity price volatility. Some energy producers subsidize energy prices, especially if energy is considered a public good. Or other countries that increasingly rely on renewable energy might continue to experience price volatility due to the seasonal nature of renewable energy and inability to store it.

**Natural Gas Imports from Russia**

Higher amounts of natural gas imports from Russia are expected to result in price volatility due to the fact that majority of Russian natural gas contracts are oil-indexed and Russia can use its monopoly power to renegotiate contracts for more favorable deals for Gazprom.
GDP percentage change

It is not possible to determine whether higher GDP volatility would result in higher price volatility. Correlation results supported my expectation as I found no correlation between energy prices and the GDP change variable.

Russia-Ukraine-Belarus Crisis

Years in which Russia had a natural gas crisis with Ukraine or Belarus, namely 2005, 2006, 2009 and 2014, are expected to result in higher natural gas and electricity price levels and volatility because cuts in natural gas flows, even if they last for only several days, lower natural gas stocks of EU countries and hike natural gas hub prices.

Southeast Europe

Due to the fact that southeastern Europe does not have a well-connected pipeline network and the countries often have to rely on a single source, Russia, and its prices, I expect that southeastern European countries have higher natural gas and electricity price levels and volatility.

Heating Degree Days

As the total number of days in a year when average daily temperature is below 18 °C increases, so does the demand for natural gas for that country. I expect that countries with higher heating degree days have more seasonal peaks in demand and experience more higher price levels and natural gas and electricity price volatility.

Industrial Index

Industrial energy consumption constitutes a significant share of total energy consumption in many countries. At the same time, industrial energy consumption is considered interruptible and the industrial sector experiences large power cuts during energy
shortages so the bigger the industry, the more likely it is that the natural gas and electricity prices will be volatile.

**Electricity Output**

Higher electricity output is expected result in higher price volatility, especially if the majority of the electricity is generated from natural gas and if the electricity generation plants are not dual-fuel plants.

**Residential Natural Gas Consumption and Industrial Natural Gas Consumption**

Higher residential and natural gas consumption is expected to result in higher price levels and volatility because countries with higher energy consumption are more prone to energy shortages during peak times.

**Natural Gas Opening Stock**

Natural gas stocks act as a buffer stock during energy shortages and natural gas cuts so the higher the opening stocks in a given year, the lower the price levels and volatility in natural gas and electricity prices.

I next discuss the results from my estimations.
VI. Results

As noted previously, I ran a total of five regressions on models 3 and 4. Overall, I have achieved somewhat robust results, with R-squared values ranging from 0.05 to 0.104 and sensitivity analysis shows that the results were consistent across different regressions. I do not report F statistics because the use of heteroskedastic robust standard errors suppress this statistic in Stata, but separate regressions show significant F statistics. The Ramsey reset test for Model 1 and 4 indicated that the models are appropriate and there are no independent variables that are highly correlated with each other.

My estimation results for how import reliance on Russia and natural gas supply disruptions impacts the European residential prices of natural gas and electricity are presented in tables 2 and 3. My first set of specifications appears in table 2. I regress *Natural Gas Residential Price (percentage change)* on *total natural gas imports from Russia, Russia-Ukraine-Belarus Crisis and Southeast Europe*, while controlling for *energy self sufficiency, GDP, heating degree days (as proxy for natural gas demand), and industrial production*.

### Table 2: Summary of Regression Results

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<tr>
<td>Population</td>
<td>1.74e-09**</td>
<td>7.74e-10</td>
<td>2.26</td>
<td>1.74e-9***</td>
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<td>-0.06</td>
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<td>0.0216</td>
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<td>Natural Gas Imports from Russia</td>
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<td>GDP (% change)</td>
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<td>-2.40</td>
<td>-4.65e-14***</td>
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<td>-3.17</td>
<td>-2.39e-14***</td>
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<td>Russia-Ukraine-Belarus Crisis</td>
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<td>-1.84</td>
<td>-0.0312*</td>
<td>0.0168</td>
<td>-1.86</td>
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<td>0.0000318**</td>
<td>0.0000</td>
<td>2.37</td>
<td>(dropping the HDD variable)</td>
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### Table 2: Summary of Regression Results

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<tr>
<td>Industrial Index</td>
<td>0.0007</td>
<td>0.0007</td>
<td>0.99</td>
<td>0.0007</td>
<td>0.0008</td>
<td>0.88</td>
<td>-0.0007</td>
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<td>cons</td>
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<td>0.0940</td>
<td>-1.09</td>
<td>-0.1022</td>
<td>0.1078</td>
<td>-0.95</td>
<td>0.1162**</td>
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<td>R-Squared</td>
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<td>0.1047</td>
<td>0.0660</td>
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*90% significance level, **95% significance level, ***99% significance level

In Model 1, my variables of interest, *Natural gas imports from Russia* and *Southeast Europe* are not significant in the OLS estimation, however *Russia-Ukraine-Belarus Crisis* is marginally significant at the 90 percent level of confidence. Natural gas supply cuts from Russia to Ukraine or Belarus, holding all else constant, causes a 3.1 percent decrease in the *Residential Natural Gas Price volatility*, which does not support my hypothesis that Russian natural gas company Gazprom’s cut of supplies to Belarus and Ukraine over pricing disputes in 2005 to 2006, 2009 and 2014 have increased the price of natural gas for European consumers. *Population* and *heating degree-days* are both positive and significant at the 95 percent level of confidence, indicating that higher demand results in higher natural gas prices, but only marginally important given the small size of the coefficients. Ceteris paribus, an increase of 1 million people increases the *Residential Natural Gas Price volatility* by 0.00174 percent.

*Energy Self-Sufficiency Index* is insignificant but the point estimate of the effect indicates that there is a negative relationship between *energy self-sufficiency* and *Residential Natural Gas Price volatility*. This could be the result of non supply-demand factors in play, such as diplomatic relations between European countries and Russia. *Natural gas imports* from Russia is also insignificant but positive, which I had anticipated.
in my hypothesis that the Residential Natural Gas Price volatility would increase as European countries increasingly depend on Russia to meet their domestic demand.

In fixed effect models 2 and 3, the significance level for estimated coefficients of population, GDP change and Russia-Ukraine-Belarus Crisis increase and Southeast Europe variable becomes significant at 90 percent and 95 percent levels respectively.

The improvement in results show that fixed effects models have fixed some of the omitted country-specific effects that are fairly constant over time, such as natural gas storage capacity and maintenance, number of dual-fuel plants, LNG import capacity, connections to electricity and natural gas supplies in neighboring states etc. that affect the security of supply for each state. Similar to Model 1, population and GDP change variables are positive and highly statistically significant at the 99 percent level of confidence, however the size of the coefficients are indicating that European countries with larger populations and economies pay slightly higher prices, however only by 0.00174 percent for an increase of 1 million people and 0.000046 percent for an increase of $1 billion in GDP.

The size and statistical significance of Russia-Ukraine-Belarus Crisis is the same for model 2, however it slightly increases in significance for model 3 where I have dropped heating degree-days variable and expanded the number of observations from 151 to 257 by including data from 2009-2014 in my regression. Southeast Europe variable becomes highly statistically significant at 99 percent level of confidence for Model 2, and indicates that holding all else constant, southern European countries paid 4.8 percent more for natural gas between 2000 to 2009 and 2.3 percent more between 2000 to 2014.
compared to the rest of Europe. *Energy Self-Sufficiency Index, Natural Gas Imports from Russia* and *Industrial Index* remain insignificant for Model 2 and 3.

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<tr>
<td>Electricity output</td>
<td>-0.0000</td>
<td>0.0000</td>
<td>-1.08</td>
<td>-0.00000868*</td>
<td>0.0000</td>
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<td>Residential Natural Gas Consumption</td>
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<td>8.34e-7</td>
<td>0.15</td>
<td>1.21e-7</td>
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<td>Industrial Natural Gas Consumption</td>
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<td>2.22e-6</td>
<td>-0.65</td>
<td>-1.45e-6</td>
<td>1.21e-06</td>
<td>-1.20</td>
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<td>Industrial Index</td>
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<td>0.0004</td>
<td>0.51</td>
<td>0.0002</td>
<td>0.0005</td>
<td>0.44</td>
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<tr>
<td>GDP ( % change)</td>
<td>-2.23e+8***</td>
<td>7.57e+7</td>
<td>-2.94</td>
<td>-2.23e+8**</td>
<td>9.76e+7</td>
<td>-2.28</td>
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<tr>
<td>Natural Gas Imports from Russia</td>
<td>7.55e-7</td>
<td>6.89e-7</td>
<td>1.10</td>
<td>7.55e-7</td>
<td>5.69e-7</td>
<td>1.33</td>
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<tr>
<td>Natural Gas Opening Stock</td>
<td>-2.04e-6*</td>
<td>1.18e-6</td>
<td>-1.72</td>
<td>-2.04e-6**</td>
<td>9.82e-7</td>
<td>-2.08</td>
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<tr>
<td>Population</td>
<td>1.07e-9***</td>
<td>4.96e-10</td>
<td>2.15</td>
<td>1.07e-9***</td>
<td>3.14e-10</td>
<td>3.40</td>
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<tr>
<td>Southeast Europe</td>
<td>0.0197</td>
<td>0.0126</td>
<td>1.57</td>
<td>0.0197***</td>
<td>0.0065</td>
<td>3.02</td>
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<tr>
<td>cons</td>
<td>0.0126</td>
<td>0.0447</td>
<td>0.28</td>
<td>0.0125</td>
<td>0.0528</td>
<td>0.24</td>
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</table>

Number of observations: 236
F-statistic: 0.0555
R-Squared: 0.0555

*90% significance level, **95% significance level, ***99% significance level

In Model 4 and 5 I look at how the same set of explanatory variables (excluding *Heating Degree Days* and including *Natural Gas Opening Stock*) affect European residential electricity prices. Residential electricity prices were correlated with residential natural gas prices by 0.33, probably due to the fact that majority of the electricity is generated in power stations using combustible fuels, mainly natural gas. The correlation was higher at 0.44 for South European countries as they tend to have one or two major power plants, which makes them more reliant on natural gas and result in a close
relationship between natural gas and electricity prices. Results show that the Models 4 and 5 explain 5.5 percent of the variability of the response data, and this is lower than models 1 and 2.

In conclusion, the results from Models 1, 2 and 3 show that *Natural Gas Imports from Russia* has the anticipated positive relationship with the dependent variable *Natural Gas Residential Price (percentage change)*, but the small size and insignificance of the coefficient shows that we cannot conclude that an increase in Russian gas imports result in increased natural gas prices for European countries. Proxies for demand, *population* and *HDD* are positive and have a statistically significant relationship with *Natural Gas Residential Price (percentage change)*, but their effects are negligible. A 10,000,000 people increase in population would only result in an increase of 0.017 percent in residential natural gas prices. *GDP* and *Russia-Ukraine-Belarus Crisis* are also significant but with a negative relationship that is contrary to what was anticipated in the empirical models. It is surprising that supply disruptions from Russia to Ukraine and Belarus cause a 0.03 percent drop in natural gas prices. The Southeast Europe dummy variable yields the anticipated positive relationship and shows that southeast European countries pay 0.02 to 0.04 percent more for residential natural gas compared to central and Western Europe, ceteris paribus.

Model 4 and 5 show that *population* and *GDP* also have a significant, positive and negative relationship, respectively, on residential electricity prices. In the fixed effects regression model that reduces omitted variable bias by controlling for time-invariant country specific characteristics of each country’s electricity market, we see that Southeast Europe has higher *Residential Electricity Price volatility* by 0.02 percent
compared to central and Western Europe, ceteris paribus. Lastly, *Natural Gas Opening Stocks* have a significant and negative relationship with the dependent variable, meaning that higher amounts of natural gas in storage in a given country decreases *Residential Electricity Price volatility*, but the effect is very minimal, a 0.0000024 percent decrease in *Residential Electricity Prices volatility* for every one million cubic meter increase in *Natural Gas Opening Stocks*.

Next, I conclude and draw policy implications from these results.
VII. Conclusion and Policy Implications

The results partially supported and partially contradicted my hypothesis that higher natural gas imports from Russia and hence dependence, result in higher levels and volatility in natural gas and electricity prices. The Russia-Ukraine-Belarus Crisis had the interesting effect of decreasing volatility for natural gas, though this could be due to the short-lived nature of the supply crisis, as the 2006, and 2007-2008 crises were each resolved within the week. The 2009 Russia-Ukraine gas dispute was the longest period in which Russia cut the natural gas flow for 13 days, completely depriving southeastern European countries. The 2004 Belarus dispute was the longest when Belarus refused to agree to a price hike from $30 to $50/mcm and had to rely on independent producers between February and June.\(^{40}\)

The Southeastern Europe dummy was significant, however, confirming that countries on the periphery indeed pay higher prices for natural gas and electricity due to their inability to diversify energy supplies, consistent with my hypothesis, and their lack of or little interconnectivity to the EU grid due to the slow progress in the European energy union project to connect 28 transmission grids to each other. Results show that Southeastern European states should focus their energy policy on reducing their reliance on Russia for their gas imports and maintain high natural gas stocks to act as buffers during times of supply shortage or gas disputes between Russia and Ukraine or Belarus to reduce volatility.

The policy implications for central and Western European countries and southeastern European countries differ because southeastern European countries such as Greece, Bulgaria, Slovak Republic, Slovenia face greater adverse consequences due to

\(^{40}\) Yafimava, K. (2010) p.3.
the higher percentage of Russian natural gas in their total consumption and lower storage capacity as a percent of Russian gas imports. The European Commission report on Energy Challenges notes “border prices for gas imports to the UK, Germany and Belgium are well below (by about 35 percent) the estimated border prices for gas imports to countries that rely on a limited number of suppliers like Bulgaria and Lithuania.”\textsuperscript{41}

The European Commission’s Energy Union Framework Strategy aims to create flexible and connected transmission networks by increasing interconnection capacity in each country to at least 10 percent by 2020 and 15 percent by 2030.\textsuperscript{42} Commission proposals also focus on strengthening intergovernmental agreements on energy between EU and non-EU countries (after an ex-ante assessment from the Commission to ensure compliance with competition rules and internal energy market legislation), increasing access to LNG and gas storage, and requiring EU countries to help their neighbors amid severe gas crisis under a solidarity principle.\textsuperscript{43} Other ambitious goals raised in the literature include repeat interconnecting European countries in the periphery to those in the west and the center to unify the energy markets and increase the number of gas hubs, and revival of pipeline projects such as Nabucco to increase imports from Caspian Sea to diversify suppliers. Addressing market imperfections that result in uncompetitive price differentials between EU states can save and estimated €15 billion annually (10 percent of gas wholesale prices), and a well integrated market for natural gas is estimated to have €30 billion benefits per year.\textsuperscript{44}

\textsuperscript{41} European Commission (2013) p.2.
\textsuperscript{42} European Commission. (2015, February 25).
\textsuperscript{43} European Commission. (2016, February 16).
\textsuperscript{44} European Commission (2013)
Although these are appropriate measures to take to ensure security of supply, especially with the gas crises of 2006 and 2009 in mind, the unification in energy markets has so far been slow in implementation and pipeline projects to increase the flow of Caspian gas will not be enough to displace Russian gas supplies. It does not make sense to focus on reducing overall EU dependence but makes more sense to “minimize individual European nations’ vulnerability to energy cutoffs by multiplying grids and pipelines within the European Union and by diversifying energy sources outside the union” as argued by Buchan.45

As Commissioner for Climate Action and Energy Miguel Arias Cañete stated: "The stress tests of 2014 showed we are still far too vulnerable to major disruption of gas supplies. And the political tensions on our borders are a sharp reminder that this problem is will not just go away."46 I will evaluate several policy implications that follow from my findings in this part to increase energy security in vulnerable EU countries, especially for periphery countries that are disconnected from Western European gas hubs.

A. Increasing reverse flow capacity and building and cross-border interconnectors to complete energy market unification

Connecting the ‘energy islands’ of EU is at the forefront of European Commission’s energy market unification strategy. By linking vulnerable Central and Eastern European member states to the northern European gas markets such as UK, Netherlands, France, Belgium and Germany where there are sufficient storage facilities and regulations in place and pipelines and LNG terminals converge, as shown in Map 1 in the Appendix, the EU can expand the number of European trading hubs for free market trading and provide vulnerable states access to markets with lower energy prices, as

shown in Map 2 in the Appendix. European Council President Donald Tusk’s call for drastic reforms to the EU’s approach to energy and its relationship with Russia in 2014 created a momentum in the energy union debate; however the existing bottlenecks in natural gas infrastructure and the [member states’] lack of will to fully comply with the Third Energy Package has hindered the completion of the common energy market.47

Studies on North West Continental European hubs NBP (UK), TTF (Netherlands), ZEE (Belgium), NCG (Germany), and PEG Nord (France) show that hub prices have largely converged across all hubs, regardless of the contract type.48 Although European Commission has the mandate to co-invest in energy infrastructure under the Projects of Common Interest, Boersman notes the total available budget of €5.85 billion for the 2014 to 2020 period falls short of the estimated €70 billion necessary to fix the infrastructural bottlenecks in the gas market and this has resulted in the initial list of 248 project to be reduced to a total of 27 natural gas and 6 electricity projects, most of which are study projects.49 Interconnector projects planned to increase gas flows from the Southern Gas Corridor and LNG terminals in Greece through Greece, Bulgaria, Romania, Serbia and further to Hungary as well as between North-Eastern Europe and Southern Gas Corridor are not as lucrative for private investors and will not be completed in the near future without the Commission’s leadership.50 Many projects also face the risk of being cancelled for not being commercially viable, such as the Balticonnector pipeline from Estonia to Finland, until the European Commission makes these strategic investments a priority of its energy market unification strategy.

B. Increasing the number of LNG re-gasification facilities in periphery countries and increasing the utilization of existing facilities to receive U.S. LNG

One of the biggest challenges in creating a single natural gas market within Europe has been the fact that natural gas is not a global commodity and often has to be transported from point A to point B via pipelines. European efforts to decrease the share of Russian gas imports by buying Caspian gas directly has long been undermined by Russia. The existing LNG import infrastructure in Europe provides an alternative to pipeline projects that often require 10 to 20 year investments.

As previously mentioned, the prospect that U.S. might join the list of significant LNG exporters, alongside with Qatar, Algeria, and Nigeria, has already prompted gas on gas competition in Europe and helped several European countries renegotiate their contracts with Gazprom. Estimates show that “between 2014 and 2020 non-U.S. LNG supply will rise by around 100 bcm/year from projects already under construction, and could be as much as 150 bcm/year. By 2030, non-U.S. LNG supply may double from its 2014 level to 700 bcm/year which, if U.S. supply reaches more than 100 bcm/year, will massively increase global LNG trade.”\textsuperscript{51} Even though the growth in U.S. LNG exports to Europe might not displace a significant amount of Russian gas due to the fact that the price will be more expensive than existing pipeline supplies, some European countries such as Poland and Lithuania are willing to pay a premium for security of supply.\textsuperscript{52} In order to compete with increased demand from Asia, especially Japan, Europe needs to signal its willingness and capacity to absorb additional LNG volumes from major

\textsuperscript{52} Shaffer, B. (2015, November 16) p.186.
exporters by increasing both the number and the import terminal capacity utilization, which stood at 23 percent in 2013,\(^{53}\) of its LNG regasification terminals.

Jaroslav Neverovic, the Lithuanian Minister of Energy suggests that third party open LNG regasification terminals, as in the case of Lithuania’s floating LNG regasification and storage facility, which also expected to benefit Latvia and Estonia, can sell transmission capacity to energy companies from neighboring countries to diversify natural gas import portfolios of periphery countries.\(^{54}\) It is also possible to lease LNG regasification vessels to neighboring countries as a security of supply mechanism to countries like Greece, Bulgaria, Romania or Slovenia if they or neighboring countries with interconnectors are every threatened with gas supply cuts due to a Russia-Ukraine crisis or price hikes.

C. Increasing storage capacity as an emergency measure in case of natural gas cuts or threats of price hikes by Russia

As Graph 5 in the Appendix demonstrates, European vulnerability to Russian gas supply is determined by both the share of Russian gas in total consumption and the storage capacity as a percent of Russian gas imports. Some insecure member states such as Estonia, Lithuania, Bulgaria, the Slovak Republic, and Turkey have zero or fewer than three natural gas storage facilities as shown in Table 5 in the Appendix. As a result, these countries cannot store strategic natural gas supplies, which can help them maintain vital functions of the economy (non-interruptible functions such as residential use) during seasonal peak consumption periods or in the worst-case scenario, during supply disruptions from Russia which increases natural gas price volatility as demonstrated in the results section.

\(^{54}\) Neverovic, J. (2014, May 20).
Member state governments can impose compulsory gas stock regulations similar to those in Poland where gas traders and importers shall fill and maintain 30 days of compulsory gas stocks at any given time,\textsuperscript{55} and regularly check fuel stocks to ensure compliance. One point to note is that the gas storage infrastructure needs to be unbundled from the gas supply infrastructure, so that gas importers are not contracted by Gazprom to rent storage facilities for Russia’s supply chain purposes, as in the case of Hungary.\textsuperscript{56}

It is important to note that results of this study are limited due to the fact that various pricing mechanisms between the supplier and importer states are not accounted for. Changing terms of existing natural gas contracts, especially a move away from long-term oil indexed contracts towards hub-pricing models could reduce adverse economic effects of this reliance. The conclusions apply as long as the importing countries are subject to volatile fossil fuel indexed contracts and Russia’s capricious supply cuts to Belarus and Ukraine, which in turn affects the rest of European gas markets.

Another limitation of the study is omitted variables, such as energy subsidies or the share of price volatility that results from tax hikes. An especially important omitted variable is the corruption variable because corrupt deals between European politicians and national energy companies and Gazprom, can explain the much of the price volatility in countries that are under the Russian sphere of influence. Corruption in local governments might result in higher prices and volatility. Turkey, for example paid very high prices that could not be explained by rules of supply and demand, possibly due to the interplay between Turkish and Russian officials. It is difficult to separate the effect of Russian natural gas imports on price volatility when there is a corruption factor involved.

\textsuperscript{55} Shaffer, B. (2015, November 16) p.188.
\textsuperscript{56} ibid p.197.
Further research should focus on developing better models that quantify energy security of individual countries by including data on interconnectors, number of storage facilities, number of dual-fuel plants, LNG receiving terminals and so forth.
VIII. Appendix

Graph 1: Natural Gas Consumption and Production in EU (2000-2014)
Graph 2: Natural Gas Consumption by Country (2000-2014)
Graph 3: Natural Gas Trade Movements by Pipeline (2014)\textsuperscript{57}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{trade_movements_by_pipeline.png}
\caption{Trade Movements By Pipeline (bcm)}
\end{figure}

Source: BP Statistical Review of World Energy 2015

Graph 4: Natural Gas Trade Movements in 2014\textsuperscript{58}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{eu_trade_movements_2014.png}
\caption{EU Natural Gas Trade Movements in 2014 (bcm)}
\end{figure}

Source: BP Statistical Review of World Energy 2015

\textsuperscript{57} BP Statistical Review of World Energy (2015, June).
\textsuperscript{58} BP Statistical Review of World Energy (2015, June).
Graph 5: European Vulnerability due to Russian Natural Gas

Source: IEA 2014 Natural Gas Information

Graph 6: Fuel Mix of Member States


60 Chyong, C., & Tcherneva, V. (2015, March 17).
Table 4: Renegotiations of gas supply contracts with Gazprom

<table>
<thead>
<tr>
<th>Company</th>
<th>Primary Market</th>
<th>Year</th>
<th>Renegotiation Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>E.On</td>
<td>Germany</td>
<td>2010</td>
<td>15% spot pricing included in LT contract (for 3 years)</td>
</tr>
<tr>
<td>Eni</td>
<td>Italy</td>
<td>2010</td>
<td>15% spot pricing included in LT contract (for 3 years)</td>
</tr>
<tr>
<td>GDF Suez</td>
<td>France</td>
<td>2010</td>
<td>15% spot pricing included in LT contract (for 3 years)</td>
</tr>
<tr>
<td>Edison</td>
<td>Italy</td>
<td>2011</td>
<td>Agreement reached out of court on price discount and total compensation of $290 mn for FY 2011</td>
</tr>
<tr>
<td>Eni</td>
<td>Italy</td>
<td>2012</td>
<td>Price discount, more flexibility in take-or-pay volumes and retroactive compensation for FY 2011 agreed</td>
</tr>
<tr>
<td>Verbundnetz Gas</td>
<td>Germany</td>
<td>2012</td>
<td>Ca. 10% price discount (lower P0) negotiated (for 3 years)</td>
</tr>
<tr>
<td>GDF Suez</td>
<td>France</td>
<td>2012</td>
<td>Ca. 10% price discount (lower P0) negotiated (for 3 years)</td>
</tr>
<tr>
<td>Wingas</td>
<td>Germany</td>
<td>2012</td>
<td>Ca. 10% price discount (lower P0) negotiated (for 3 years)</td>
</tr>
<tr>
<td>SPP</td>
<td>Slovakia</td>
<td>2012</td>
<td>Ca. 10% price discount (lower P0) negotiated (for 3 years)</td>
</tr>
<tr>
<td>Botas</td>
<td>Turkey</td>
<td>2012</td>
<td>Ca. 10% price discount (lower P0) negotiated (for 3 years)</td>
</tr>
<tr>
<td>Econgas</td>
<td>Austria</td>
<td>2012</td>
<td>Ca. 10% price discount (lower P0) negotiated (for 3 years)</td>
</tr>
<tr>
<td>Sinergie Italiane</td>
<td>Italy</td>
<td>2012</td>
<td>Ca. 10% price discount (lower P0) negotiated (for 3 years)</td>
</tr>
<tr>
<td>E.On</td>
<td>Germany</td>
<td>2012</td>
<td>Arbitration started, agreement on ca. 7-10% discount and $1.3 retroactive compensation</td>
</tr>
<tr>
<td>PGNiG</td>
<td>Poland</td>
<td>2012</td>
<td>Arbitration started, agreement on ca. 10% discount and $930 mn retroactive compensation for FY 2011 and 2012</td>
</tr>
<tr>
<td>RWE Transgas</td>
<td>Czech Republic</td>
<td>2013</td>
<td>Arbitration court awarded ca. $1.3 bn compensation</td>
</tr>
<tr>
<td>Eni</td>
<td>Italy</td>
<td>2013</td>
<td>Price discount of ca. 7% agreed for FY 2013</td>
</tr>
<tr>
<td>Lietuvos Dujos</td>
<td>Lithuania</td>
<td>2014</td>
<td>Negotiated 20% price discount for renewed contract post-2014</td>
</tr>
<tr>
<td>Eni</td>
<td>Italy</td>
<td>2014</td>
<td>100% spot indexation in all LT contracts from FY 2014</td>
</tr>
</tbody>
</table>

Source: Center on Global Energy Policy based on industry and press reports.

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61 Bordoff, J., & Houser, T. (2014) p.18
Map 1: European Natural Gas Grid (2015)

The European natural gas grid in 2015 includes pipelines integrated in the European system, existing, under construction, projected or planned, other pipelines, existing, under construction, projected or planned, natural gas fields, liquefied natural gas (LNG) receiving terminal in operation, LNG receiving terminal under construction or projected, liquefaction plant.

Map 2: EU Wholesale Gas Prices in 2015 Q3

The colour code for each Member State is defined according to a simple average of all available types of prices (hub, LTC, LNG) in the respective Member State.

"Germany: BAFA data on border price for Germany reported as 'Other', July - September 2015.

Sources: EBP estimates and LNG: ESTAT.COMEX, Thomson-Reuters, HUB Price: Finnish Gas Exchange, Gaspoint Nordic for Denmark; POLPX for Poland; BAFA for border prices for Germany.

For the administrative boundaries: © Eurogeographics, © DG ENER - November 2015.

Table 5: Natural Gas Storage in the EU

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of storage facilities</th>
<th>Working capacity (Mcm)</th>
<th>Peak output (Mcm per day)</th>
</tr>
</thead>
<tbody>
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<td>Austria</td>
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<td>8250</td>
<td>94.4</td>
</tr>
<tr>
<td>Belgium</td>
<td>2</td>
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<td>57</td>
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<tr>
<td>Bulgaria</td>
<td>1</td>
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<tr>
<td>Croatia</td>
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<tr>
<td>Cyprus</td>
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<td>0</td>
<td>0</td>
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<tr>
<td>Czech Republic</td>
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<td>59</td>
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<td>Denmark</td>
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<td>1035</td>
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<tr>
<td>Estonia</td>
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<tr>
<td>Finland</td>
<td>0</td>
<td>0</td>
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<tr>
<td>France</td>
<td>16</td>
<td>12894</td>
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<td>Germany</td>
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<td>Greece</td>
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<td>0</td>
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<td>Hungary</td>
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<td>Luxembourg</td>
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<tr>
<td>Netherlands</td>
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<td>Poland</td>
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