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NATURAL GAS IMPORT DYNAMICS AND RUSSIA'S ROLE IN THE SECURITY OF GERMANY'S SUPPLY STRATEGY

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Summary: The aim of this paper is to explain the natural gas demand dynamics of Germany and to determine the factors affecting the import of natural gas from Russia. In the existing literature, there are several studies which investigate the demand structure of single sectors (like industry or households), but there is a lack of analysis that tries to explain import quantities as a whole. On the basis of a theoretical discussion, the components of natural gas import quantities have been tested through different time series analysis. We found that the European natural gas and oil prices are co integrated with a time lag of 7 months. We interpret this result as revealing that natural gas is a viable substitute for oil. The time series estimation results support our hypothesis and demonstrate a positive relationship between oil price and natural gas demand. Furthermore, we found that the German industry production level is also an important determinant for natural gas import. In the next step, we used a technological variable, energy intensity change over time, to explain the change in natural gas import. Then, a new variable was implemented within the analysis: The purpose of natural gas import which is a hybrid variable and indicates which purpose dominates, i.e. either heating or electricity production. After a positively resulted significance test, we made a simple forecast analysis using an AR-Process to show that the positive trend of natural gas import will continue, if all of the significant variables have the same development in the future. It is important to show this trend because this kind of development raises the increases the issue of dependence of both countries from each other. Against this background alternatives will be discussed as to how Germany could improve security of its natural gas supplies.

Zusammenfassung: Das Ziel der Arbeit ist es, die Nachfragedynamik Deutschlands nach Erdgas zu erklären und die Faktoren zu bestimmen, die den Import von Erdgas aus Russland beeinflussen. In der aktuellen Literatur gibt es zwar eine Vielzahl von Studien, die die Nachfragestruktur einzelner Sektoren (wie die der Industrie und der Haushalte) untersuchen, aber kaum welche, die die Importmenge als solche erklären. Basierend auf einer theoretischen Diskussion wurden in dieser Studie daher die Elemente der Importmenge von Erdgas durch verschiedene Zeitserienanalysen getestet. Unser Ergebnis, dass Erdgas- und Ölpreise in Europa mit einer Zeitdifferenz von 7 Monaten co-integriert sind, interpretieren wir als Nachweis, dass Erdgas ein gangbares Substitut für Öl darstellt. Die Ergebnisse der Zeitreihenannährung unterstützen unsere Hypothese und zeigen einen positiven Zusammenhang zwischen Ölpreisen und der Nachfrage nach Erdgas. Darüber hinaus zeigen unsere Resultate, dass das deutsche Industrieproduktionsniveau eine wichtige Determinante der Erdgasimporte darstellt. In einem nächsten Schritt haben wir eine technologische Variable, die Veränderung der Energieintensität im Zeitablauf, eingeführt, um Abweichungen der Erdgasimporte zu erklären. Außerdem wurde eine weitere Variable in der Analyse implementiert: der Verwendungszweck von Erdgasimporten, eine hybride Variable die angibt, bei welcher Verwendung, Wärme- oder Stromerzeugung, der Erdgaseinsatz dominiert. Nach einem positiven Signifikanztest haben wir auf Basis eines AR-Prozesses eine einfache Vorhersageanalyse durchgeführt um zu zeigen, dass der positive Trend von Erdgasimporten anhalten wird, wenn all signifikanten Variablen ihre bisherige Entwicklung in der Zukunft fortsetzen. Das Aufzeigen dieses Trends ist von großer Bedeutung, da diese Entwicklung den Aspekt der gegenseitigen Abhängigkeit beider Länder weiter verdeutlicht. Vor diesem Hintergrund werden dann Alternativen diskutiert wie Deutschland die Versorgungssicherheit seiner Erdgasversorgung verbessern kann.

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1. Introduction

In the backdrop of the oil shocks in the 1970s and 1980s and political instabilities in the 1990s, scientific research like the 2006 Stern Review has increased the importance of natural gas because of its environmentally friendly characteristics and abundant reserves. Recent research and discussions show that environmental and economic development based on the combustion of conventional energy resources like coal is not sustainable. In this context, natural gas seems to be an essential alternative for over the mid-term.

Natural gas has been of great importance for the heating market, but over the last several years, its value for other purposes has gaining importance as well. Apart from different trends like renewable energy resources, however, OECD countries are trying to increase the diversity of their energy resources for their energy supply security, environmental sustainability and economic competitiveness. In this relationship, the role of natural gas importers on the world energy market is increasingly important. As a strategic partner, Russia is now a critical natural gas exporter of the EU and Germany. Explaining the fundamentals of this relationship within an empirical analysis can contribute to forming a more rational and effective energy policy for both sides.

A reliable provision of energy is crucial for economic development and growth. Major energy importers such as the EU27 countries have emphasized the role of energy security over many years; besides the price and the volatility of prices, energy security matters. As regards oil and gas imports from Russia, the European Energy Charter has been a crucial document. However, Russia has not signed the document – partly because the EU has not offered a package deal which makes such a long-term joint venture sufficiently attractive for Russia. To some extent, one may also wonder whether Russia has a realistic perception of the long-term alternatives in terms of EU energy imports.

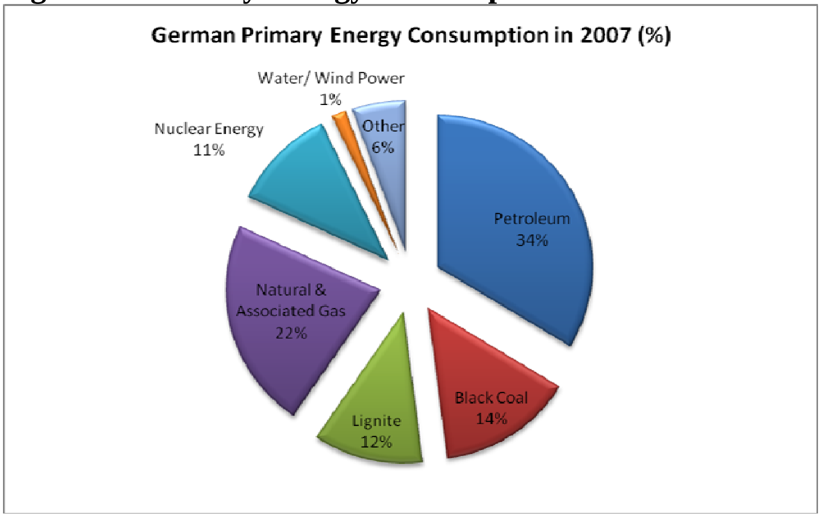
Conflicts of gas deliveries from Russia have been a major issue between the EU and Russia as well as the Ukraine, a transit country causing serious problems. While natural gas already has a significant share in the overall energy mix, its role is expected to increase even further in the future. This statement is based on several considerations. A major one is that compared with other fossil fuels, natural gas is an environmentally friendly source of energy, emitting significantly less carbon dioxide than, for instance, coal. Natural gas is therefore of great importance for the heating market. At the same time though, it also becomes increasingly essential as a source for electricity production aimed at reducing the application of coal. Moreover, along with technological development, new forms of application are expected in the transportation sector as a possible substitute for petrol. While these considerations will be explicated in further detail below, it can be expected that natural gas will continue to be a crucial factor in the overall energy mix, if not one of growing significance. While these issues of demand itself require careful consideration for provision with natural gas, Germany's resource situation poses additional constraints as domestic natural gas supplies are on the decline. As a consequence, the role of imports will play an even more important role in the future. A major part of German natural gas demand is satisfied by imports from Russia, which has been a reliable supply partner for about three decades. Recently, though, this reliability has started to become more unstable following political conflicts between Russia and Ukraine as the major transit country for natural gas from Russia to Western Europe. At the same time, issues such as the negotiations between Russia and third countries, particularly China as an increasingly growing consumer of natural gas, and threats from Russia to divert gas away from Europe have raised concerns over stable supplies from Russia. The aim of this paper therefore is to determine Germany's natural gas import dynamics and Russia's role regarding German security of supply strategies. Before doing so, a short overview over fundamental factors of influence shall be given.

When looking at determinants of energy consumption, many influences such as demographic and economic developments as well as political requirements and climatic conditions have to be taken into account. Population, for example, impacts electricity consumption, households to be heated as well as the number of cars used. While the German population has grown by 3.5% annually since 1990 to currently about 82 million inhabitants, overall primary energy consumption has declined by nearly 7% from 14,905 PJ in 1990, reaching its lowest level of 13,878 PJ in 2007. Primary energy consumption per capita, which is a crucial indicator of energy efficiency of an economy, decreased from 188 GJ to 170 GJ. Another important indicator is economic development. Looking at the same time period as above, economic growth showed a constant positive expansion of 30% to 2.2 billion Euros in 2007. Comparing economic data and energy consumption rates again shows that the development of energy intensity has significantly improved. Since 1990, energy intensity has been reduced by 2% annually on average (own calculations, data from BMWI, 2008), suggesting a decreasing – or at least stable – demand for energy in the future. At the same time, though, it has to be taken into consideration that along with economic prosperity in industrialized nations, the utilization of energy using appliances, particularly electricity consuming devices, has continuously grown and will probably do so in the future as technical gadgets become more powerful, thus consuming more energy. As a consequence, industrialized nations may record an increase in energy demand in the future, possibly resulting in the fact that energy efficiency gains become obsolete. This makes the concern for the future of a secure and stable supply even more prevailing.

1.1 Natural Gas Consumption and Demand

Playing a crucial role in the German energy mix, natural gas accounts for more than one-fifth of overall primary energy consumption. With a share of 18% of overall European consumption, the German gas market is the second largest behind the British with a share of 20% (EUROSTAT, 2008). While total primary energy consumption has stayed relatively stable at around 14,000 PJ since 1990, there has been a considerable change between the individual energy sources that compose the overall energy mix. This development has taken part in favour of natural gas whose share has continuously increased from 15.4% in 1990 to 22.5% in 2007. At the same time, the share of other fossil fuel sources such as petroleum and coal has declined – in the case of petroleum and black coal, relatively moderately, i.e. from 35% to 33.9% and 15.5% to 14.3% between 1990 and 2007, respectively. This was more drastically the case for lignite, though, whose share fell from 21.5% to 11.6%. The following graph shows the composition of primary energy consumption in Germany for the year 2007.

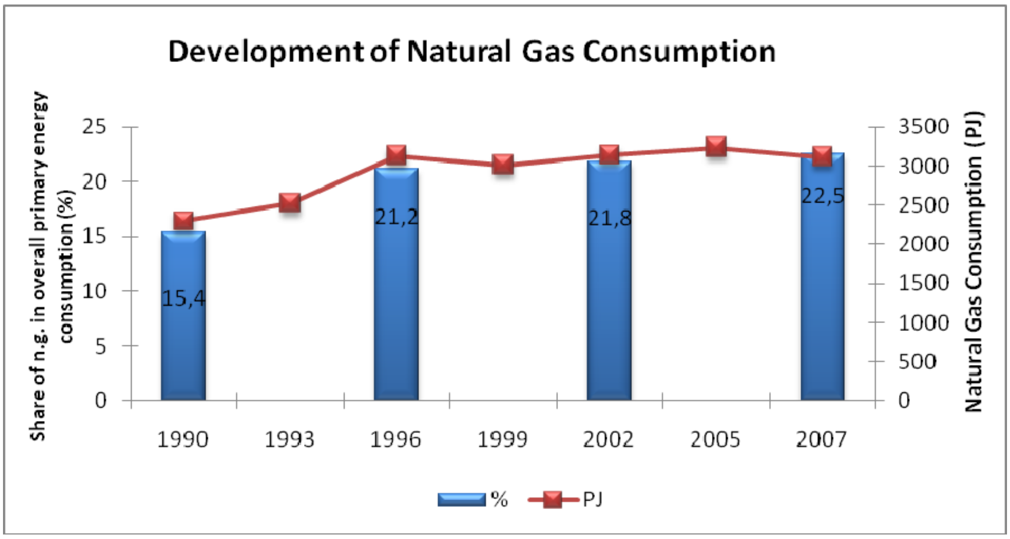
Figure 1: Primary Energy Consumption.



Data Source: Eurostat (2008).

When looking at the development of natural gas consumption in more detail, it can be seen that its share as well as absolute consumption volumes have constantly grown. A striking increase from 2,293 to 3,132 PJ took place in the period between 1990 and 1996, presenting a growth in demand of 37% while overall consumption from 1990 to 2007 again has increased by 36%. When looking at the period from 1990 to 2005, utilization has even grown by 42%. The decline from 3,285 to 3,118 PJ from 2006 to 2007 again, meaning a decrease by 5%, serves as an example for the dependence of natural gas consumption on weather conditions as this period was influenced by a particularly warm winter. This also led to a decline of domestic production as will be shown in chapter 2. The following chart (figure 2) depicts the development of natural gas consumption in total as well as by share over the period from 1990 to 2007.

Figure 2: Development of Natural Gas Consumption.



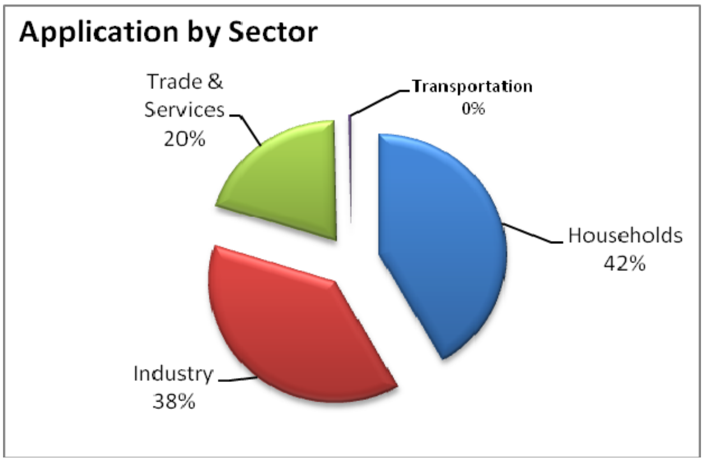
Data Source: Eurostat (2008).

As shown in the graph above, the share of natural gas in the overall energy mix has remained relatively stable at around 20% compared with the development of absolute consumption of natural gas as depicted above. While its share grew only slightly from 21.2% in 1996 to 22.5% in 2007, there has been no change from 2006 to 2007 where gas accounted for 22.5% in both years, a development which can be attributed to the substitution of other energy sources by natural gas in the different sectors of application (see below). On average, consumption grew by a stable 1.8% per annum between 1990 and 2006, a development which can be attributed to the substitution of other energy sources by natural gas in the different sectors of application (see below). This development was not homogeneous across the individual sectors of demand, though, as will be illustrated in the following section.

1.2 Natural Gas Consumption by Sector

In the case of the application of natural gas in the end user sector, consumption has followed a positive development, having continuously grown by 22.5% from 1,688 PJ in 1991 to 2,067 PJ in 2007 (BMWI, 2008). This means that – compared with other final energy sources such as electricity, coal, heating oil or fuel sources – natural gas has increased its share in the final energy mix from 16% in 1990 to nearly 25% in 2007, indicating its increasing importance in this sector. Looking at the structural composition for the year 2007, natural gas is the second most important final energy source, following directly behind fuel sources which have a share of 27% in the overall mix. The third most important final energy form is electricity with a share of 20%. The breakdown of natural gas use by sector shows that both the household and the industry sector account for around 40% of overall natural gas application (see figure 3).

Figure 3: Application of Natural Gas by Sector.



Data Source: Eurostat (2008).

The household sector is the largest end user sector at 42%, accounting also for the quantitatively second most significant increase in consumption, having grown by 29% from 673 to 864 PJ between 1991 and 2007. The major area of natural gas application in households is heating. Currently as many as 18.4 million households are heated with gas, amounting to a market share of 48%. Between 1990 and 2007, the total number of households – as an important indicator for heating requirements – has grown even further by 14%, thus at present amounting to nearly 40 million households. In newly built houses, natural gas heating already accounts for two-thirds of the heating systems installed. Particularly in the household sector, other liquid and fossil fuels such as heating oil and coal have been increasingly substituted by natural gas (BDEW, 2008), leading to a growing share of natural gas in the overall energy mix. With regards to heating, natural gas consumption is highly dependent on climatic conditions. Due to a warm weather period, for instance, household consumption, which had increased to 1078 PJ in 2004, declined by 8.5% to below thousand PJ again in 2005 and even further in the year after (Data from BMWI, 2008). In the first half-year of 2008 in contrast, because of a stronger winter, natural gas demand for heating purposes in private households increased by one-tenth compared with the period before (BDEW, 2008). Another major area of gas application in the household sector is warm water supply, accounting for a share of more than 50%, and, to a lesser extent (about 9%), gas is used for cooking purposes (RWI/ FORSA, 2005). Generally, an increase in the number of households[1] will further drive growth of natural gas demand.

The second largest end user sector of gas usage is industry, accounting for a share of currently 38%. In this segment, natural gas is particularly applied for process heating and drive purposes, accounting for 65% and 24%, respectively, of industry application (own calculations based on data from BMWI, 2008). Overall, utilization of gas in the industry sector has increased by about 12% from 1991 to 2007. With 851 PJ, the quantitatively largest year of consumption was 2003, thereafter declining to 824 PJ in 2004 and further to 799 PJ in 2005. While demand has marginally increased again by about 1% to 809 PJ in 2006, it already decreased again to 791 PJ in 2007. This sector is particularly impacted by economic activity and price developments as well as legal requirements such as energy saving policies.The third major sector that is distinguished is the trade and services sector which accounts for 20% of natural gas application in final energy usage. This sector experienced a strong increase over the period from 1990 to 2007, recording a growth of 35% from 305 to 412 PJ. From 2005 to 2007, though, this sector has also been the one with the most significant decline in consumption of 25% from 548 to 412 PJ (own calculations based on data from BMWI, 2008).

The transportation sector, as the fourth area of use, still only shows a very small share in overall composition. In absolute numbers, the transportation sector accounted for 7 PJ in 2007. Since 2005, though, demand has increased by 150% and thus, despite its relatively small share, growth in this sector has been strongest (own calculations based on data from BMWI, 2008).Another crucial area of application is electricity production. As figure 4 shows below, natural gas usage for electricity generation has continuously grown, i.e. from 332 PJ in 1990 to 594 PJ in 2007, presenting an increase of 79%. This is a continuation of the development since gas was first used for electricity production. A major decline only occurred in the middle of the 1970s when European policy measures limited the deployment of natural gas in power plants because of fear of domestic resource shortages and the extension of nuclear power energy in many member states.

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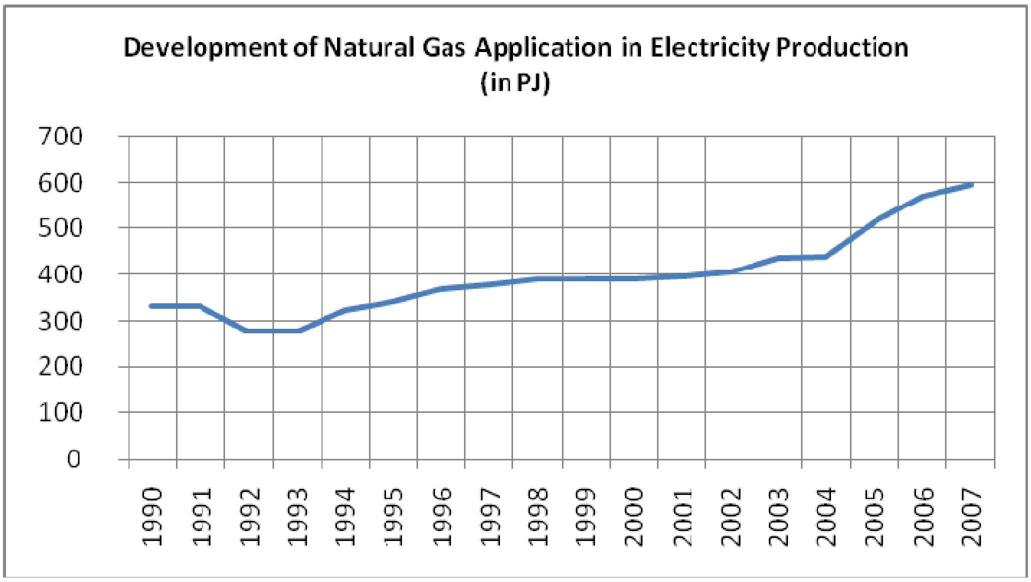
[1] While overall population is expected to decline in the future (EWI/ PROGONOS, 2005), the number of single households is predicted to increase, thus indicating an increased demand for energy.

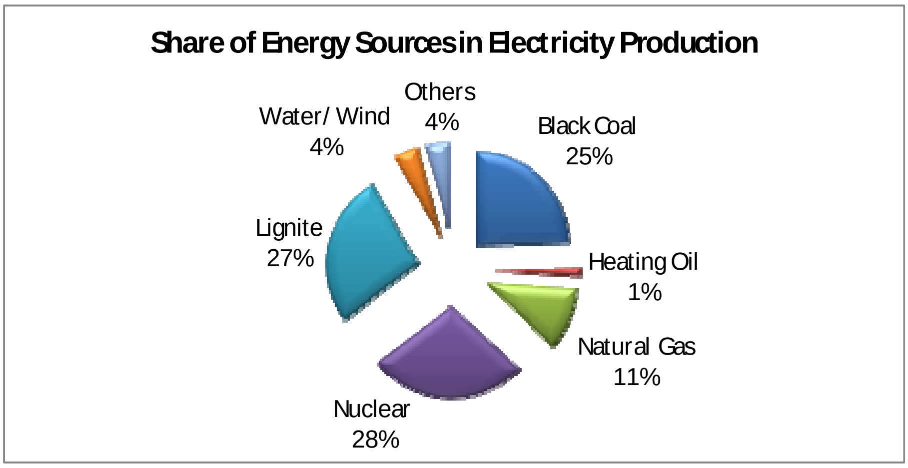
Figure 4. Development of Natural Gas Application in Electricity Production (in PJ).



Data Source: Eurostat (2008).

In Germany, the share of natural gas used for electricity generation has increased from 6.2% in 1990 to nearly 11% in 2007. Due to its favourable combustion characteristics, i.e. lower carbon dioxide emissions than coal, as well as the relatively low fix costs gas-fired power stations and their quick-start attributes, natural gas application in electricity production is predicted to continue with strong growth in the future (PROGNOS, 2007). This development is also further pushed by an increase of electricity heating systems, which currently only account for about 6% in German heating structure (BDEW, 2008).

Figure 5. Share of Energy Sources in Electricity Production.



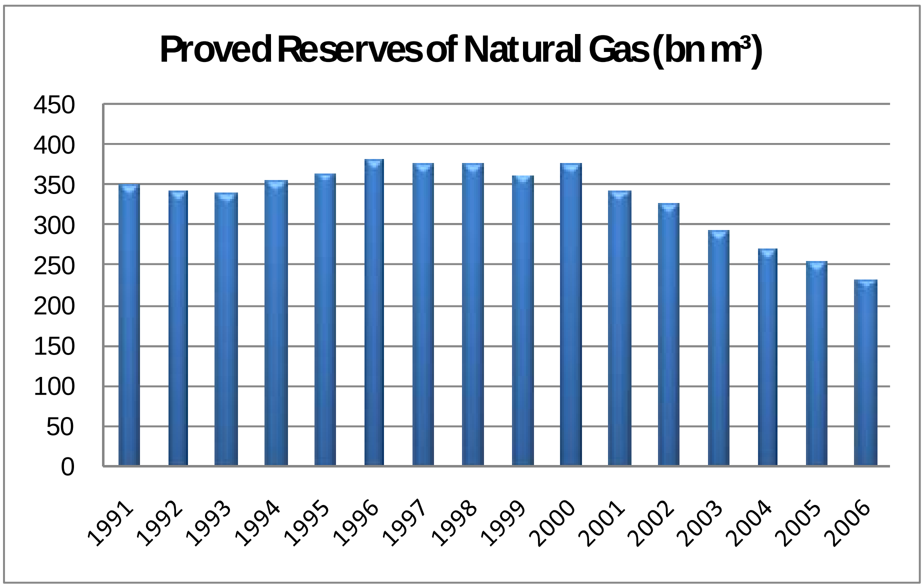
Data Source: Eurostat (2008).

2. Reserves and Production Situation

2.1 Natural Gas Reserves

In order to satisfy the consumption needs depicted above, large volumes of gas are needed. Germany itself does possess small amounts of natural gas resources in domestic grounds. In 2006, proved reserves, i.e. those quantities which with reasonable certainty can be recovered in the future from known reservoirs under prevailing economic and operating conditions, amounted to 233 billion m³ - a quantity which in comparison with global reserves only amounts to a share of 0.1% (BP, 2007; BGR, 2007). Over the past years, the amount of proved reserves has been steadily declining as can also be seen from the following graphic (figure 6). Having reached their highest number in 1996 with 382 billion m³, proved reserves fell below 300 billion m³ (293 bn m³) for the first time in 2003 and to 255 billion m³ two years later. This decline can be attributed to ongoing extraction efforts (see section 2.2 below) as well as to a re-evaluation of results following drilling activities. In the future, a further decline of reserves is expected as geological conditions and maturity of the gas fields make the development of new reserves increasingly difficult and costly. Many of the recent exploration projects in Germany, for example, have failed or have only been marginally successful. Thus, in order to secure future potential of domestic production, a continuous advancement of technology, crucial innovations and improvements in production are required (WEG, 2007, p. 21). Otherwise, the need for natural gas imports will become even larger.

Figure 6. Proved Natural Gas Reserves (bn m^3).

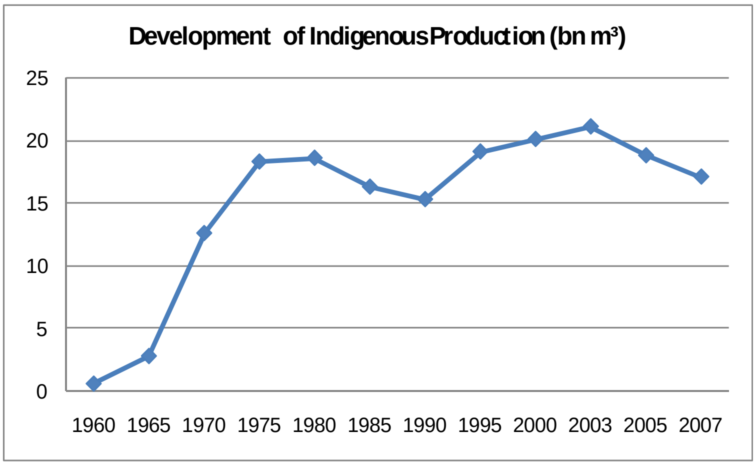


Data Source: Eurostat (2008).

2.2 Natural Gas Production

Indigenous production of natural gas started more than 40 years ago with a relatively marginal quantity of 0.6 billion m³. Over the following decade, this amount strongly increased to reach 21 billion m³ in 1974. After that, production began to slowly decline to 15 billion m³ in 1990, accounting for 9% of German primary energy production. As figure 7 shows, though, this was only an intermediate low as production was increased again in the following decade, reaching more than 21 billion m³ in 1999. Since then, production decreased even further to 17 billion m³ in 2007, despite continuous developments of production technologies. In comparison, the production of coal, which started with a share of more than 80% in 1990 – of which lignite production accounted for 50%, black coal production of 34% - in overall primary energy production has significantly decreased over the years, in the case of lignite to 42% and to 17% in the case of black coal (AG ENERGIEBILANZEN, 2008). In large parts, this development can be attributed to substitution through natural gas as mentioned above.

Figure 7. Development of Indigenous Production



Data Source: Eurostat (2008).

3. Resulting Supply Gap

By and large, German gas provision has traditionally been met by a combination of domestic production and imports. Nevertheless, despite the fact that about 10 million German households could be heated with gas from domestic resources, indigenous production can only satisfy demand by 18% (AG ENERGIEBILANZEN, 2008). Thus, it becomes obvious that local supply can only cover a small part of required consumption, resulting in a major supply gap of 80%. This situation again implies that large volumes of natural gas requirements have to be imported. In fact, Germany is the world's second largest gas importer (by pipeline)[2] behind the US (BP, 2008). When calculating the static

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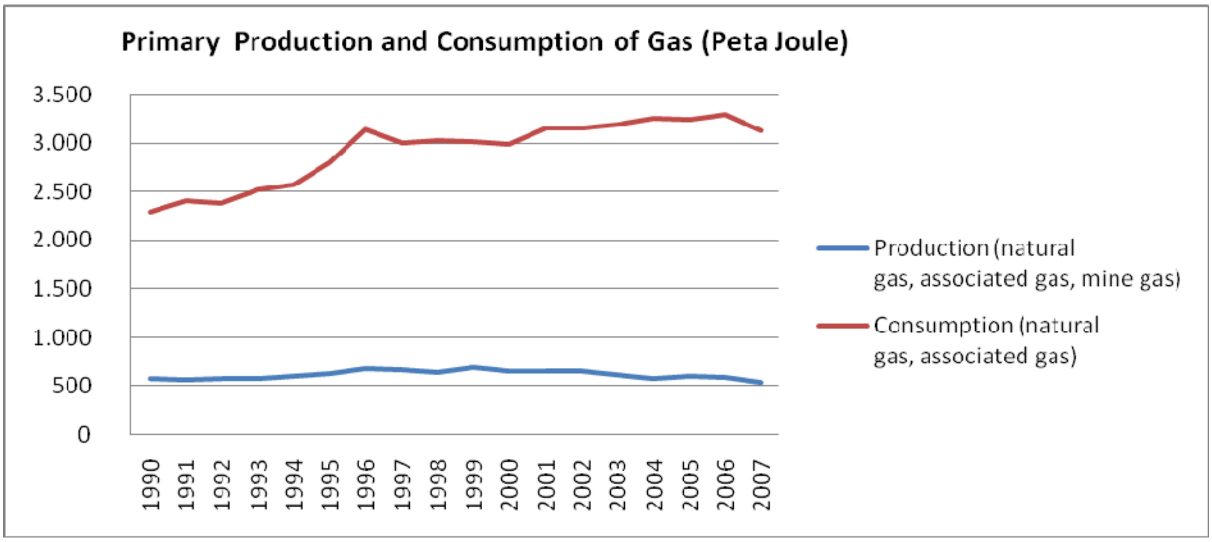
[2] When also considering LNG imports, Germany is the third largest importer behind the US and Japan (IEA, 2008, p. 13).

reach, i.e. the duration of remaining reserves compared to current levels of consumption, there will be sufficient gas reserves in Germany for the next 23 years. When taking into account production levels instead of reserves (of which large amounts cannot be extracted), though, the situation looks much different. This is also depicted by the major gap between consumption and production as shown in figure 8 below.

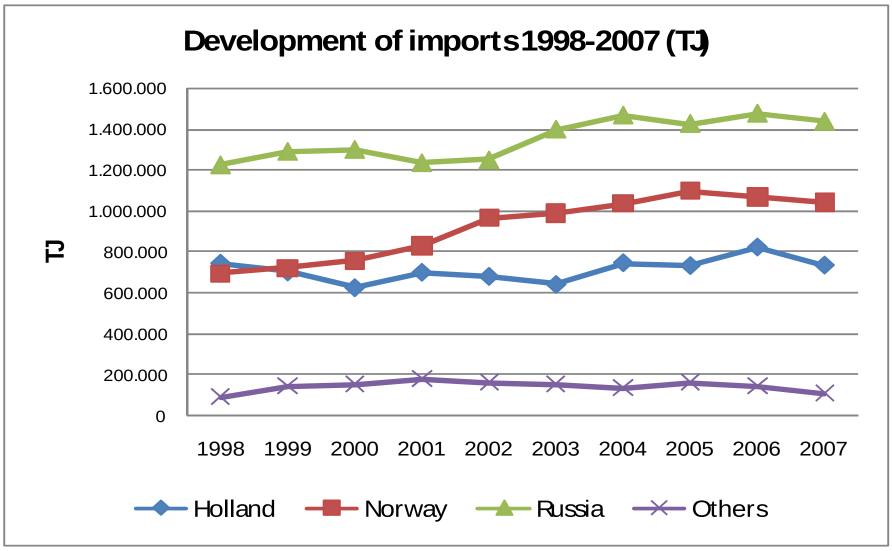
Figure 8. Primary Production and Consumption of Gas (PJ).



Data Source: Eurostat (2008).

Regarding the origin of imports, Russia, as the world's largest producer and exporter of natural gas (IEA, 2008), is Germany's quantitatively most important natural gas provider, accounting for 45% of total volumes (see figure 9). For Germany, gas supply from Russia is important due to its geographical proximity which reduces transportation costs. Similarly, Norway and the Netherlands as Germany's second and third most important provider are also geographically close. This advantage will not hold much longer, however, as natural gas production in the EU region is on the decline, recording a projected reduction from 191 Mtoe in 2010 to 112 Mtoe in 2030 (EUROPEAN COMMISSION, 2003). The UK, for example, which has been an important supplier for many decades, became a net importer of natural gas in 2004 on declining domestic production. In 2006, import volumes increased more than six fold compared with 2004 (see data on EUROSTAT, 2009). Consequently, when looking at the resulting supply gap (see figure 8), Russia presents a critical source of gas imports for Germany. This position may become even more delicate in the future, depending on the development of natural gas demand in Germany. This will now be determined in the next chapter.

Figure 9. Natural Gas Imports.



Data Source: Eurostat (2008).

4. Characteristics of Natural Gas Demand and Germany’s Import Requirements

According to the IEA (2008a) reference scenario, world demand for natural gas will increase to 4.4 trillion cubic metres by 2030, growing at an estimated 1.8% per annum. It is expected that the share of natural gas in total primary energy demand will increase to 22% in 2030. The reasons for this, as mentioned earlier, are the characteristics of natural gas which make it a more environmentally friendly source of energy, supporting emission reduction targets agreed upon in the Kyoto protocol. In this respect, particularly European OECD countries are looking to increase natural gas application while at the same time decreasing their demand, especially for coal. While coal production amounted to 603 Mtoe in 1980, it is expected to have declined to 208 Mtoe by 2030. Natural gas, on the other hand, is expected to increase its share in the energy mix in the long term, growing from about 29% in 2010 to above 32% in 2030. In absolute terms, gas consumption is expected to increase to 502 Mtoe in 2020 and further to 548 Mtoe in 2030 (IEA, 2008b; for data for Germany see also BMU, 2006 and BMWi, 2007).

Consequently, for calculations in this study it is assumed that coal is going to be a weaker substitute for natural gas over the next 20 years. Oil, on the other hand, is believed to be a competitive fuel to natural gas also in the future. Thus, the relationship between oil and natural gas has to be looked at closely, particularly with regards to natural gas prices as will be explained in the following two sections. The first subsection will discuss relevant aspects from a purely theoretical basis and examines the options independent from the current market situation. The second subsection then analyses the actual market situation. Based on these two pillars, the relationship between European (Brent) crude oil and

(London Exchange) natural gas prices will be determined by using a cointegration test that can help us understand the long-term price linkage. This kind of a test is crucial for further modelling that assumes oil prices to be a critical parameter for natural gas import quantity. In the next section, Germany's import quantity over the last 10 years will be explained by referring to different influential factors like oil prices, climatic impacts, the share of natural gas in electricity production, overall industrial production and technological issues in form of energy intensity data. Based on these factors, a simple forecast regarding Germany's natural gas import quantities through 2015 will be conducted. These calculations and respective results will again serve as a basis for drawing conclusions on necessary policy implications, which will be done in chapter 5.

4.1 Production of Natural Gas and Its Relevance for Oil: Pure Theoretical Aspects

Generally, different arguments can be made concerning the relationship between natural gas and crude oil prices which are independent of market situations. By discussing the theoretical relationship through demand and supply aspects, VILLAR/JOUTZ (2006), for example, draw conclusions regarding the quantity and price linkage between natural gas and oil prices, assuming them to be complimentary and substitutes in production and consumption. Additionally, they assume that no agreement or market-based binding between oil and natural gas exists. Their particular statements can be summarised as follows:

- A crude oil price increase forces consumers to switch to natural gas consumption, a decision which is followed by a rise in natural gas demand and hence a rise in prices. Here, oil and natural gas are substitutes primarily in electricity production and industrial sectors.[3]
- An increase in mineral oil demand increases production which again also augments the produced amount of natural gas, because it is a co-product of mineral oil in many extraction fields. Theoretically, this would tend to decrease natural gas prices.
- An oil demand and price increase might raise the cost of natural gas production as natural gas and crude oil producers compete for similar economic resources such as labour and drilling rigs. On the other hand, this kind of increase can trigger more investment in oil fields, which again can increase the production of natural gas and decrease natural gas prices in a roundabout way. For this reason, it is crucial to take into account price dynamics in both markets.

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[3] Here we should remark that interfuel substitutions of economic actors are not considered in a short-term but rather mid- to long-term basis.

4.2 Demand for Natural Gas and Its Relevance for Oil: Market-Based Aspects

The mechanisms underlying natural gas prices are complex and different from price formation in other markets. Other than is the case for oil, no global benchmark price is available, as natural gas markets are regional in focus. Historically, when natural gas was first introduced into the market, it posed a major competitive threat to oil in the heating end-user business. In Europe, natural gas price formation underlies two major principles.

First, a base price exists in order to enable the spreading of risks between buyers and suppliers. Second, indexing to oil prices guarantees competitiveness of gas and facilitates the incorporation of changes which occur on the energy market without buyers and suppliers having to renegotiate their whole contract. Additionally, in order to ensure a high degree of stability and guarantee amortisation of large investment sums for the development of gas fields and the transportation business, most of the contracts have been fixed – and remain so – on a long-term basis, indexed to the development of oil prices which they follow with a lag of about 7 months[4] (CHABRELIE, 2004). Furthermore, another important reason for the price linkage is take-or-pay agreements.[5] The linkage between oil and natural gas prices can be explained by long-term ”Take or Pay (ToP)“ contracts with a duration of 20 to 30 years, which are very common especially in Europe. These contracts obligate costumers to pay a major part of ordered gas volumes, regardless of the quantity which is finally consumed. Such a guarantee is important as major supply projects could not be achieved otherwise. Moreover, it is not in the interest of petroleum exporters – who at the same time are also suppliers of natural gas – to promote competition between their energy products (BEURET, 2005). For these reasons, natural gas prices have been linked to oil prices since the 1960's. In order to take account of these issues, crude oil prices have been chosen as a reference for calculations in this model.

4.3 Relevance for Modelling

Natural gas prices are derived mostly from long-term moving averages of oil prices. On occasion, though, the high volatility of oil prices may cause large differences between oil and natural gas prices. Therefore, substitution effects and price elasticities between oil and natural gas are extremely difficult to estimate. Interfuel substitution theoretically should be related to price effects, primarily in the case of power generation. Often though, power generation projects take a couple of years to realise. Still, as long as there are fuel switching capacities like dual fuel burning that can be used, only minor scaled short-term substitutions occur. Nevertheless, in the case of a price linkage, a long-termed substitution cannot be constituted. Furthermore, modelling is also made more difficult as there is neither a single natural gas market with a global price nor sufficient data about disaggregated technical aspects which could be of help (EAGLES, 2008).

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[4] See AIC results in the appendix.

[5] Please see WILCOX, 2004; SCHIRMER, 2005 and BEURET, 2005 for further information.

Nevertheless, the empirical analysis proves the long-run relationship (cointegration) between natural gas and oil prices. Furthermore, the estimation results in the next step provide a positive relationship between crude oil prices and imported quantities of natural gas. Also, the relationship between oil and natural gas prices has been researched before for other countries in numerous economic papers. The study by ASCHE/SANDSMARK/OSMUNDSEN (2006), for example, suggests that oil, natural gas and electricity prices in the United Kingdom are cointegrated. The question is whether these findings can be generalized for the rest of Europe, as the UK energy markets has its own unique dynamics due to earlier liberalisation and advanced spot markets. In addition, these findings show the dependency of domestic prices on the global petroleum price. BACHMEIER and GRIFFIN (2006) again examine the cointegration between different commodity prices, showing that there is a long-term relationship between domestic crude oil prices, but not between coal prices. SERLETIS/RANGEL-RUIZ (2004) examine the relationship between Henry Hub and WTI prices from 1991 to 2001. Their study states that prices do not have uniform price cycles within the USA. They therefore determine that US American and Canadian natural gas prices are cointegrated. At the same time, there are some empirical studies about the substitution of different petroleum products and fuels. BACON (1992) analyses the national substitution relations of energy and capital resources and explains to what extent this substitution is dependent on capital unit costs. BALKE/BROWN/YÜCEL (1998) show that in the USA, small asymmetrical price relations between crude oil and natural gas exist, but this is not observable in all petroleum product markets. WLAZLOWSKI (2001) supports this finding and directs attention to the asymmetry of prices, particularly in the upstream sector of the oil market. The results of the analysis for Northern Europe (ASCHE/GJØLBERG/VÖLKER, 2001) suggest that there is a long-term price relationship between crude oil, gasoline, kerosene and naphtha, however not between crude oil and fuel oil. L'HEGARET/SILIVERSTOVS/VON HIRSCHHAUSEN (2004) state that the continental gas markets (Asia/Japan, North America and Europe) are not cointegrated and that future market integration is expected due to new and improved technologies such as LNG[6] which can contribute to a convergence of prices. BORENSTEIN/CAMERON/GILBERT (1997) determine that gasoline prices react with the rising crude oil price much faster than with falling crude oil prices. In a microeconomic sense, DAVIS/HAMILTON (2003) support this statement. Nevertheless, natural gas generating capacity limits, weather or supply issues can also increase fuel substitution tendencies.

As indicated, the different studies generally agree that a long-term relationship between oil and gas prices exists. However, there is a lack of research which investigates the price relationship in Europe. Based on the results of the studies previously mentioned, though, one should expect a long-term relationship also in the European case. The next figure shows the logarithms of European gas and oil prices since 1990.

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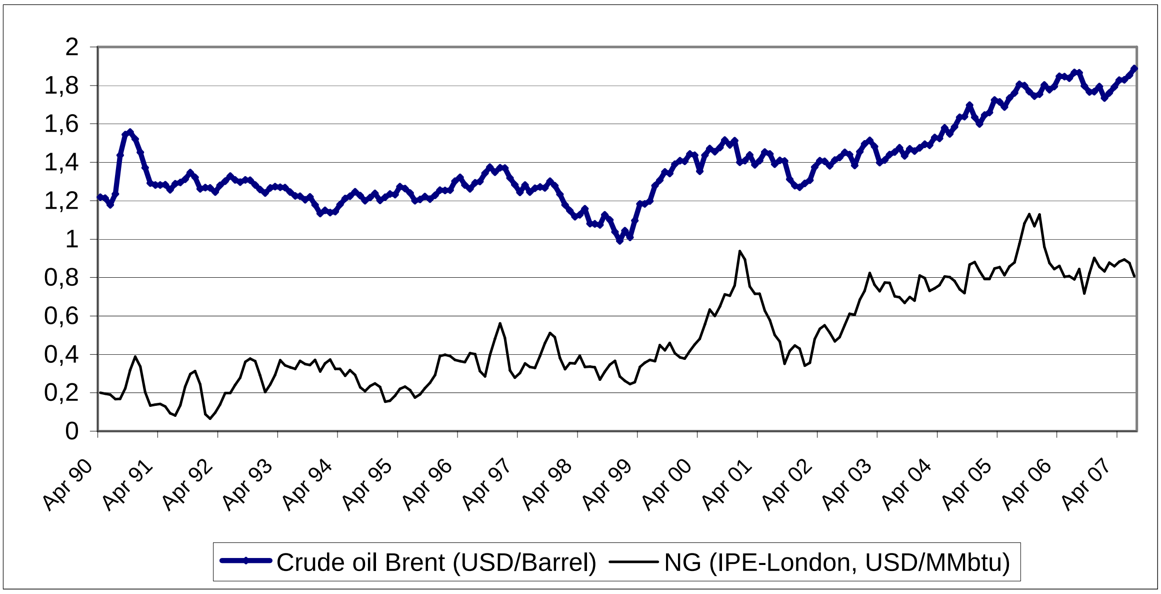
[6] LNG stands for Liquefied Natural Gas and is produced by cooling down natural gas to below 161 degrees.

Figure 10. Logarithms of European Oil and Natural Gas Prices.



Data Source: www.bloomberg.com (2008).

In this context, the next section investigates the long-term relationship between natural gas and oil prices.

4.4 Are European Oil and Natural Gas Prices Cointegrated?

Whether European oil and natural gas prices are correlated is a supplementary but critical question of this study. As figure 10 shows, natural gas prices have been periodically adjusted to oil prices. For studying this kind of case, a simple regression analysis for non-stationary processes can be problematic. While the conventional measures for the evaluation of the quality of the model or for the evaluation of significance of the estimated parameters - the t-statistics - suggest a good estimation in some cases (high R^2 and high t-values), residues may correlate strongly with each other and may be non-stationary. Hence, these quality criteria are not consistent and these criteria assume that the residuals are independently identically distributed. For this reason a hypothesis test would not grade consistent results. However, one can examine also non-stationary time series with the cointegration analysis for linear connections while a simple regression test can point to a spurious correlation.

ENGLE and GRANGER (1987) define cointegration as follows:

The components of a k-dimensional vector are cointegrated of the order *(d,c), Y~CI(d,c)*, exactly then when all components of *Y* are integrated by the order *d* and there exists (at least) a nontrivial linear combination *z* of this variables, which are integrated by the order d-c, whereby $d \geq c > 0$ is valid, i.e. if

$$\beta' Y = z \sim I(d-c)$$

β is called the cointegration vector whereby the number of linear independent cointegration vectors shows the rang r. One can formulate further as follows:

- *$r = k$*: The system consists of k stationary variables and is suitable for VAR model.
- *$r = 0$*: No cointegration is present so that the first differences should be taken into account.
- *$0 < r < k$*: Cointegration is present.

As a cointegration test, the Johansen approach - which is based on the VAR process - can be conducted. The quintessential point of the Johansen test is the investigation of the mathematical characteristics of the *Π* matrix which contains important information about the dynamic stability of the system. Starting point of the procedure is VAR without a deterministic trend:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \dots + A_p Y_{t-p} + U_p$$

The Johansen approach can be conducted only if the above equation can be transformed into a vector error correction model (VECM). Then the following equation is valid for the VECM:

$$\Delta Y_t = -\Pi Y_{t-1} + A_1^* \Delta Y_{t-1} + A_2^* \Delta Y_{t-2} + \dots + A_{p-1}^* \Delta Y_{t-p+1} + U_t \text{, while } \Pi = I - \sum_{j=1}^{p} A_j \text{ and}$$

$$A_j^* = -\sum_{i=j+1}^{p} A_{ij} \text{ ,} j=1,2\dots, p-1 \text{ .}$$

Matrix I is a unit matrix while in matrix Π the long-term relations between the variables is noted. Here, the rank of matrix Π is tested, i.e. the number of positive eigenvalues are tested. With this test the rank of matrix Π becomes estimated. Two test statistics results are:

$$Tr(r) = \sum_{i=r+1}^{k} \ln(1-\hat{\lambda}_i) \text{ (Trace-Test)}$$

H_0: There are maximally r positive eigenvalues vs. H_1: there are more than *r $(r < k)$* positive eigenvalues.

The tests begin with *$r=0$* and end if the null hypothesis cannot be rejected any longer. The cointegration rang corresponds then to the value r with which the null hypothesis could not be rejected. Null hypothesis is exactly rejected if the values resulting from the test statistics are larger than the critical parameter.

In this respect, the analysis of a long-term relationship between European oil and gas prices shows that these variables are cointegrated. The results of the stationarity test (ADF) and cointegration (Johansen-Test) analysis can be found in the appendix. As indicated before, the consideration of this linkage is that the natural gas market is a “proxy” for the oil market. The results of the cointegration test show that the first argument of JOUTZ/VILLAR, which assumes that an oil price increase leads to a natural gas price increase, is the most consistent. The market-based acquirements solidify this argument as well.

4.5 Estimation of the Determinants of Germany's Natural Gas Import from Russia

After identifying the linkage between oil and natural gas prices the next step will be to investigate the determinants of German natural gas imports from Russia.[7] In this context, as discussed before, the influencing factors are crucial for policy conclusions.

In the existing literature there are several studies which investigate the demand structure of single sectors (like industry or households), but there is a lack of analysis that tries to explain the import quantities as a whole. NILSEN/ASCHE/TVETERAS (2008) study the natural gas demand in the European household sector, using data from 12 European countries and the dynamic log-linear demand model. They choose explanatory variables including lagged demand per capita, heating degree days index, real prices of natural gas, light fuel oil and electricity and real private income per capita. Furthermore, they focused on short run and long run elasticities of households in different countries. The Energy Information Administration (EIA) of the U.S. Energy Department (DOE) developed the Short-Term Integrated Forecasting (STIFS) model to estimate short-term (up to 24 months), monthly forecasts of U.S. supplies, demands, imports, stocks, and prices of various forms of energy. It implemented models for six sectors and took weather, industrial sector production, household formation, commercial employment, relative prices of natural gas substitutes are the main factors affecting natural gas demand. In the electric utility sector, gas demand is affected by the level of overall electricity output, which is determined primarily by various factors affecting electricity demand as well as the availability of hydroelectric and nuclear power and the price of gas relative to other fuels.

In order to explain the determinants of Germany's import needs for Russian natural gas, a linear natural gas demand model is applied. A similar model has been developed by OBERHEITMANN and FRONDEL (2005) who take into account two important determinants of natural gas demand:

$$\ln(E_{gas.t}) = c + \alpha \ln(E_{oil.t}) + \beta HDD_t + \varepsilon_t$$

where $E_{gas.t}$ is the natural gas demand at time t, c is a constant and the variable ε_t is the estimation error term. In their analysis, OBERHEITMANN and FRONDEL estimate the entire energy demand structure of China by considering different primary energy supplies, including mineral oil, coal, hydro, nuclear and renewable energy. In the natural gas demand analysis, mineral oil is assumed as a substitute of natural gas.

The lagged EI_{t-1} (Import quantity from Russia in the previous period) plays an important role for the explanation of EI_t (Import quantity from Russia in the current period) because it shows the inertia of the energy demand system. Investments in energy supply and demand-side are long-term. Therefore, the capital stock turnover does not change to a large extent from one year to the other (OBERHEITMANN, 2008). However, another important determinant of energy demand is the gross domestic production (GDP) of a country, while

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[7] The value of natural gas import volume is calculated in Tera Joule (TJ) because of the differences in energetic values of different natural gas types.

the industrial production (IP) counts as a consistent indicator of it, including a monthly total output of factories and mines[8].

Another important determinant for the empirical analysis is technological progress. Technological progress has a key role for energy demand quantities and energy efficiency improvement. Energy intensity (T) is the most commonly used basis for assessing trends in energy efficiency since a truly technical definition of energy efficiency can only be obtained through measurements at the level of a particular process or plant. Energy intensity is thought to be inversely related to efficiency (i.e., the less energy required to produce a unit of output or service, the greater efficiency) (EIA, 2008). A logical conclusion is that declining energy intensities over time may be indicators for improvements in energy efficiencies and technical trends. For this reason, "T" represents for intensity, while dT represents the change in intensity over time.

Another crucial determinant seems to be the oil price as explained above. Because natural gas prices are dependent on oil prices with a lag of above 7 months, expectations of demand for natural gas can be explained by oil prices. WELFENS (2008) identifies critical oil price expectation dynamics in a more conventional pricing approach to the oil market and focuses expectations on oil price inflation.

The hybrid variable "v" is an indicator for the weighting of the natural gas consumption purpose. It contains two different datasets. The first one is the Heating Degree Day (HDD) and shows the climatic impact on natural gas consumption. The second is the share of natural gas in electricity production (1-SG). The larger the hybrid variable, the more dominate the consumption for heating purposes.

$$\ln(EI_t) = c + \alpha \ln(EI_{t-1}) + \varphi dpoil_t + \beta d\ln(IP_t) + \eta dT_t + \sigma v_t + \varepsilon_t$$

E_t: Natural gas imported from Russia at time t
$poil_t$: Price of crude oil at time t
IP_t: Industry production at time t
dT_t: Energy intensity change over time
v_t: Purpose of natural gas import at time t.
d stands for the first difference: $dx_t=x_t-x_{t-1}$

The table below shows the estimation results for the parameters of the natural gas import model. An augmented Dickey-Fuller Test has been conducted for stationarity and results are not spurious. The regression uses the least square method, showing that oil price (p), purpose of natural gas consumption (v) and energy intensity (T) are highly positively significant in explaining the amount imported natural gas at a 5% level of significance. The industrial production level is also significant at the 10% significance level. All variables have the expected sign: the higher the levels of variables are, the higher the amount of imported gas. Other statistic criteria are also on moderate levels.

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[8] In our calculation: 2000=100

Table 1. Estimation Results

Dependent Variable: LNEI

Method: Least Squares

Sample (adjusted): 2 121

Included observations: 120 after adjustments

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	3,749588	0,426990	8,781434	0,0000
LNEI(-1)	0,250129	0,085330	2,931292	0,0041
DPOIL	0,003682	0,001782	2,065842	0,0411
DLNIP	8,611695	4,777599	1,802515	0,0741
DT	0,194268	0,059300	3,276027	0,0014
V	1,52E-07	4,43E-08	3,436855	0,0008
R-squared	0,327693			
Adjusted R-squared	0,298205			

4.6 Natural Gas Import from Russia: A Simple Forecast for 2015

The estimation in the previous section showed some of the central components of Germany's natural gas imports. The historical data shows that these imports have risen by more than 20% in the last 10 years. A further increase in demand and thus imports can be expected following the reasons explained above. In this respect, a forecast on the basis of time series for natural gas import from Russia could demonstrate Russia's importance in the future.

In time series modelling, the information inherent in the previous values of an economic variable like EI_t can help to forecast the future values. This kind of modelling can be realized with Autoregressive (AR), Moving average (MA) and ARMA or ARIMA models. Here, the Box-Jenkins approach (1976) is applied for the preparation of the data and the identification of an appropriate ARIMA. Based on different tools like R^2, F- Statistics approach, Akaike Information Criteria (AIC) or Schwarz Information Criteria (SIC), the optimal model for the natural gas import is ARX that enables forecasting. The residuals do not exhibit any structure (i.e., serial correlation). Under the assumption that the industrial production of Germany increases at the same pace, its energy intensity falls with the same tendency and climate impacts and SGG will stay the same, the table and figure below show the expected natural gas import volumes of Germany.

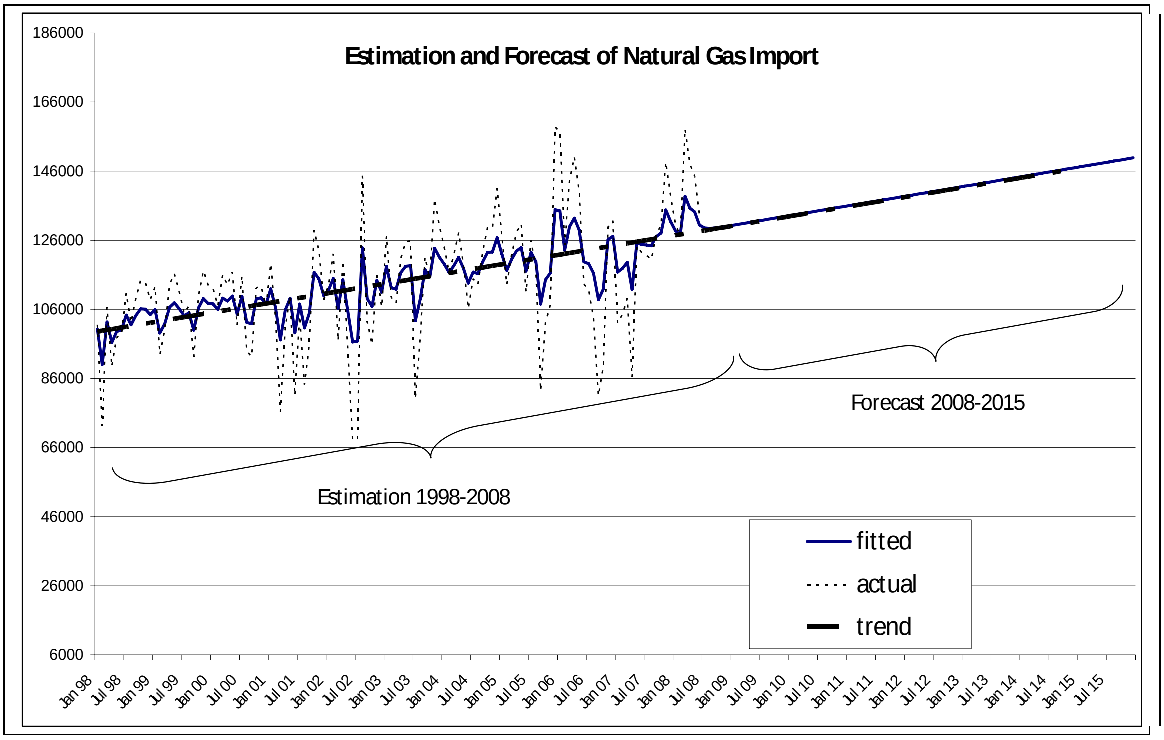
Table 2. Regression Results for Forecast

Dependent Variable: EI
Method: Least Squares
Sample (adjusted): 2 126
Included observations: 125 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	64275,44	8835,383	7,274776	0
EI(-1)	0,352764	0,084745	4,162645	0,0001
TIME	151,8088	42,27517	3,590967	0,0005
R-squared	0,314397			
Adjusted R-squared	0,303158			

As a result, based on the forecast, the expected value of natural gas imported can rise up to 1.779.814 TJ (temp. maximum), signifying an increase of about 12 % in 8 years. This means that Germany's import dependency on primary energy will rise. A similar development is predicted by calculations of the International Energy Agency (2008). Detailed forecasts for single years can be found in the next table and figure.

Figure 11. Forecast of Natural Gas Import.



Total

2009	2010	2011	2012	2013	2014	2015
1.577.168 TJ	1.610.938 TJ	1.644.713 TJ	1.678.488 TJ	1.712.263 TJ	1.746.038 TJ	1.779.814 TJ

2007= 1.436.060 TJ

5. Conclusion and Policy Implications

Under the assumptions made, i.e. that German industrial production increases at the same pace, that energy intensity falls with the same tendency, and that climate impacts as well as SGG will stay the same, results of calculations show that natural gas imports from Russia will increase to nearly 1.800.000 TJ by the year 2015. This means an increase of 12% in the eight years from 2008 and implies an even stronger reliance on Russia as Germany's main supplier of natural gas than is already existent today. While the fact that large amounts of gas supply mainly come from one source has itself caused concern, additional anxieties have been raised regarding the reliability of Russia as the major provider. Whereas Russia has proven to be a reliable supply partner in the past – supply relations have been in existence since first contracts were signed by Ruhrgas and the Soviet gas industry in 1973 (E.ON, 2008) - recent events, in particular the gas conflict with Ukraine (which has already been termed a "Christmas ritual" (THE ECONOMIST, 2009a) as it has occurred every winter since January 2006), have not only already physically led to a gas shortage or even supply stop to Germany but have also created considerable concern over future stability and security of deliveries. In addition to such political issues, concern over Russia's ability of supply has also been raised on the technical side as enormous investments are required to replace existing and to develop new gas fields. Moreover, the Russian domestic market has experienced high consumption rates of natural gas demand itself in the past while at the same time being characterized by low efficiency and profound underinvestment, leading to a situation where natural gas demand has outpaced Gazprom's rate of production (TSYGANKOVA, 2008). Apparently, Gazprom has already applied for financial support from the Russian government for being able to stem investments (THE ECONOMIST, 2009b). Thus, considerations on how to reduce Germany's dependency on Russian gas are a critical issue. Several proposals, which will be presented in the following, can be made.

5.1 Diversification of Supply Sources

While Russia is the quantitatively largest supplier of gas to Germany, it is not the only one. As shown in chapter 3, remaining gas needs are provided by the European neighbours Norway and the Netherlands. While attempts should be made to increase volumes from each of these existing suppliers – Germany and Norway, for example, have just concluded new and extended supply contracts (MÜLLER, 2009) –, additional efforts are required to develop new suppliers, particularly as indigenous gas deposits in European countries, even in resource-rich, are on the decline (such as the UK as explained above). Instead, supplementary supplies could come from Africa or the Middle East, particularly as these suppliers lie within pipeline transportation distance to Germany and have evinced economic interest in supplying Europe. Nigeria, for example, already accounts for a share of 4% of gas supplies to the EU-27.

Similarly, small amounts of LNG are already shipped from Qatar. Volumes from these regions should be enlarged in the future, especially as LNG prices are expected to decline due to improvements on the technical side, over long distances making transportation of LNG competitive with gas transported by pipeline. This requires a serious improvement of infrastructure though. While main LNG landing terminals already exist in France, Greece, Italy and Spain, Germany's plan to build a terminal in Wilhelmshaven have continuously been postponed as investments have not been considered economically reasonable thus far. Moreover, while several new LNG projects are planned in other European countries, Germany has so far not been able to take advantage of these, as the necessary pipeline infrastructure does not exist to transport re-gasified LNG to Germany.[9] Thus, in order for Germany to benefit from LNG as an alternative form of supply from Russia, construction of a national terminal seems necessary in the long-run. At the same time, though, it must be kept in mind that LNG supply is not able to completely substitute for the volumes of pipeline gas (see also EUROPEAN COMMISSION 2007 and 2008).

5.2 Pipeline Extension

Apart from the diversification of supply sources, similar considerations must be made regarding the diversification of transportation routes as already indicated for the case of extending supply by LNG. In this respect, diversified shipping by pipeline plays a major role. Currently, several projects are planned in addition to existing routes, major ones being the North Stream and the South Stream pipeline as well as the Nabucco project. These will be briefly presented in the following:

The North Stream and the South Stream pipeline are of particular importance for German gas supply with regards to further possible disruptions in the Ukraine as both pipelines bypass this current transition country. The North Stream route brings Russian gas from Wyburg in the North of Russia through the Baltic Sea directly to Greifswald at the German border. Operated by consortium of Gazprom (51%) and the German companies E.ON Ruhrgas (20%) and BASF (20%), North Stream is expected to start operation in 2010, reaching full capacity in 2016. As regards the South Stream pipeline, gas is shipped over a distance of 900 km from Russian Noworossijsk through the Black Sea to Warna in Bulgaria. The $ 20 billion project, a co-operation between Gazprom and Italian ENI, has a carrying capacity of 31 billion m^3 and is expected to start operation in 2013.

While these pipelines present a diversification of supply routes, the actual problematic of dependence on Russian gas remains, even increases as Russia could stop deliveries more easily on either way. Thus, developing alternative pipeline routes which bypass Russia altogether is critical. A major project in this respect is the Nabucco pipeline, managed by a consortium of six European energy companies (including German RWE) and supported at the foreign policy level between Germany, Austria, Hungary, Romania, Bulgaria and Turkey. The new pipeline is one of the most important European Union projects in this policy range. From 2011 onward, Nabucco is scheduled to supply gas via a 3,300 km long pipeline from the Caspian region, and possibly Central Asia, via Turkey to European markets, covering between 10 and 15% of the European Union natural gas needs by the

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[9] In this respect, solutions would also have to be found of who carries investment costs for and ownership of such pipelines to Germany, e.g. from an LNG terminal in Southern Spain or Italy.

year 2025. Signifying its importance, the European Investment Bank has just recently agreed to hedge for investment risks of the eight billion Euro project. One of the remaining problems though still is by which sources the gas will finally be fed in as Gazprom has locked in nearly all former Soviet States in long-term contracts. Iran, which possesses the world's second largest gas resources, has always been a possible candidate to supply gas to Nabucco, assuming though that political issues can be resolved. Concrete negotiations, on the other hand, have apparently already been taken up with Iraq and Egypt as two possible sources which are considered. At the same time, project progress has been hindered by Turkey, which has attempted to use Nabucco as a political instrument to accelerate its membership negotiations with EU (SCHRAVEN, 2009). In this respect it has been stated that "the project is beyond that noteworthy, since it clarifies the thought that the European Union borders are not equal to the borders of the European energy market and third countries and not-yet-EU members which are merged concretely into projects of the European Union" (NOTZ, 2006). Thus, as becomes apparent, apart from technical and financial challenges, pipeline projects are also severely threatened by political disputes.

5.3 Diversification of the Energy Mix

While a diversification of supply sources and means of transportation is a fundamental cornerstone of reducing dependence, it may not be the major focus of efforts as development of alternative sources and routes is costly and enduring, and often also environmentally hazardous. Other options such as the diversification of the energy mix should also be considered.

In reaction to the gas conflict, the former German Federal Minister for Economic Affairs and Technology, Michael Glos, particularly emphasized the importance of diversified supply sources and means of transportation, emphasising the importance of 'not betting on the wrong horse' by focusing on a single energy carrier. Instead, as Glos claimed, security of supply should be based on a broad energy mix, one which also includes coal and nuclear energy, and enhanced efficiency measures (BMWi, 2009). Being a sensitive issue in terms of environmental protection with regards to coal and safety with regards to nuclear energy, further promoting these energy carriers in the overall energy mix will require much effort to gain public (and political) support. In addition to fossil fuels though, renewable energy sources need to also be promoted further, financially as well as in terms of gaining wider acceptance among the public. With regards to gas demand, particularly biogas is an increasingly important option to substitute a part of natural gas provision. Biogas is very well applicable in the heating as well as the electricity production sector where it is expected to account for a share of more than 30% of power generation by 2020. In total, biogas is expected to cover 6% gas consumption in 2020 and 10% in 2030 (BEE, 2009; BUCK, 2009; E.ON, 2009). Crucial for a reduced dependence on natural gas imports is also the advancement and support of new technologies such as the production of 'renewable coal' through a recently developed process which allows producing bio-coal from renewable organic material. This coal cannot only be used for electricity generation but particularly serves as a supplier of heat produced in large amounts during the process (DONNER, 2009). In the heating market, bio-coal may therefore come to serve as a substitute for at least part of natural gas heating.

5.4 Storage and Infrastructure

Historically, gas storage had the function of balancing demand and supply peaks over the year (i.e., storing gas in the summer to be used in high consumption times in winter). Over the years though, storage has also become strategically important regarding the security of supply in times of unexpected disruption. Germany currently is the largest stock keeper of natural gas in Europe, possessing 46 underground storage systems with a capacity of about 20 billion m³.[10] Although, other than with oil, keeping natural gas stocks is not compulsory yet, Germany can cover around 25% of annual demand volumes through stocking. Germany also has one of the most advanced gas infrastructure systems in Europe, pipeline length having grown to 420,000 km. Pipeline extension and maintenance is also an important supporter of supply security as pipelines can partly be used as storage devices. Between 2000 and 2008, nearly 11 billion Euros were invested in developing and preserving infrastructure. In 2008, investments into gas storage alone amounted to 130 million Euros, presenting an increase of 30% compared with 2007. At a European level, though, further development of storage capacities is required in order to improve security of supply and enable reciprocal standby supplies within the EU (BDEW, 2008a; BDEW, 2008b).

5.5 Domestic and Foreign Political Endeavours

On a political level, several issues have to be addressed. From an overall European perspective, it is essential to further press ahead the liberalization of European energy markets in order to create a common market which facilitates transition and exchange of natural gas flows, thus enabling a more efficient supply. On a national scale (i.e., within Germany), it is frequently pointed out that more efforts are required from politicians, especially with regards to a ‘political will’ (ARETZ, 2009) for change. Amongst others, this includes the settling of differences between ministerial resorts as well as stronger confessions regarding future technologies (STRATMANN, 2009). Moreover, a more stable legal framework is necessary, serving as a sign of reliability to companies for carrying out necessary investments. This also means allowing energy companies to generate a reasonable rate of return from their investments and not to governmentally restrict these yields (BDEW, 2008c). This becomes even more important when considering that the German power plant fleet is outdated and needs replacement. In this respect, it should be noted that while renewal had been planned on the basis of an increased use of gas-fired plants, the recent gas conflict has led to initial statements that the number of gas-fired stations will be reduced in the future (FLAUGER/ STRATMANN, 2009). At the same time, it is worth pointing out that gas saved through efficiency measures in the heating sector is likely to be re-directed to be used in gas-fired power generation stations (MÜHLSTEIN/ KÖPKE, 2008), particularly when taking into account politically driven pressures for climate protection which lead to profound changes in the electricity sector

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[10] Exact data is not available as storage facilities or gas stored in leased storage is owned by energy companies that do not publish this data.

(MATTHES/ ZIESING, 2008). Both paths of development would have significant impacts on natural gas demand in the long-term.

5.6 Involvement of Energy Companies

While many issues regarding the energy market first need to be resolved at the political level, growing effort and involvement is also required by German energy companies which, for example, possess over relevant technical and market expertise that again is required by producing countries such as Russia. E.ON, for instance, has been allowed to participate in the development of difficult to access gas fields in Russia, in this way stabilizing relationships for supply (MÜLLER, 2009). At the same time, it can be criticised that exactly by strengthening these ties, other opportunities for developing alternative sources may not be pursued, either for financial reasons or not to endanger projects with Russia. On the other hand, though, many German energy companies have begun to invest in renewable energies, increasingly realizing this to be an important business segment for supporting the provision of future demand and thus setting the basis for diversifying Germany’s overall energy mix as demanded above.

6. Final Word

As a final conclusion, it can be maintained that Germany’s dependence on natural gas imports is not likely to become weaker in the future as indicated by the modelling above. This again implies that the development of alternatives becomes ever more crucial. In this respect, as has been indicated by considerations on policy implications above, it is crucial to take into account several options, as there most likely will not be a single way to proceed. Moreover, as can also be drawn from the above, it is important to take into account that these solutions take place on different levels (i.e., political – within national boundaries as well as on a geopolitical basis –, corporate, and technical levels).

Moreover, Germany cannot follow a strategy of its own as other European Member countries are also heavily dependent on Russian gas supply and thus face similar concerns over security of supply. In this respect, it can be expected that the attempt by other members to diversify their supply sources will increase competition further. The UK, for example, has begun to pipe in gas from the Netherlands through the Balgzand-Bacton_Line (BBL) and import capacities shall be increased in the future. Significantly, gas is currently only flowing in one direction, i.e. from the Netherlands to the UK (OTZEN-ODRICH, 2008), gas amounts which thus are not at German disposal anymore. Individually pursued strategies may therefore lead to conflicts within the EU and weaken bargaining power vis-á-vis suppliers. Accordingly, in order not to become hostage to further disputes,[11] it becomes even more crucial in the future that the EU promotes a common approach toward energy policy and “speaks with one voice” in order to strengthen its bargaining position. Officials of the European Parliament, for example, have claimed that EU energy policy is still driven by bilateral and secret deals and has instead demanded that the infrastructure systems need to be further connected and common emergency plans established (EUROPEAN PARLIAMENT, 2009).

Furthermore, despite arguments that Russia is also dependent on Europe as one of its major buyers, this has recently not prevented Russia from dispensing of a large part of sales revenues from Europe and risking its reputation as a reliable supplier in order to increase pressures in the gas conflict with Ukraine. Furthermore, when taking into account the fact that gas resources are likely to increase in value in the future (based on growing demand which faces decreasing supplies), and thus increase Russia’s power, a common European approach is a prerequisite. At the same time though, political will and technical solutions are essential prerequisites to be provided from the Russian side (MAKARYCHEV, 2006). Fundamentally, energy relations between the EU and Russia have to be promoted further, an approach that needs to be driven on a political level but must be supported from energy companies as well. A beginning of setting up and strengthening relationships has been made by the EU-Russia summit where energy topics have also been a major content (MAURING/ SCHAER, 2006).

In this connection, the Energy Charter Treaty (ECT) is a key issue for the energy supply security of Germany and the sustainable NG export income of Russia. The ECT supports energy trade based on WTO principles and tries to force the members to protect the investments from non-economic risks. The main purpose of the ECT is to guarantee profit repatriation for both sides. Promoting energy efficiency is another focus.

The treaty focuses on 4 important points of energy supply:

- the promotion and the support of foreign investments
- no discrimination for trade in energy products and energy-production equipment based on WTO rules, and provisions to ensure reliable cross-border energy transit flows through pipelines, grids and other means of transportation;
- the resolution of disputes between participating states, and - in the case of investments - between investors and host states;
- the promotion of energy efficiency, and attempts to minimise the environmental impact of energy production and use. (ENERGY CHARTER, WEB).

The Energy Charter Treaty obligates member countries to smooth the progress of energy transportation and the security of these routes. Most transition countries have signed the Energy Charter Treaty, which sets international standards for commerce in the energy sector. Armenia, Azerbaijan, Georgia, Moldova, Kazakhstan, Kyrgyzstan, Turkmenistan, Ukraine and Uzbekistan have already ratified the ECT, while Belarus and Russia have signed but not ratified it. Belarus is postponing its ratification, and waiting on agreement between Europe and Russia.

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[11] According to experts, the Russian-Ukrainian gas conflict was not raised by technical details as claimed by the parties, emphasising that German and European gas supply security is a political matter (LATUSSECK, 2009).

The EU tries to take an effective application of ECT rules on investment and transit. The EU tries to enable an arbitrage or negotiation possibilities for investors in conflict situations. In this context, Transit Protocol proposed by the EU should be an attempt to strengthen the applicability of the GATT/WTO principles of freedom of transit and to facilitate transit on a non-discriminatory basis. Hoever, the provisions to be considered became a controversial issue between the EU and Russia. To date no compromise has been reached on the final text of the protocol. Some of Russia's reluctance to ratify the ECT is related to its unwillingness to give a third party access to gas transmission pipelines in Russia to transit Caspian resources, especially Turkmen gas (EUROPEAN COMMISSION, 2008b). On 6 August 2009, Russian Prime Minister Putin announced his decision not to sign the Energy Charter Treaty. This decision once again raised the question as to whether energy sources should be used as a political instrument.

The following table briefly shows some key issues and arguments that have been advocated by Russia and related opinions argued by the EU.

Russian (Gazprom) arguments	**ECT advocates**
ECT provision on free and competitive access to transit pipelines will increase the transit of Caspian gas across Russia to Europe, directly competing with Russian gas. Ratification will open the door for Turkmen gas travelling via Russian existing pipeline capacities, at inexpensive Russian domestic tariffs, to Western countries.	The ECT does not oblige a transit nation to provide its capacities for transit. However, it states that if the access is provided, it should be done on non-discriminatory terms. The ECT does not regulate and does not interfere with transit tariffs for gas extracted in Russia and does not demand access to Asian gas transit. Besides, it does not require the access to Russian fields.
Transit Protocol does not work in the EU (considering the EU as a single market), implying that e.g. Russian gas transited through Poland to Germany would not be governed by Transit Protocol while Asian gas through Russia to Europe would be (Russia finds this unfair). Norway has not ratified the ECT and the EU does not seem to be pressing it at all.	The ECT provides legal instruments for transit regulation (legal protection of Russian exports) Possibility to enjoy European domestic tariffs (domestic regime for trade and transit that EU members established for themselves)
It increases system risks and uncertainty of gas market development (according to some Russian experts, the restrictions on long-term contracts on European markets (which ECT ratification would imply) would hamper Russian gas business, as its gas fields require large investments that can only be guaranteed under long-term contracts)	The ECT does not forbid long-term contracts, nor does it impose any purchase obligation at EU border. The ECT would decrease system risks, as it would set identical legal obligations, which would provide a minimal standard of non-discrimination.
The treaty will fail to improve the investment climate It will not attract more FDI in the Russian gas sector	The ECT provides a favorable investment regime that could help foreign investments in the Russian energy sector

Source: EUROPEAN COMMISSION, 2008b, P.195

As key conclusions, one may emphasize that a) there should be reliable framework for EU-Russia energy cooperation – this is not only a political challenge, also an economic challenge for both sides; b) there must be a critical minimum of energy modernization projects which are profitable for EU energy firms and Russian energy firms, respectively; c) there could be joint R&D projects with a focus on climate policies in which the EU and Russia would cooperate, which would naturally include projects in the gas industry and the oil sector as well as the renewable sector. Joint research projects and promotion of alternative energy sources is of central interest to both sides, because interdependency based on a politically sensitive issue like this can danger the economic sustainability of both parties. In this context, the historical experiences showed that an economy based on natural resources can risk the long run economic development of the exporter. This phenomenon called “Dutch Disease” could also be an obstacle to the Russian economic development. The question as to whether and how much Russia is dependent on the natural gas exports to Germany is a research question for further analysis.

7. Appendix

7.1 ADF - Stationarity Test

EUR. Brent Oilprices		t-Statistic	Prob.*	***EUR. IPE NG Prices***		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.634587	0.9953	Augmented Dickey-Fuller test statistic		- 1.972.901	0.2987
Test critical values:	1% level	- 3.461.938		Test critical values:	1% level	- 3.461.938	
	5% level	- 2.875.330			5% level	- 2.875.330	
	10% level	- 2.574.198			10% level	-254.198	

MacKinnon (1996) one-sided p-Values

Null Hypothesis: D(OP) has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-12.62487	0.0000
Test critical values:	1% level	-3.461938	
	5% level	-2.875330	
	10% level	-2.574198	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(OP) has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-12.62487	0.0000
Test critical values:	1% level	-3.461938	
	5% level	-2.875330	
	10% level	-2.574198	

Determinats of Natural Gas Import

Null Hypothesis: LNEI has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.722.485	0.0000
Test critical values:	1% level	-3.483.312	
	5% level	-2.884.665	
	10% level	-2.579.180	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: DLNIP has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.095.996	0.0014
Test critical values:	1% level	-3.485.586	
	5% level	-2.885.654	
	10% level	-2.579.708	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: DT has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.428.777	0.0001
Test critical values:	1% level	-3.486.064	
	5% level	-2.885.863	
	10% level	-2.579.818	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: V has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.062.927	0.0000
Test critical values:	1% level	-3.486.551	
	5% level	-2.886.074	
	10% level	-2.579.931	

*MacKinnon (1996) one-sided p-values.

7.2 Lag Order Selection

VAR Lag Order Selection Criteria
Endogenous variables: EOP EGP **EOP (Brent Rohölpreise)EGP (Gaspreise an der London-Börse)**
Exogenous variables: C
Sample: 1990M04 2007M07
Included observations: 200

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1178.619	NA	459.6382	11.80619	11.83918	11.81954
1	-679.5935	983.0809	3.254978	6.855935	6.954885*	6.895979*
2	-676.9952	5.066797	3.300977	6.869952	7.034868	6.936691
3	-667.6911	17.95678	3.130568	6.816911	7.047794	6.910346
4	-662.7975	9.346895	3.102916	6.807975	7.104823	6.928105
5	-660.2602	4.795355	3.148955	6.822602	7.185417	6.969428
6	-657.8457	4.515133	3.199743	6.838457	7.267239	7.011979
7	-645.7132	22.44518*	2.950405*	6.757132*	7.251880	6.957349
8	-643.8071	3.488127	3.013613	6.778071	7.338785	7.004984

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

7.3 Johansen Cointegration-Test

Sample (adjusted): 10 209
Included observations: 200 after adjustments
Trend assumption: Linear deterministic trend
Series: GP OP
Lags interval (in first differences): 1 to 7

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.090716	19.37903	15.49471	0.0123
At most 1	0.001796	0.359519	3.841466	0.5488

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.090716	19.01951	14.26460	0.0082
At most 1	0.001796	0.359519	3.841466	0.5488

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

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