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Effect of Hold-Up Potential on Natural Gas Exports

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Abstract

Producers and users of natural gas are often connected by a single pipeline which represents a high up-front sunk cost and which may pass through a number of jurisdictions before reaching its final destination. Given the lack of alternatives available to producers and consumers, there is considerable potential for postcontractual opportunism not only by the parties to the contract but by transit countries as well. Hold-up potential, which creates uncertainty about future revenue from the resource, may provide incentives for the resource owners to shift the revenue stream towards the present, hence accelerating resource extraction. The data analysis tests the importance of hold-up potential in the decisions of gas exporters. Using panel data and instrumental variables, to account for endogenous prices, the analysis shows that holdup costs play an important role in the decision making process of natural gas suppliers.

Keywords: hold-up, quasi-rents, gas exports

1. Introduction

The hold-up problem may arise when one of the parties to an agreement has made investment that is specific to the agreement and that loses much of its value to the owner outside the agreement.

Suppose that before the investments were made the parties had agreed on sharing the profits that are created by their involvement in a deal.

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After the asset specific investments have been made the investor stands to incur a loss if the deal is not implemented.

Hence, the other party may decide to re-negotiate the sharing of the profit, leaving the investor with a smaller share. In this case the other party holds up the investor.

Hold-up problem concerns any party that is involved in trade of a natural resource, because it requires large upfront investments. However, this problem is especially important for the international trade of natural gas. The reason for this is the fact that there are fewer modes of transportation of natural gas compared to oil. While oil can be transported via pipeline, on tanker ships, trains and even trucks[3] , natural gas is mainly transported via pipeline. As discussed earlier, natural gas can also be transported by specialized tanker ships, if the gas is liquefied before the transportation. However, even this additional option doesn't generally make natural gas as easy to transport as oil. The reason is that liquefaction requires costly investments into the liquefying plants, specialized tanker ships from the exporter; it also requires investments into de-liquefying plants by the importer. Hence, the limited transportation options play an important role in making the hold-up potential especially important for natural gas industry.

The issue of hold-up potential has a connection with political aspects. A corrupt government is more interested in enriching itself in the short run than in optimal use of the resource in the longer term. This is exacerbated if the country experiences political instability, which further increases the discount rate of the ruling party. The importers or transit country may have more bargaining power, if the government of the exporter wants to make use of the resource earlier rather than later. Based on the above, hold-up potential may have a positive rather than negative effect on natural gas exports.

This paper develops a method of measuring hold-up potential for twenty two natural gas exporting countries, and examines the effect of hold-up potential on natural gas exports. The measure of hold-up potential is based on factors external and internal to the exporting country. The external factor is how remote main importers are from an exporter. Being located further away from main importers, with more transit countries along the pipelines, increases the potential for an exporter to be held up.

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[3] Although, most of oil in wholesale deals is transported via pipelines or on tanker ships.

The internal factor is political instability within an exporting country, as mentioned above; it can force a corrupt government to try to make use of natural gas as soon as possible.

2. Literature REVIEW

2.1. Post-Contractual Opportunism

The notion of hold-up costs is often illustrated using the classic example of the Fisher Body – General Motors contractual relationship (Klein, 1988, 2000, 2007). Klein, Crawford and Alchian (1986) explore the possibility of post-contractual opportunistic behaviour in the presence of appropriable specialised quasi-rents. They define the quasi-rent value of an asset as the excess of its value over the value in the next best use of the asset. After a specific investment is made and such quasi-rents are created, the possibility of opportunistic behaviour to appropriate some or all of the quasi-rents is very real. This problem can be solved by vertical integration or long-term contracts. The authors assume that as assets become more specific and more appropriable quasi-rents are created, the costs of contracting will increase more than the costs of vertical integration. Hence, vertical integration is a more likely scenario for activities with expensive and specific assets.

Klein, Crawford and Alchian assume that long-term contracts used as alternatives to vertical integration can take two forms: (1) an explicitly stated contractual guarantee enforced by government; (2) an implicit contractual guarantee enforced by the market mechanism of withdrawing future business if opportunistic behaviour occurs. Explicit long-term contracts can in principle solve the problem of opportunistic behaviour, but they are often very costly. Since it is expensive to specify every contingency in a contract, transactors may also rely on an implicit type of long-term contract. Such implicit contracts employ as enforcement mechanism the imposition of capital loss by the withdrawal of expected future business. The authors argue that this market enforcement mechanism is a major element of contractual alternative to vertical integration.

According to the Klein, Crawford and Alchian, in order to avoid opportunistic behavior future “premiums” are offered to the potential cheater by the market enforcement mechanism.

The present discounted value of this future premium must be greater than the increase in wealth that the potential cheater may gain if the opportunistic behaviour is exercised and the firm is terminated. Hence, this premium is similar to insurance payments to prevent cheating. As long as both parties make the same estimate of the potential short-term gain from cheating, the parties will agree on the level of the premiums and no opportunistic behaviour will occur.

The above mentioned market enforcement mechanism is also discussed in Klein (1996), where the range of possible market changes that still do not result in opportunistic behavior due to the loss of future business is called a self-enforcing range of contractual relationship. This range is defined by the magnitude of the private sanctions that can be imposed on each of the transactors. Each transacting party compares the potential gain from engaging in holdup with the capital loss from private sanctions. The self-enforcing range measures the extent to which market conditions can change without precipitating hold-up by either party. By setting contract terms the transactors are trying to minimize the expected value of hold-up. The contract may decrease the probability of being outside the self-enforcing area by specifying the performance in detail. Hold-ups occur when unanticipated events place the contractual relationship outside the self-enforcing range. However, if a hold-up does occur, detailed specification may make it more severe. This corresponds to the rigidity costs associated with literal court enforcement of contract terms. The conclusion suggested by Klein (1996) is that transactors choose contract terms in order to economize on their limited (and often unequal) amounts of private enforcement capital and thereby to define the optimal self-enforcing range for their relationship.

Another option, in addition to choosing the contract terms, which seem appropriate for the given market conditions, is vertical integration. This is considered in Klein (1988) vertical integration is compared with contractual relations between separate entities. Vertical integration appears to avoid transaction costs by eliminating the second transactor, it substitutes bureaucratic costs for contracting costs. This is obvious for cases of physical capital, where a hold-up, by definition, becomes impossible with vertical integration. However, many real-world examples involve human capital. To understand the gains from vertical integration in the context of human capital, the economic question should be phrased not as whether to own or rent an asset, but as whether to make or buy an input. The firm that produces an input itself may not own the physical capital associated with its production.

However, a firm that makes rather than buys an input generally has a particular relationship with the firm-specific human capital.

2.2. Applications of Hold-Up Problem to Energy and Other Industries

The following papers consider the importance of asset specific investments for contracts in the energy and other industries. Masten and Crocker (1985) state that to avoid repeated bargaining in transactions supported by asset specific investment, parties may use long-term contracts. Since long-term contracts may be inflexible in face of market changes, the authors argue that "take-or-pay" obligations in gas contracts can be viewed as a mechanism for providing appropriate incentives for contractual performance. Under some stringent assumptions, take obligations induce buyers to release purchased output to alternative uses only when it is efficient to do so. Using empirical tests, Masten and Crocker show that contracted take percentages are lower for gas wells associated with small numbers of sellers and many buyers.

Joskow (1987) also tests empirically the importance of asset specific investment for the duration of contracts in coal industry of the USA. When exchange involves asset specific investment, hold up incentives are created once the investment is sunk. A long-term contract guards against ex post performance problems. Joskow's tests, which consider three types of asset specific investment, support the hypothesis that as asset specific investment becomes more substantial, the parties rely on longer-term contracts, rather than relying on repeated bargaining.

Mulherin (1986) examines the complex provisions of long-term gas contracts, such as takeor- pay and price adjustment provisions, by using the data on ownership of gathering lines, magnitude of take-or-pay provisions and the use of most favoured nation clause. He tests whether the provisions of gas contracts are best explained by the hypotheses of transaction costs (from asset specificity of investments), market power, risk allocation or non-price competition. The primary result of the paper is that transaction cost hypothesis is the most consistent with the data.

Saussier (1999) analyses contracts for coal transportation in France, focusing on the costs and benefits of contract duration.

Saussier shows that contracts' duration was positively correlated to the value of asset specific investments (as measured by the value of start-up investments and guaranteed contract quantities) and negatively correlated to the level of demand-related uncertainty over time. Additionally, Saussier considers endegeneity between duration and asset specific investments. He shows that the results mentioned above are largely robust to the inclusion of endogeneity.

3. Data Description

The analysis employs panel data on 22 large net exporters of natural gas during 1985 – 2006. The list of net exporters includes: Algeria, Argentina, Australia, Bolivia, Brunei, Canada, China, Denmark, Indonesia, Kazakhstan, Libya, Malaysia, Netherlands, Nigeria, Norway, Oman, Qatar, Russia, Trinidad and Tobago, Turkmenistan, UAE and Uzbekistan. Table 1 below presents a summary of the data.

Table 1: Summary of the Data

Variable	Obs	Mean	Std. Dev.	Min	Max	Median
price	1449	118.4396	50.80634	34.07614	286.7551	160.4156
net export	1461	25.5859	31344.63	-102294	201241	49473.5
gfcf	448	107310.8	306219.8	320.3727	2188700	1094510.2
yn	1417	402814.6	1176924	860.5503	1.31E+07	6558680.3
ymn	474	2070.59	2416.309	35.7631	13116.5	6576.13
po	1483	24.14886	12.07743	11.66	66.92	39.29
mr	474	1.242939	0.619662	1	4	2.5
pri	474	49.45359	11.72874	24	80	52
h	474	62.8353	40.6035	28	240	134
ih	427	135232.9	367256	2722.215	3603260	1802991
i	448	2194.841	3669.729	41.88023	24760.29	12401.1

price – Regional price of natural gas (USD / 1000 cubic metres).
net export – Net exports of natural gas (million cubic metres).
gfcf – Gross fixed capital formation (million USD).
yn – Gross domestic product (million USD).
ymn – Weighted average of nominal GDP of importers, using share of exports as weights (billion USD).
po – Average cost of total crude oil imports for Europe, Northern America, and Asia and Oceania (USB / bbl).
mr – Index of accessibility of natural gas markets (from 1 to 4).
pri – Political risk index (from 0 to 100).
h – Hold-up potential index (h = mr * pri).
ih – Multiplication: i * h
i – Share of natural gas investments in total gross fixed capital formation for the country: gfcf * (local price * production of natural gas / GDP).

Regional gas prices are used in the regressions. The prices correspond to the following regions: North America, South America, Europe and Asia/Pacific. The import price of gas in the USA (EIA, 2007) was used as the regional price for North America. The Bolivian export price (INE, 2007) was used as regional price for South America. The Norwegian gas price (Statistics Norway, 2007) was used as the European regional gas price. The Japanese gas import price (IEA, 2009) was used as a regional price for Asia/Pacific. For the regions of Africa, Middle East, and the CIS, the European regional gas price was employed due to difficulty of finding consistent data that would also stretch back till mid 1980s. Besides, the price that can be achieved in the large European market is likely to influence decisions of the suppliers in Africa, Middle East, and the CIS.

The data on net exports as well as production of natural gas was obtained from Natural gas information 2007, a report by the International Energy Agency (IEA, 2007). The proxy for investments into the natural gas industry was developed based on gross fixed capital formation (World Bank Global Development Indicators), GDP, and the value of natural gas production. The calculation of the proxy is based on the following formula[4]:

$$i = \frac{gfcf * local\ price * prod\_value}{GDP}$$

i – Proxy for investments into the natural gas industry.
gfcf – Gross fixed capital formation (million USD).
local price – Gas export price received by the supplier (USD/1000 cubic meters).
prod_value – Value of natural gas production (based on local price).

As mentioned above, there can be external and internal factors that contribute to potential hold-ups. The external factors (for example, number of borders the gas delivery has to cross) are incorporated into the econometric model in the form of a market remoteness variable. The further the exporting country is from its importers the greater the potential for a third party to influence the exports. The internal factors (for example, political situation within the country) are added into the model as the political risk index.

[4] The share of natural gas industry in GDP of the countries was calculated for the period 2000 – 2006. For the earlier period this share was obtained from extrapolation, since data on local natural gas prices was not available.

We expect the political risk to increase the potential for hold-ups for the following reasons. Political risk increases uncertainty about the future for the management of the country, or owner of the natural resource. Thus, it may shift the extraction and export patterns from future towards the present, making the country “want” to export more now rather than save some of the resource for the future. This, in turn, makes the country more vulnerable to external influence. Higher political risk in a dependent exporting country may lead a transit country or importer to believe that a hold-up can be implemented, without too great a risk to future cooperation, if the political instability brings a change of the ruling elite.

The data on political risk index (BERI, 2007) varies from 0 to 100, where 0 is a prohibitive risk. In order to have the risk increasing with the value of the index, the political risk index used in the analysis is the result of subtracting the index by Business Environment Risk Intelligence (BERI) from 100. The index focuses on the socio-political conditions in a country by creating a multi-component system with flexibility to weigh key factors, utilizing a permanent panel of experts with diplomatic careers and training in a political science, and providing data that can move independently of other risk measures by BERI.

Due to endogenous price and export volumes, instrumental variables are used for the regional price of natural gas. Natural gas price is likely to be correlated with oil price and with the size of the buyers’ economies, due to greater demand by larger economies. Hence, the instrumental variables are the price of oil and the weighted average of GDP of gas buyers (with the export volumes being the weights). The data on average price of oil for Europe, Northern America, and Asia/Pacific, as well as for each of the OECD countries was obtained from the report on Energy Prices and Taxes by the International Energy Agency (IEA, 2009). For each of the OECD countries its average oil price was used in the regressions. Non-OECD countries were assigned oil price of Europe, Northern America or Asia/Pacific, depending on its location and main exports market. The data on GDP of the countries in our sample was obtained from the World Bank Global Development Indicators.

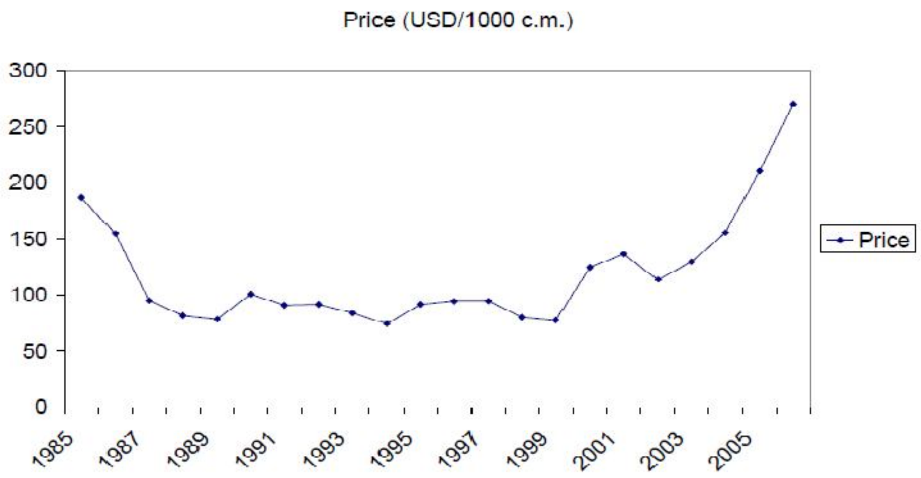
A market remoteness index was created to reflect accessibility of natural gas markets for the exporting countries. The index simply reflects the number of transit countries the gas supplies have to cross plus one. So in case of LNG deliveries or sales to neighbouring importers, the market remoteness index equals 1.

If a given exporter sells gas to a number of importers, then the assigned market remoteness index is a weighted average based on the export volumes. The hold-up index was employed as a measure of potential for hold-up in the supply equation. The index was calculated by multiplication of the political risk index and the market remoteness index. The exogenous variable of the supply equation are investments, hold-up potential and multiplication of investments and hold-up.

4. Descriptive Statistics

During the period 1987 – 2002 the price of natural gas fluctuated around 100 USD per 1000 cubic metres. Before and after this period the price of natural gas was significantly higher.

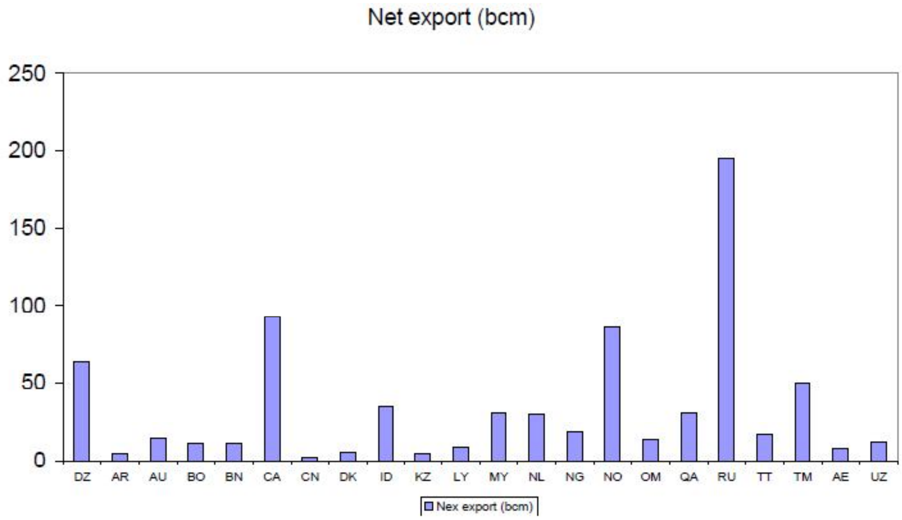
Figure 1: The Annual European Price of Natural Gas



Source: Statistics Norway, Statistical Yearbook of Norway 2007

As mentioned above, our sample includes all of the major exporters of natural gas. Out of 22 net exporters of natural gas, five countries (Russia, Canada, Norway, Algeria and Turkmenistan) exported at least 50 bcm (billion cubic metres) each in 2006. The average net exports of other suppliers was approximately 14.9 bcm.

Figure 2: Net Exports of Natural Gas in 2006



Source: IEA, Natural gas information 2007

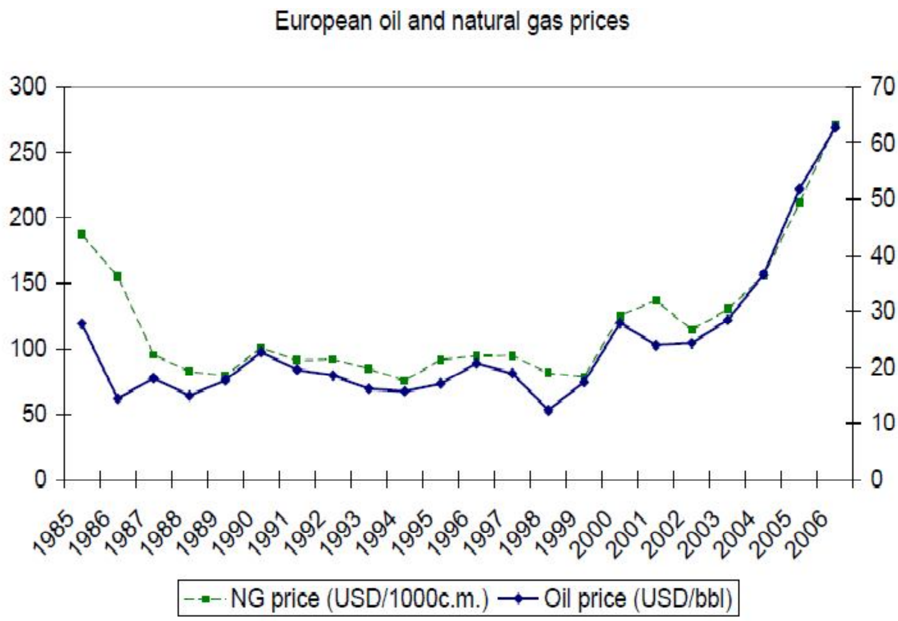
For the sample of 22 exporters over the time period 1985 – 2006, the correlation coefficient between price of natural gas and net exports is 0.1138. The average price elasticity of supply during the period 2000 – 2006 is positive for 18 out of 22 countries. This is the result that most would foresee, expecting supply to grow with increasing price and vice versa. Among the countries with positive average supply elasticity, 13 countries have average price elasticity below unity, and five countries have price elasticity above unity. Three countries (Algeria – 0.1, Brunei – 0.16, and Trinidad and Tobago – 0.09) have negative average supply price elasticity, and for 1 country (Russia) it is equal to zero. However, the negative elasticity values are small in absolute terms.

The proxy for investments into natural gas industry varies from 42 million USD to 24.76 billion USD per year. The mean is 2.19 billion USD and the median is 12.4 billion USD, hence this variable is skewed to the left. The standard deviation is very large and the data on investments is widely spread.

The oil price in our sample varies from 11.66 to 66.92 USD/bbl. The mean is 24.15 USD/bbl and the median is 39.29 USD/bbl.

Between the late 1980s and early 2000s average oil price was fluctuating around 20 USD/bbl; in the mid 1980s, and especially during recent years, the oil price was significantly higher. Figure 3 below is a graph of average European oil and gas prices.

Figure 3: The Annual European oil and Natural Gas Prices



Source: IEA, Energy Prices and Taxes 2009

The figure above shows that European oil and natural gas prices may be correlated; which is unsurprising for prices of the same market, since the products are substitutes to some extent. Additionally, gas price is often tied to oil price in long-term gas supply contracts. The average cross price elasticity of supply for the natural gas exporters during 2000 – 2006 is positive for 14 countries out of 22, and negative for eight countries. The average supply cross price elasticity is positive and above unity for 6 countries.

The market remoteness index and the political risk index are included in the calculation of hold-up. The market remoteness index only varies from 1 to 4, its mean is 1.24 and median is 2.5; hence our sample tends to include more countries with relatively better access to sales markets regarding the passage through transit countries. This is largely influenced by the presence of many LNG exporters, for whom the market remoteness index (in accordance with our formula) equals unity.

The issue of transit is mostly pronounced in the European market. Table 2 below lists the main transit countries for gas trade outside of the former Soviet Union (FSU) in the descending order of the volume of transit flows. As can be seen from the table, most of the main transit countries are in Europe.

Table 2: Main Transit Countries, Sources and Destinations in 2003

Transit country	Source and destination
Ukraine	All Russian gas to non FSU (former Soviet Union), except deliveries via Poland and Belarus.
Slovakia	All Austrian and Czech transit plus Russian gas to Austria and Czech Republic.
Czech Republic	Russian gas to Germany.
Belarus	All Russian gas to Poland and partly to Germany plus part of gas towards Ukraine.
Germany	All Norwegian gas to Italy, Austria and Czech Republic; Dutch gas to Italy; Belgian gas to Italy, Russian gas to France and Switzerland.
Belgium	All Dutch gas to France, some Norwegian gas to Italy and Spain; UK gas to France and Germany.
Austria	Russian gas to Croatia, France, Germany, Hungary, Italy, Netherlands, Slovenia and Switzerland, except for gas via Czech Republic and Poland.
Poland	Part of Russian gas to Germany and The Netherlands.
Tunisia	All Algerian gas to Italy.
Romania	All Russian gas to Bulgaria, Greece and Turkey.
Switzerland	All Belgian, Dutch and Norwegian gas to Italy.
Bulgaria	All Russian gas to Greece and partly to Turkey.
Morocco	All Algerian gas to Portugal and Spain.
France	All Norwegian gas to Spain.
Spain	All Algerian gas to Portugal.

Source: ECS, Gas transit tariffs in selected energy charter treaty countries 2006

Political risk index theoretically varies from 0 to 100, however, in our data its smallest value is 24 (Norway in 1986) and highest value is 80 (Nigeria in 2005 and in 2006). The median value in our sample is 52, with the mean value of 49, this index seems to have almost no skew. Approximately 96% of the observations are within the range from 29 to 69, and approximately 60% of the observations are within the range from 39 to 59. Hence, most of the data points are spread around the mean value.

As mentioned above, the hold-up potential variable is calculated as the product of the market remoteness and political risk indices. The measure of hold-up potential is an index that varies in our sample from the minimum of 28 (in relation to Brunei in 1990 and 1991) to the maximum of 240 (in relation to Turkmenistan in 2003). The mean for hold-up is 62.8, while the median is 134; hence, the data is skewed to the left, which means that many of the countries in our sample face a relatively low hold-up potential. Below is the scatter plot of hold-up observations.

Figure 4: The Scatter Plot of Hold-Up Potential Index

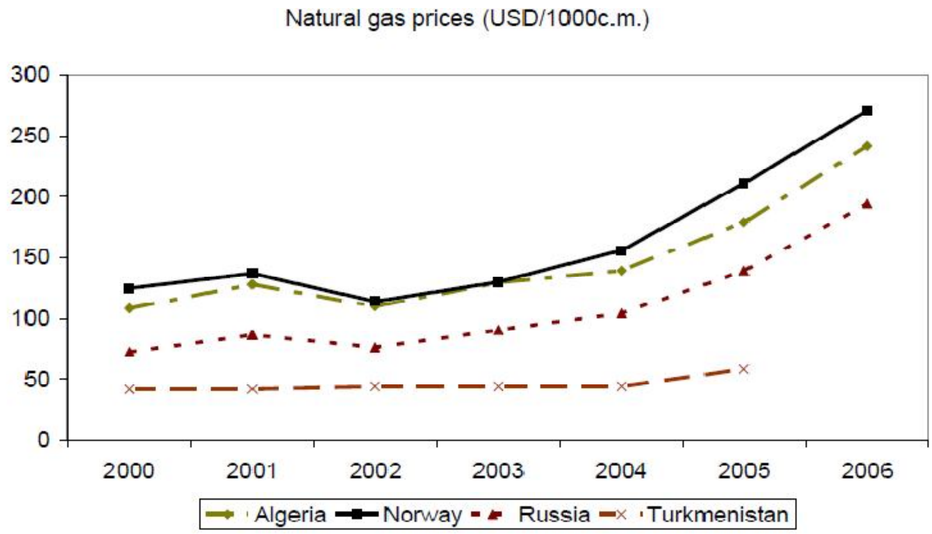
In Figure 4 we see that there are three outliers that have a high value of the hold-up potential index (considerably higher than about 80% of the sample): Algeria, Russia and Turkmenistan. There are also two countries where the index is somewhat higher than for most other countries: Nigeria and Uzbekistan. The hold-up potential index is high for the five countries mentioned partly due to their political risk index being higher than average. However, the external factors also have a significant effect for the outliers.

Most of Algerian exports of natural gas are sent to France, and some of this gas goes through a single pipeline that passes through Spain. Hence, Algeria's export volumes and price may to some extent depend on the transit country. Russian exports of natural gas to Europe also have to go through transit countries, such as Ukraine, Belarus and Poland. There were well known gas disputes between Russia and Ukraine (and a less discussed dispute between Russia and Belarus) in January 2006 and January 2009. For detailed analysis of these disputes see Stern (2006) and Pirani, Stern and Yafimava (2009). Most of Turkmenistan's exports of natural gas go to Ukraine; and they have to be pumped through the territories of Kazakhstan and Russia.

When a supplier is vulnerable to potential hold-up costs imposed by a transit country or importer, the price received for exported gas may exhibit relatively low volatility. This is because relatively small market changes may be absorbed by quasi-rents and/or costs of renegotiations. Larger market changes may be required to affect the receipts of a highly dependent supplier.

Figure 5 presents a comparison of Norwegian export prices of natural gas (representative of European prices) and export prices in some of the countries with high value of hold-up index – Algeria, Russia and Turkmenistan. The export gas price as well as its volatility is significantly lower in the countries with high hold-up potential. One reason for the difference in prices may be the transportation cost; however, it may also be partly due to quasi-rents. Throughout 2000 – 2005 the hold-up potential index is lowest in Norway and highest in Turkmenistan, followed by Algeria and Russia. In these countries, volatility of gas export prices (measured by standard deviation) is 35 in Norway, 26 in Algeria, 24 in Russia, and 6 in Turkmenistan.

Figure 5: The Annual Natural Gas Export Prices for Selected Countries



Source: EIA, Energy prices and taxes 2009, and various newsagents (for Turkmen price)

5. Regression Analysis

The empirical analysis consists of two stage least squares estimation of supply equation. The regression analysis employs a fixed effects model with an instrumental variable to account for endogeneity between gas price and export volumes. The choice of the fixed effects model was suggested by the results of the Hausman test. The null hypothesis that the fixed and random effects coefficients are similar is rejected at the 5% significance level. The data was also tested for unit root using the Im-Pesaran-Shin and Levin-Lin-Chu tests. At least one of the tests could not reject the hypothesis of a unit root for the variables of net exports, gas price, oil price, GDP, investments into the natural gas industry and hold-up potential. However, the tests showed no unit root for the first differences of the variables. Hence, all of the regressions employ the first differences of all of the variables, except for time dummy variables.

The oil price and the weighted average of GDP of the importers are used as instrumental variables for the endogenous price in the supply equation. According to Baum, Schaffer and Stillman (2010), the validity of the IVs (instrumental variables) can be tested by regressing the endogenous variable on the IVs and testing for joint significance of the regressors (with a rule of thumb that the F-statistic should exceed the value of 10). Table 3 below is the regressions of gas price on the IVs. The F-statistic indicates that the IVs are jointly valid for the supply equation.

Table 3: Validity of IVs in the Supply Equation

Dependent variable: dp	Instrumental variables		
	Constant	dpo	dymn
Coefficient	0.1257	2.9412	-0.0034
Standard error	1.0465	0.1486	0.0053
P-value	0.904	0.000	0.521
R-sq: 0.5055; F (2,392) = 199.23			

dp – first difference of regional gas price,
dpo – first difference of oil price,
dymn – first difference of the weighted average of GDP of importers for exporting country,

Table 4 below shows the results of estimating the supply equation using 2SLS method.

Table 4: Estimation of Supply of gas, 2nd stage of 2SLS

Dependent variable: dnx	Explanatory variables				
	Constant	dp	di	dh	dih
Coefficient	946.915	33.0868	-1.7575	164.3474	0.0094
Standard error	181.787	10.5642	0.9507	93.5886	0.0072
P-value	0.000	0.002	0.064	0.079	0.191
R-sq: 0.0190; Chi2 (4) = 60.09					

The result of the second stage shows that that change in hold-up potential, which reflects the issues of market remoteness, and political instability, has a positive and statistically significant (at 10% level) influence on the decisions of extraction and sales of natural gas. This is because uncertain future revenues can encourage the owners to shift extraction patterns from the future towards the present. The change in price of natural gas is also statistically significant (at 1% level) with the expected positive sign when the above mentioned factors are accounted for. Naturally, ceteris paribus, the changes of gas price can be expected to positively influence the supply decisions. Investment changes are also statistically significant (at 10% level); however, the negative sign was not expected. This could be due to the time lag between making the investments and the growth of the sales quantity. Another reason for the unexpected sign could be that the proxy for investments into the natural gas industry used in this analysis is not highly correlated with true investments. Change in the multiplication variable of investments and hold-up is statistically insignificant and has a positive sign.

In comparison with the results of the OLS estimation, the price of natural gas in the 2SLS method has a larger coefficient and somewhat greater statistical significance. The investment variable becomes significant, although with an unexpected sign, in the 2SLS estimation. Both the hold-up and the multiplication variables do not change substantially between the OLS and 2SLS estimation results.

This analysis also considers model specifications that include dummy variables. The purpose is to see if taking into account some considerable events can influence the results of the econometric model. To some extent, it tests the robustness of the results to a slightly different model specification. Two events were chosen that might have influenced all of the regional gas markets: collapse of the USSR and a slowdown in the growth of USA's GDP. For these events two time dummy variables were used in the extensions of the above 2SLS estimation. The following table 5 contains the results of estimating the supply equation with the time dummy variable for the collapse of the USSR.

Table 5: Supply of gas with USSR time dummy, 2nd stage of 2SLS

Dependent variable: dnx	Explanatory variables					
	Constant	dp	di	dh	dih	t1
Coefficient	932.07	33.152	-1.76	164.298	0.0094	16.638
St. error	515.14	11.033	0.995	93.742	0.0072	571.25
P-value	0.070	0.003	0.065	0.080	0.192	0.977
R-sq: 0.0191; Chi2 (5) = 60.69						

t1 – time dummy for the collapse of the USSR

The above results suggest that that the inclusion of a dummy variable for the breakdown of the USSR does not make any appreciable difference to the results. The variables of gas price, investments and hold-up potential are statistically significant and have the same sign whether or not the dummy variable is included. Additionally, the coefficients do not alter considerably. The time dummy itself has an insignificant statistical influence. Table 6 below presents the results of estimating the gas supply equation with time dummy variable for a slowdown in the change of GDP of the USA in 2001.

Table 6: Supply of gas with USA time dummy, 2nd stage of 2SLS

Dependent variable: dnx	Explanatory variables					
	Constant	dp	di	dh	dih	t2
Coefficient	991.69	31.278	-1.748	160.39	0.0094	-551.49
St. error	186.63	10.081	0.946	93.671	0.0072	694.99
P-value	0.000	0.002	0.065	0.087	0.188	0.427
R-sq: 0.0202; Chi2 (5) = 60.56						

t2 – time dummy for the slowdown of change of GDP in the USA in 2001. As table 5 and table 6 indicate, the estimation results obtained with time dummy variables are close to those obtained without them. The specific coefficients do change somewhat, but their statistical significance and signs do not change. Additionally, both of the time dummy variables are statistically insignificant in the second stages of 2SLS estimation of the supply equation.

6. Conclusion

Hold-up potential arises in the international trade of natural gas due to large partner-specific investments in case of pipeline transportation, limitations of LNG to non-landlocked suppliers and buyers with de-liquefying facilities, and high transportation costs. When the markets are remote hold-up potential becomes even more considerable due to dependence on third parties. This creates de facto ill-defined property rights over the resource in the ground in the sense of generating uncertain claims to the future revenue stream. For any expected value of a finite amount of natural gas, there can be a last period problem in bargaining for quasi-rents created by asset specific investments. Consequently, there will be a propensity of the resource owner to inefficiently shift his extraction pattern of natural gas towards the present.

Having developed a measure of hold-up potential in international trade of natural gas, based on political stability within the exporting country and number of transit countries between the importer and the supplier, this paper tests the importance of hold-up potential in international trade of natural gas. This is done using a sample of the world's largest 22 exporters of natural gas over a period of 22 years. The tests show that changes in potential for hold-up is statistically significant and is positively correlated with changes in exports; this supports the hypothesis that increases in hold-up potential shift extraction patterns toward the present. Additionally, it was shown that variability of gas export price can be lower if the supplier is prone to hold-up potential. This indicates that hold-up potential should be taken into account when considering the relationship between price and export of the resource.

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