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ENERGY SECURITY COST AS AN EXTERNALITY — INCREASED GAS IMPORT PRICE AND ECONOMY OF UKRAINE

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In this research, the tolerability of the economy of Ukraine for the increase of the gas import price is investigated. The relationship between the economic growth and imported gas price is analyzed, and it was found that the gas consumption of the food and other smaller industries was growing while the gas price was increasing; although, the larger industries such as chemical and manufacturing industries reduced the gas consumption. It was also found that Ukraine may hold a capability to lower the gas import price to the degree comparable to the current price. For the analysis, the national statistics of every month from 2002 through 2008 was used with the least squares model and the ARMA model for time-series forecasting. The data contains the GDP, the imported gas price and volume, the PPIs for the food industry, the chemical industry, the manufacturers and the energy industry, as well as the gas volumes consumed by the industries of low price band, other than the manufacturers and the chemical industries.

INTRODUCTION

The term, energy security, refers to the economic security of a country that is relatively dependent on imports of energy resources from one or more suppliers with considerable market power such as OPEC and/or that is vulnerable to oil price shocks [1]. Energy security costs have two major components. One component of the energy security cost is the macroeconomic adjustment for the sudden change of the import price in a short term, which is not reflected in the market price of the energy supply. One more component is the economic rent as a long term cost of the imports, which the oil/gas producing countries extract from the market through its power as cartel, which makes the price of energy resource unnecessarily high. Theoretically an importer with considerable market power, such as the USA, could recover this rent owing to its monopsony power as a major consumer of oil. Here, the energy security cost is an externality, which is a concept of microeconomics theory, and which creates a negative or positive impact that is not included in the domestic market price of energy.

The territory of Ukraine is on the major route of natural gas pipe-lines exported from Russia to the countries of the European Union, while the natural gas being consumed in Ukraine is currently imported from Russia and Turkmenistan

in addition to the domestic gas production. The price of the imported natural gas is being increased over the last decade. The price negotiation is a political issue every year between Ukraine and Russia, and it led to an international gas crisis in Europe as the gas supply was stopped for a few months to the European Union due to the delay of the price settlement at the beginning of 2009. Therefore the price negotiation is not only the issue of only Ukraine and Russia, and it is necessary to analyze the macroeconomic adjustment capability of the price increase and the potential bargaining power of the price.

In this study, the approach to identify the energy security cost of energy importing countries [1] was used for investigating the tolerability of the economy of Ukraine for the increase of the gas import price. The analysis made in this research is twofold. First the relationship between the economic growth and imported gas price was analyzed upon the Gross Domestic Production (hereinafter, «GDP») imported gas price, imported gas volume, the Production Price Index (hereinafter, «PPI»), the Consumer Price Index (hereinafter, «CPI»), and consumed gas volumes by different industries. On this step, it was assumed that the increase of gas import price gives negative impact to the economy as it was observed in the precedent study in the US [1, 2]. Second, the potential bargaining power of Ukraine upon the gas-price was discussed. On this step, a model of monopsony [1–4] was used, which assumes that the importer is a single buyer.

METHODOLOGY

The issues on energy security caught attentions by the oil importing countries such as the United States, Germany and Japan after the oil embargo in the 1970s, which was triggered by the Yom Kippur War in the Middle East that started in October 1972. Later the concept of the energy security cost emerged in the United States during the 1990s, and the Oak Ridge National Laboratory published relevant studies [1, 3, 4] within the series of the studies on external costs of electricity generation systems. The general layout of an adaptive data processing and model selection procedure is given in Fig. 1, *a*, *b*.

The modeling and forecasting methodology reflected by Fig. 1, *a*, *b* corresponds to the system analysis approach that is based on hierarchical model search procedure and optimization of model parameters by appropriately selected estimation technique. The methodology presented is highly flexible thanks to the use of ACF and PACF functions, correlation matrix and various tests for stationarity analysis and detection of nonlinearity. Also flexibility is provided by the wide set of modern parameter estimation techniques such as maximum likelihood, Monte Carlo for Markov chains and others.

Macroeconomic adjustment cost is estimated as the negative impacts to the GDP, upon the sudden hike of the oil price [1, 4]. To estimate the impacts, the common approach is to analyze the history of the price shock. In this study, the national statistics of Ukraine of every month from 2002 through 2008 was used for the analysis with the tools for the statistical analysis, the least squares model and the ARMA model for time-series forecasting. The data contains the GDP, the imported gas price and volume, the PPIs for the food industry, the chemical industry, the manufacturers and the energy industry, as well as the gas volumes consumed by the industries of low price band, other than the manufacturers and the chemical industries. The descriptive statistics of those input data are shown in Table 1.

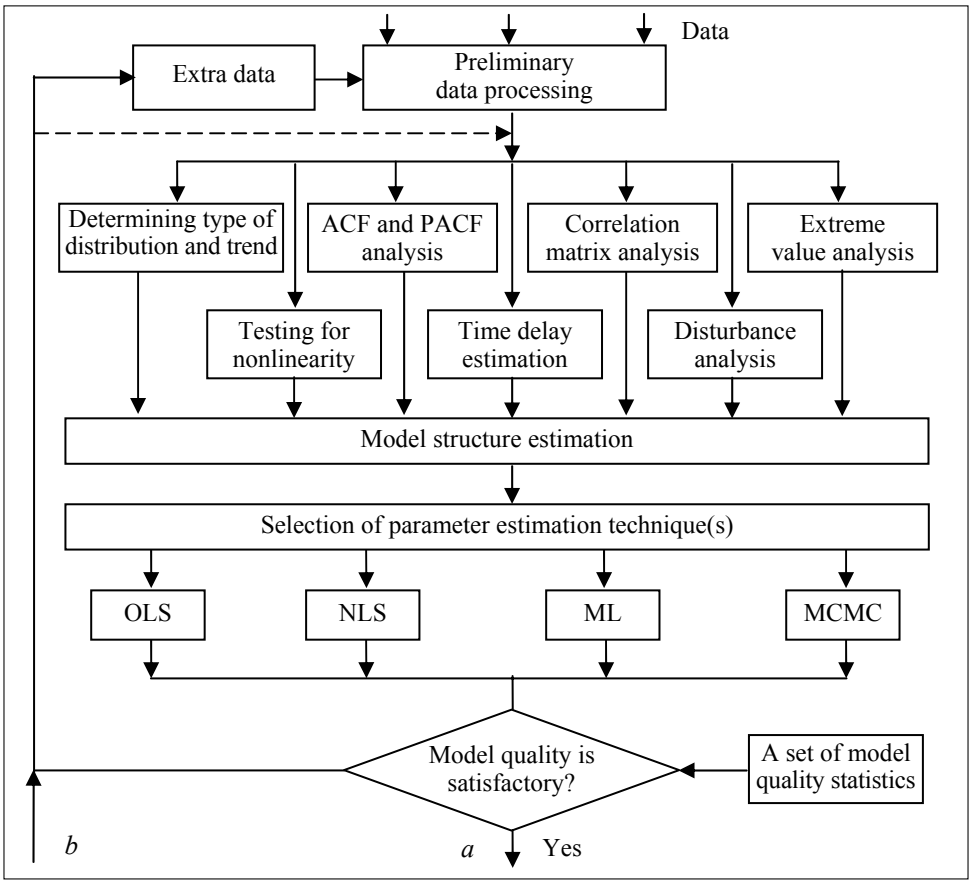

Fig. 1, a. Adaptive estimation of a process model

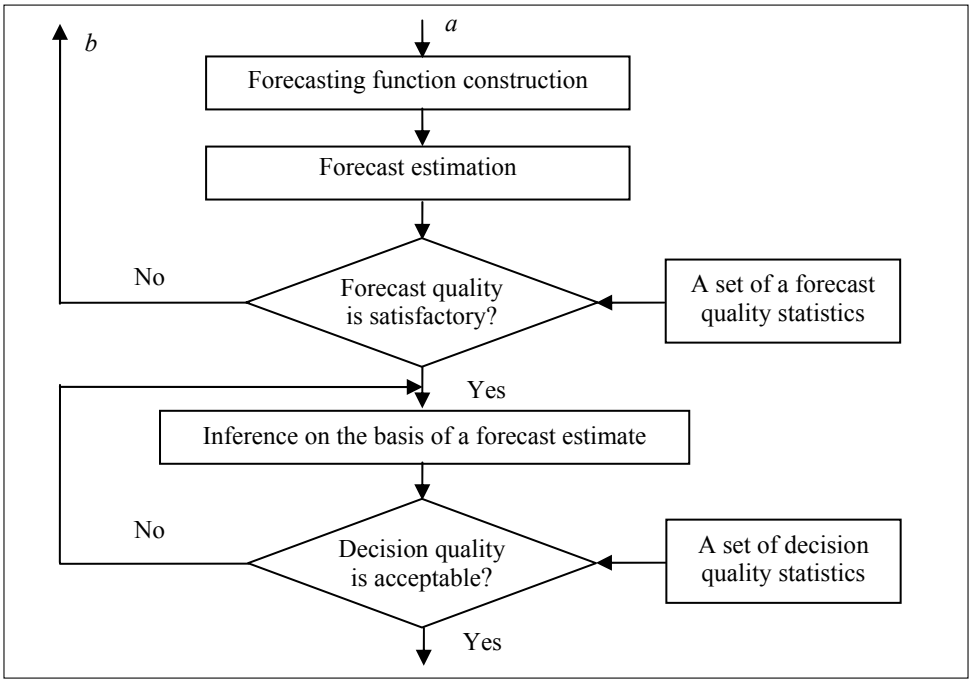

Fig. 1, *b*. Adaptive estimation of a process model

Table 1. Descriptive statistics of the variables

Statistiks	GDP (Billion US$)	P (US$/1000 m^3)	Q (Billion m^3)	Q_{others} (Billion m^3)	PPI_f	PPI_m	PPI_c	PPI_e	AP (Million U$)
Mean	5.21	97.7	4.40	0.963	100.8	101.4	101.2	101.6	982
Median	4.35	75.0	4.43	0.890	100.6	101.5	101.1	100.9	727
Maximum	11.6	220	4.73	1.82	104.5	106.2	110.7	114.5	5835
Minimum	1.84	40.0	4.00	0.730	98.3	94.2	92.5	93.6	180
Std. Dev.	2.68	59.0	0.270	0.240	1.18	1.71	2.17	3.26	916
Skewness	0.769	0.569	−0.215	1.31	0.672	−0.987	0.0234	1.16	2.49
Kurtosis	2.56	1.89	1.48	4.44	3.94	7.25	10.3	6.15	11.7
Observa-tions	84	84	84	84	84	84	84	84	84

The next step is to estimate how much economic rent held by the energy exporting country can be bargained by the importer's monopsony power. According to Leiby [2], the US can influence the world oil price by reducing the domestic oil consumptions with some policy like excise tax as a monopsony (single buyer), and this is an externality which is not accounted in the domestic oil price. This theory is also reviewed by the International Atomic Energy Agency [1] and the US National Academy [4]. In this study, the applicability of this theory was investigated in the case of gas import from Russia to Ukraine, and the range of potential recovery of the economic rent to be held by the gas exporters, which is to be used for forecasting the changes of gas import price in near future. The amount of the premium price E^M of natural gas import, which is the recovered amount by the monopsony power of Ukraine from the economic rent of gas producing countries, is to be calculated by the following equation [2]:

$$E^M = M\frac{dp^w}{dM} = \frac{p^w}{\varepsilon}. \qquad (1)$$

Here, ε is the price elasticity of supply, $\varepsilon = M\frac{dM}{dp^w}\frac{p^w}{M}$; M is the imported volume of oil or gas; p^w is the world price of oil or gas.

Descriptive statistics of the variables used for analysis is given in Table 1.

Note. GDP*:* Gross Domestic Production*,* P — the natural gas import price*;* Q the imported gas volume*;* Q_{others} — the gas volumes consumed by the industries of the low price band, other than the manufacturers and the chemical industries; PPI_f — PPI of the food industry; PPI_m — PPI for the manufacturers; PPI_c —PPI for the chemical industry; PPI_e — PPI for the energy industry; AP — Agricultural product (million US dollars).

RESULTS

Gas Import Price and Economic Growth

In the precedent studies in the US [1, 4], there was a view such that the macroeconomic adjustment cost that absorbes the sudden increase of the oil import price is the externality that is not included in the oil price in the US domestic market. This view was based on the assumption that the sudden increase of the imported oil price disturbed the GDP growth, and therefore this economic loss is not included in the market price of the imported oil. However, the data of natural gas import price and the GDP shows an opposite relation in case of Ukraine, i.e., when the gas import price went up, the GDP grew as shown in Fig. 2. On the other hand, when the gas import price went up, the imported gas volume was reduced as shown in Fig. 3. Upon these findings, the futher analysis was made as shown bellow.

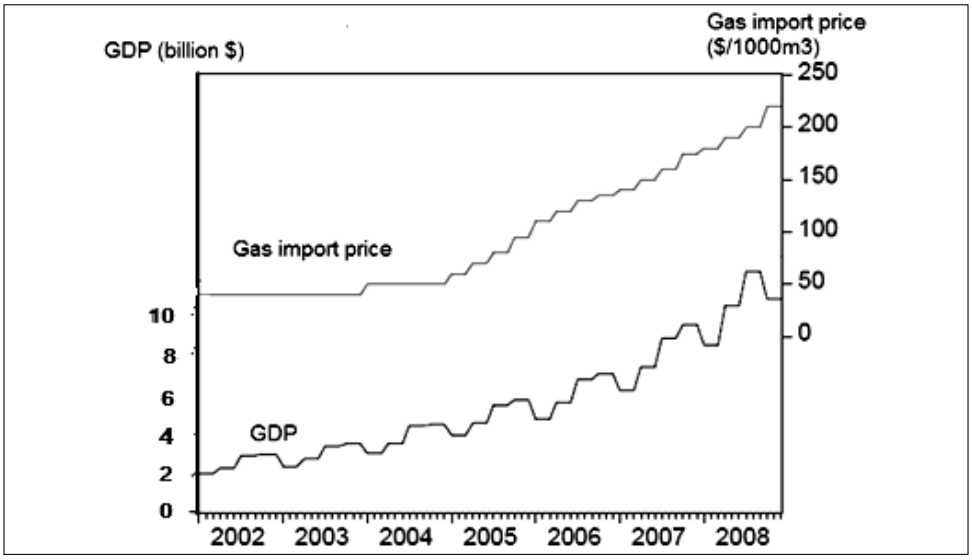

Fig. 2. Temporal change of GDP and Gas Import Price

For finding the reason for the positive correlation between the gas import price and the GDP, the degrees of correlations between the variables are investigated as shown in Table 2. As a result, it was found that the GDP, the gas import price, the PPI for the food industry and the consumed gas volume by the industries of low price band such as the food industry have the correlations with each other. Upon this finding, a model was constructed as shown in Fig. 4, with the assumption that the change of the gas import price influenced the demand of the gas

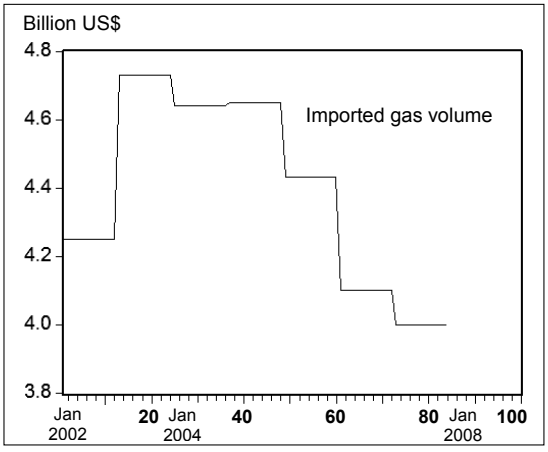

Fig. 3. Temporal change of Imported Natural Gas Volume

consumption for the industries of low price band, and then the input price rose, inducing the higher PPI for the food industry, and then the GDP grew. Each step of the model constructing was investigated with the least squares method, and the results are shown in Table 3.

Table 2. Correlations between the variables

Variables	GDP	P	Q	Q_{others}	PPI_f	PPI_m	PPI_c	PPI_e	AP
GDP	1	0.963	–0.694	0.828	0.404	–0.021	0.132	0.133	0.500
P		1	–0.762	0.871	0.396	–0.052	0.0763	0.173	0.355
Q			1	–0.687	–0.133	–0.149	–0.130	–0.236	–0.218
Q_{others}				1	0.477	–0.00513	0.114	0.119	0.205
PPI_f					1	0.241	0.181	–0.0767	0.0557
PPI_m						1	0.567	0.124	0.0307
PPI_c							1	0.0904	0.120
PPI_e								1	–0.0343
AP									1

Table 3. Regression Analysis on Gas Import Price, GDP, PPI and Gas Consumption

Model		Independent variable	Coefficient (a, b, c..)	t-Statistics	R^2	Durbin-Watson	AIC	Schwartz
1	$GDP = a + b * P + c * Q$	Interception	–3.60	–1.71	0.932	0.481	2.18	2.26
		P	0.0470	23.2				
		Q	0.960	2.16				
2	$GDP = a + b * PPI_f + c * PPI_c + d * PPI_m + e * PPI_e$	Interception	–94.2	–3.56	0.233	0.353	4.65	4.79
		PPI_f	1.01	4.36				
		PPI_m	0.219	1.48				
		PPI_c	–0.396	–2.07				
		PPI_e	0.150	1.83				
3	$PPI_f = a + b * Q_{\text{others}}$	Interception	98.5	208	0.227	0.742	2.95	3.00
		Q_{others}	2.34	4.91				
4	$Q_{\text{others}} = a + b * P$	Interception	0.616	24.5	0.759	1.25	–1.40	–1.34
		P	0.00355	16.1				

The correlation between the PPI of the food industry and the GDP is relatively stronger than with the other PPIs (Table 3, Model 2). Here the PPI for the food industry is the indicator of the changes of the price over time period. In general, when the quantity of the production increases over the whole industry, the prices of input materials will also increase [3]. As the evidence, the PPI for the food industry has a correlation with the gas consumption of the smaller size industries including the food industry (Table 3, Model 3). Therefore, the above correlation means that there is a possibility that the growth of the food industry contributed to the GDP growth.

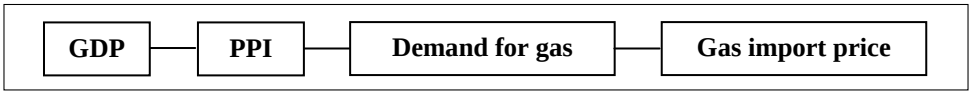

Fig. 4. The relations of GDP, the gas import price and the other variables

The further investigation was made on the growth of the food industry, which is the correlation between the gas consumption of the food industry and the gas import price. Here, however, the gas consumption volume specific to the food industry was not available, but the small and middle size industries, including the food industry. As a result, it was recognized that there is a considerable correlation between the gas import price and the gas consumption by the industries of low price band including the food industry (Table 3, Model 4).

The gas consumption volume by the small-middle size industries has a positive correlation with the gas import price. With this finding, it is assumed that the input prices of the food industry rose, and it led to the GDP growth. Given this assumption, the food industry consumed more gas and led to the GDP growth.

Upon the above finding, Fig. 2 and Fig. 3 can be explained, which shows that the GDP was still growing while the imported gas volume was being reduced. At first, the small-middle size industries such as the food industry grew, while the larger industries such as the energy, the chemical and the manufacturing industries reduced the gas consumption, in order to minimize the negative impacts to the economy, which could be led by the increased gas import price. Then, the saved cost by reducing the imported gas volume could have been spent elsewhere of the macro-economy of Ukraine, such as in the food industry, and it could be the macroeconomics adjustment cost. Upon this assumption, the marginal increase of the gas import price per unit volume of the reduced imported gas was calculated to obtain the sum of the saved cost by reducing the gas import volume, as shown bellow:

$$P_0 = \sum_{i=1}^{n} P_i \times (Q_1 - Q_i). \tag{11}$$

Here, P_0 is the unit saved cost per volume; Q_1 is the gas imported volume in January 2004 when the imported gas volume started declining; P_i is the monthly gas import price, and Q_i is monthly imported gas volume; i is the suffix that indicates each month. For example, $i = 1$ means January 2004 and $i = n$ means December 2008.

Calculated values are 3,484,050,000 US dollars for $\sum_{i=1}^{n} P_i \times (Q_1 - Q_i)$, 22,000,000,000 m^3 for $\sum_{i=1}^{n} (Q_1 - Q_i)$, and 159 US dollars/1000 m^3 for P_0.

However, the macroeconomics adjustment costs are usually calculated as the reduction of the GDP due to the sudden increase of the energy price [1, 4], and this case, as shown in Fig. 2, is opposite to such common practice. Therefore, there is also a possibility that the calculated value, 159 US dollars/1000 m^3, is not the adjustment cost of the macro-economy, which is to respond to the price shock, but rather there should be a view such that the economic growth could have induced the imported gas price.

The GDP growth was further analyzed with the gas import price with the autoregression, and then the forecast of the GDP growth was made. The result is shown in Table 4 and Fig. 5. The analysis was made upon the actual data between January 2002 and December 2008, and Fig. 5 shows that the GDP is growing after December 2008. However, due to the economic crisis in 2008, the actual economy of Ukraine shrunk in 2009, while it was recovered in 2010 with 4.3 % increase of the GDP.

Table 4. Forecast of the GDP increase

Model	Independed variable	Coeff. (a, b, c..)	t-Statistics	R^2	Durbin-Watson	AIC	Schwartz
$GDP = a + b * GDP(-1) + c * P(-1) + d * P(-7) + k$	Intercept	0.174	1.14	0.969	1.91	1.41	1.56
	$GDP(-1)$	0.722	8.71				
	$P(-1)$	–0.00594	–0.629	RMSE	MAPE	Theil	Numb. of ovs.
	$P(-7)$	0.0125	1.39	0.626	9.01	0.0517	77
	k	0.0201	1.87				

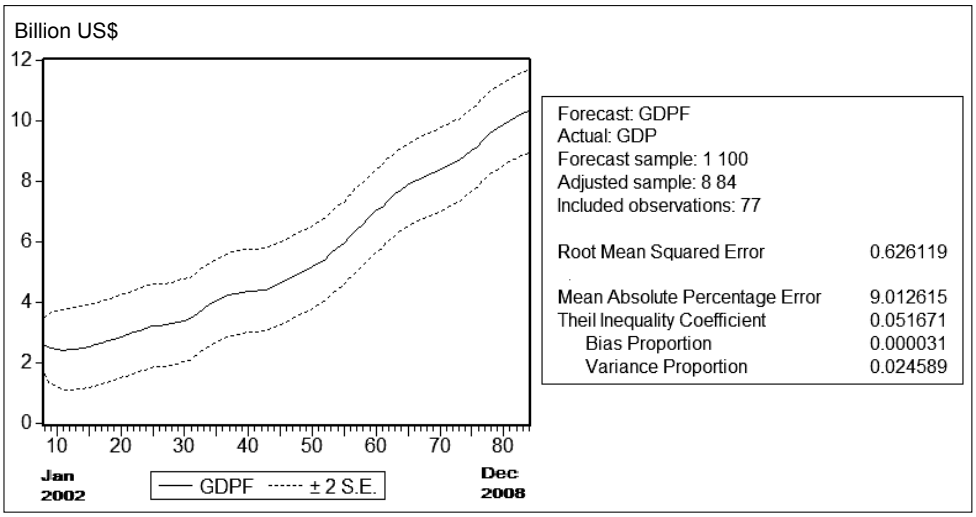

Fig. 5. Forecast of GDP by Gas Import Price with autoregression (–1, –7)

Influence to the gas import price as a monopsony

With the equation (1), the amount of the premium price E^M of natural gas import, which is the theoretically bargained amount by the monopsony power of Ukraine out from the economic rent of gas producing countries, is dependent on the price elasticity of gas supply ε. But the price elasticity of gas supply ε is not obtainable because it is related to the marginal production costs of the producers. Therefore in this study, the premium was calculated for 9 discreet values of ε from 0.2 to 5.0 as shown in Table 5.

As of January 2011, the announced gas import price to Ukraine was 264 US dollars/1000m^3, therefore if the price elasticity of supply ε is 1.0, the premium

price, E^M, of natural gas import is 264 US dollars/1000m^3; while, if ε is 2.0, E^M will be 132 US dollars/1000m^3. However, regarding the gas pipelines installed in the territory of Ukraine as well as the further gas export to the EU from Russia, the price elasticity of supply ε could be inelastic, i.e., less than 1.0 because the elasticity will be smaller if the suppliers have less flexibility in changing the quantity of supply upon the change of the price. In this case, the premium price, E^M, of natural gas import could exceed the current gas import price. This finding means that the gas import price could be as higher as this premium price if Ukraine doesn't have the monopsony power.

Table 5. The premium price of natural gas import (US dollars/1000 m^3) at the gas import price of 264 US dollars/1000m^3

Price elasticity of supply ε	0.2	0.4	0.6	0.8	1.0	2.0	3.0	4.0	5.0
Premium price E^M (US dollars/1000 m^3)	1320	660	440	330	264	132	88	66	52.8

CONCLUSIONS

The national statistics of Ukraine from 2002 through 2008 was used for the analysis, with the statistical tool, the multiple regression model and the ARMA model. As the result, despite the preliminary assumption, it was found statistically with accurate correlations that the GDP still grew while the gas import price was increased; although, the imported gas volume was reduced while the GDP was growing.

The modeling and forecasting methodology presented in this paper corresponds to the system analysis approach that is based on hierarchical model search procedure and optimization of model parameters by appropriately selected estimation technique. The methodology presented is highly flexible thanks to the use of ACF and PACF functions, correlation matrix and various tests for stationarity analysis and detection of nonlinearity. The flexibility is also provided by the wide set of modern parameter estimation techniques such as maximum likelihood, Monte Carlo for Markov chains and others.

Upon the above finding, the further investigation was made on the relationship between the gas import price and the PPI of different industries; and, it was found that PPI of food industry has stronger correlation with the GDP growth than the PPIs for the other industries such as the chemical, the manufacturing and the energy. Also, the gas consumption of the industries of low price band, such as the food industry, was found positively correlated with the gas price increase.

The result of the above investigation suggests that the gas consumption of the food and other smaller industries was growing as the gas import price was increasing; while, the larger industries such as the chemical and the manufacturing reduced the gas consumption.

Assuming that the saved cost by reducing the imported gas volume was spent elsewhere of the macro-economy of Ukraine, such as the food industry, and it

could be the macroeconomics adjustment cost, the marginal increase of the gas import price per unit volume of the reduced imported gas was calculated as 159 US dollars/1000 m^3.

There is also a possibility such that the growth of the GDP by the food and other small industries rather stimulated the increase of gas import price. Therefore, further investigation is needed before determining that the cost used for growing the food industry is the externality of the energy price.

Ukraine may hold a monopsony power to lower the price of gas import with the size comparable to the current gas import price, although depending on the price elasticity of gas import price, which further depends on the options of exporters' current capacity of gas production and gas delivery. Further investigation is needed for identifying the price elasticity of gas supply to Ukraine.

The above assumption of the monopsony power held by Ukraine is based on the fact that the natural gas pipelines installed in the territory of Ukraine is the major route of the natural gas export from Russia and Turkmenistan to the EU. However, this situation may not be sustainable because of the volatile global natural gas trades, and it is necessary to observe any possibility of changes in near future. Besides, Russia will start to use the Northern Flow pipeline soon what will change the situation with the natural gas transit.

The future research should be directed towards taking into considerations extra economic indicators as well as further improvement of the model construction methodology based on the use of statistical data and adaptive system analysis approach. The current economy of Ukraine after the world-wide economic crisis in 2008-2009 is of interest for the further investigation in near future.

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