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Forecast Scenarios of World Prices for Natural Gas

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Abstract:

The study proposes forecast scenarios for the development of world prices for natural gas based on economic and mathematical modeling and the analysis of the historical trend of extraction, consumption, export and import of natural gas.

The main research method is correlation-regression analysis which allowed establishing how strong the correlation of world prices for natural gas and world oil prices is. Also, the methods of historical trend and mathematical analysis were used to determine the main forecast scenarios for price levels of natural gas.

The study represents a new approach to the analysis of the dynamics of world prices for natural gas based on economic and mathematical modeling.

The article examines the dynamics of the global natural gas market and analyzes trends in price changes, as well as establishes the relationship between global prices for natural gas and the world oil market for making forecasts of the cost of natural gas.

Keywords: *forecasting, natural gas, oil, world prices, natural gas market.*

JEL Classification: F14, F17, F47

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1. Introduction

Currently, natural gas is one of the main types of fuel. The world gas market includes separate regional markets for natural gas, which is associated with the specifics of its transportation. Natural gas plays one of the crucial roles in the global energy stability, as it is a strategic natural resource for many states and has a strong influence on the oil and gas revenues of the countries budgets.

To make a forecast of world prices for natural gas in conditions of volatile global oil prices, it is necessary to conduct a historical analysis of world prices for natural gas using economic and mathematical modeling (Markova, 2013; Vasiljeva, 2013; Thalassinos and Kiriazidis, 2003). We believe that the findings of this study will enable more accurate predictions on the world prices for natural gas, as well as more realistic forecasts of oil and gas revenues for state budgets.

The global gas market has been considered in many scientific papers, such as: U.S. Energy Information Administration, International Energy Agency and works by Elyakova *et al.* (2016). The authors of these works considered the development of the gas market, its evolution, as well as energy markets in general, including the development of oil markets. It was necessary to examine the oil market regarding the link between natural gas prices and oil quotations. The article uses statistical data of the U.S. Energy Information Administration and International Energy Agency.

2. Methodology

In this study we used the method of correlation-regression analysis to establish the relationships between variables through point and interval estimation of pair (private) correlations, calculation and verification of the significance of multiple correlation and determination coefficients; in addiction to that, we selected factors that have the most significant effect on the resulting attribute after measuring the colligation between them.

Using paired correlation coefficients, we identified the intensity and binding strength between the main factors influencing changes in oil prices for each period of the world oil market development.

Pair correlation coefficients were used to determine priority factors with the strongest influence on oil prices. The method of least squares enabled us to determine the quantitative level of the priority of factors influence on the oil prices level, which allowed us to assess the strength of relationship between different variables and to evaluate the effect of the factor on the resulting attribute. The significance of the factors influence is represented in the regression model (Mandelbrot, 1963; Thalassinos and Pociovalisteanu, 2007; Pociovalisteanu *et al.*, 2010; Thalassinos *et al.*, 2009; 2013; Pociovalisteanu and Thalassinos, 2008; Thalassinos and Politis, 2012).

To estimate forecast values of production and consumption volumes, we made a model for calculating future values, including the analysis of historical data and based on exponential smoothing with confidence intervals determined (the ETS AAA algorithm). Thus, the forecast values are based on existing data and continue the timescale.

When doing calculations, we used a Holt-Winters additive model of the triple exponential smoothing. The time series is denoted as Y_t:

$$\begin{aligned} \hat{y}_{t+d} &= a_t (r_t)^d \varpi_{t+(d \bmod s)-s}, \\ a_t &= \alpha_1 \cdot \frac{y_t}{\varpi_{t-s}} + (1-\alpha_1) a_{t-1} r_{t-1}, \\ r_t &= \alpha_3 \cdot \frac{a_t}{a_{t-1}} + (1-\alpha_3) r_{t-1}, \\ \varpi_t &= \alpha_2 \cdot \frac{y_t}{a_t} + (1-\alpha_2) \varpi_{t-s}, \end{aligned}$$

where s is a seasonality period, s-1 – seasonal profile, r_t – trend parameter, a_t – forecast parameter, cleared of the influence of trend and seasonality (Goodwin, 2010; Winters, 1960).

3. Results and Discussion

To conduct historical analysis and make forecasting scenarios, we analyzed the world natural gas market for 1950-2015 and the markets of the main countries that have been producing and consuming natural gas from 1993 to 2014. The world market of gas trade was developing very rapidly during the period of 1980-2010. Table 1 shows the volume of world gas trade in 1950-2015. The share of natural gas transported by gas pipelines estimates about 67.5%, respectively, with the volume of 704.1 bln cubic meters of gas. The data show that piped gas makes up the largest share in the world trade in natural gas since the costs of its transportation are much lower than when using a liquefaction technology for its transportation.

Table 1. *Volumes of world gas trade for 1950-2015* (Independent Statistics and Analysis. U.S. Energy Information Administration (EIA))

Time period	Pipeline gas, bln m^3	Share, %	Liquefied natural gas, bln m^3	Share, %	Total, bln m^3
1950	0.8	100	-	0	0.8
1960	5.3	100	-	0	5.3
1970	43	94.1	2.7	5.9	45.7
1980	169.6	84.4	31.3	15.6	200.9
1990	235.3	76.6	72.1	23.4	307.4
2000	492.8	78.2	137.7	21.8	630.5
2010	718.9	70.8	296.3	29.2	1015.1

2015	704.1	67.5	338.3	32.5	1042.4

The development of the natural gas market largely depends on the volume of its production and consumption. We analyzed five European countries which have significant influence on the natural gas market in Europe: Russia, Germany, Norway, the Netherlands and France. Russia, Norway and the Netherlands are the main natural gas producers in Europe, whereas France and Germany are the main European consumers of natural gas that cannot provide themselves with their own reserves. To assess gas markets in other regions, we selected China, Canada and the USA as the largest players in their markets.

The volumes of gas production are shown in Table 2, and the volumes of consumption are presented in Table 3. The tables were created using the data of US Energy Information Administration (Independent Statistics and Analysis. U.S. Energy Information Administration (EIA)) which were recalculated from billion cubic feet to million cubic meters.

Table 2. *Production of natural gas by country, mln* m^3

Country	1993	1995	2000	2005	2010	2014
Russia	627 104	605 102	557 614	629 341	609 746	617 221
France	3 426	3 341	1 869	1 784	1 359	17
Germany	19 595	21 691	23 673	20 898	16 112	10 392
Netherlands	88 292	84 611	72 604	78 579	88 688	70 339
Norway	41 569	47 204	90 274	130 795	148 748	-
China	15 801	17 018	27 241	49 923	94 408	123 461
Canada	171 005	192 498	217 473	219 002	189 581	179 047
USA	606 687	635 656	641 460	619 288	705 910	834 638

Table 3. *Natural gas consumption by countries, mln* m^3

Country	1993	1995	2000	2005	2010	2014
Russia	458 307	410 792	369 789	405 780	438 004	431 293
France	32 791	33 499	39 728	49 271	47 997	36 727
Germany	80 137	89 821	87 725	90 699	94 606	79 202
Netherlands	48 535	48 167	48 846	49 300	54 850	40 266
Norway	2 549	2 860	3 964	5 295	5 493	5 862
China	15 319	16 480	24 551	46 864	106 698	181 143
Canada	76 201	81 326	84 696	89 028	97 410	116 552
USA	588 706	628 831	660 716	623 366	673 232	753 029

Analyzing the figures in Tables 2 and 3, we can see that some European countries, namely France, the Netherlands and Germany, have reduced the consumption of natural gas in recent years. However, they remain the largest consumers in the region. The decrease in consumption is due to the development and use of new energy-saving and energy-efficient technologies in the energy sector (BP Statistical Review of World Energy, 2015).

The volumes of gas produced by France during the studied period are minimal due to the ban on reservoirs hydraulic fracturing since 2011. Consequently, France imports almost all of the consumed gas. The largest share of natural gas in France is consumed by the private sector as it is used as fuel for heating and food preparation. Thus, gas consumption is seasonal and varies greatly depending on winter weather conditions. For example, in 2005 and 2010, gas consumption was higher than in other years due to cold winters. The warm winter of 2014 led to the opposite – consumption declined by 16% compared with 2013 (Energy Regulation Commission, 2016; International Energy Agency, 2016).

Germany is the largest consumer of gas in Europe. It covers an average of about 10% of its consumption. The remaining volume of natural gas consumption is covered by imports. Natural gas in Germany is used in such sectors of economy as industrial, housing and utilities and energy sectors. Due to the specifics of the use of natural gas in the economy, its demand is seasonal, and consumption increases in winter periods (International Energy Agency, 2013; International Energy Agency, 2012a).

Norway is the world's third largest exporter of natural gas after Russia and Qatar, and the seventh largest in terms of dry natural gas production as of 2015. Despite the exhaustion of some gas wells in the North Sea, natural gas production has been increasing annually since 1993. This was made possible by the development of new fields and drilling of new wells (International Energy Agency, 2017; Independent Statistics and Analysis. U.S. Energy Information Administration, 2016).

The Netherlands is one of the main suppliers of natural gas in Europe. Most of their deposits are in the North Sea, but there are some onshore, including the Groningen field, one of the largest in the world. The Government of the Netherlands limits annual production volumes of the Groningen deposit to stimulate the development of small deposits and to increase the lifetime of the Groningen field (Correljé *et al.*, 2003).

In Asia, China is steadily and rapidly increasing not only the volumes of natural gas production, but also the volumes of its consumption. However, natural gas consumption is growing at a higher pace than its production volumes. The Chinese government actively supports the development of the gas industry and plans to continue increasing consumption of natural gas. This is part of China's plans to reduce the active use of coal, such a decision driven by serious environmental

problems in the country. Energy and transport are the main consumers of natural gas. In the energy sector, the main consumers are new thermal power plants that use natural gas, and which were built to replace coal ones. In the transport sector, natural gas is used as fuel for public transport (U.S. Energy Information Administration, 2015b).

In North America, Canada is one of the largest producers of natural gas and the main importer of natural gas in the United States. The volume of natural gas production in Canada was growing until 2005, but after that it started to decline. This occurred due to the exhaustion of used deposits. However, new technologies make it possible to increase gas production in the future as shale deposits are being actively developed. Canada is consuming more natural gas due to the development of the power industry and growing residential sector since natural gas is used in the private sector. Most of the natural gas consumed by the residential sector is used for generating heat and electricity (U.S. Energy Information Administration, 2015a).

The US remains the largest producer and consumer of natural gas throughout the entire period under review. Since 2007, the volume of US natural gas production exceeds the volume of natural gas produced in Russia. Over 20 years, natural gas production has increased by 37% and consumption volumes by almost 28%. The high performance of the US can primarily be explained by the fact that their power industry has a developed gas sector. Natural gas is also used in industry, to generate power and thermal energy (BP Statistical Review of World Energy 2015; Independent Statistics and Analysis. U.S. Energy Information Administration (EIA)). Data on the import and export of natural gas are presented in Tables 4 and 5, respectively.

Table 4. *Import of natural gas by countries, mln m^3*

Country	1993	1995	2000	2005	2010	2014
Russia	20 190	8 212	8 891	27 411	38 001	24 154
France	29 648	32 451	0	49 016	48 762	45 137
Germany	67 932	77 192	41 031	94 153	94 040	89 906
Netherlands	3 681	3 851	17 415	22 937	25 740	29 110
Norway	0	0	0	0	0	0
China	0	0	0	0	16 339	60 286
Canada	821	680	1 614	9 514	22 682	21 889
USA	66 544	80 448	107 094	122 923	105 933	76 314

Table 5. *Export of natural gas by countries, mln m^3*

Country	1993	1995	2000	2005	2010	2014
Russia	179 613	192 214	186 608	222 598	210 394	193 913

France	566	708	765	906	1 529	7 079
Germany	1 841	3 370	5 380	20 247	20 473	22 285
Netherlands	43 948	40 663	41 427	52 160	59 522	58 757
Norway	24 834	27 609	48 903	81 694	100 864	102 960
China	481	566	2 690	3 058	4 021	2 605
Canada	63 005	79 145	101 261	106 273	95 598	77 956
USA	3 964	4 361	6 909	20 643	32 196	42 872

The main exporters of gas in the European market are Russia, the Netherlands and Norway (BP Statistical Review of World Energy, 2015).

Russia is one of the main exporters of natural gas. Almost 90% of Russia's export goes to European countries through gas pipelines passing through Germany, Belarus, Turkey, Ukraine and Italy. The remaining 10% is currently supplied to Asian countries as liquefied natural gas. However, soon the situation may change drastically in connection with the construction of Power of Siberia gas pipeline which is to supply China. Imports occur due to the differences in natural gas supply within the country and Russia's vast territory. Most of the imported gas comes from Central Asia to cover the demand of nearby regions of the country (International Energy Agency, 2014; Gazprom; Independent Statistics and Analysis. U.S. Energy Information Administration (EIA)).

The volume of natural gas imports to France and Germany declined in 2014 due to a decrease in consumption by these countries. As mentioned above, the milder winter of 2014 resulted in the reduced natural gas consumption in France and Germany since a considerable share of natural gas is used for heating (International Energy Agency, 2016; International Energy Agency, 2013; Independent Statistics and Analysis. U.S. Energy Information Administration (EIA)).

Germany is highly dependent on natural gas imports, and more than 80% of the consumed natural gas is imported. Germany imports most gas from Russia, Norway and the Netherlands. The country does not have terminals for liquefied natural gas (LNG), but is connected to other countries by a system of gas pipelines – gas is supplied from Russia through Nord Stream Pipeline and goes through Belarus and Poland. Norwegian gas comes to Germany through Euro pipe I and Euro pipe II. Also, the gas pipelines relate to neighboring countries, which makes it possible to supply natural gas to the countries exporting it through Germany. Gas is exported by Germany due to its location: gas pipelines pass over it to other countries of Western Europe (International Energy Agency, 2013; International Energy Agency, 2012a).

France is almost completely dependent on imported gas. The ban on the use of hydraulic fracturing of the reservoir introduced in 2011 has blocked almost all production of natural gas. Imported gas comes to France from the Netherlands,

Norway and Russia through many international gas pipelines, with these countries being the main suppliers (BP Statistical Review of World Energy 2015; Energy Regulation Commission, 2016; International Energy Agency, 2016).

Norway is one of the main exporters of natural gas. Norwegian natural gas is exported to Germany, Belgium, Great Britain and France. Norway is connected by main gas pipelines with these countries. The domestic demand for natural gas in Norway is fully covered by its domestic gas production. The small volume of domestic consumption and the high volumes of natural gas production have enabled the country to become one of the main suppliers of natural gas in Europe (International Energy Agency, 2017; Independent Statistics and Analysis. U.S. Energy Information Administration, 2016; Independent Statistics and Analysis. U.S. Energy Information Administration (EIA)).

In Asia, China was a natural gas exporter till 2005, but since 2006 it has become an importer of natural gas, despite growing production volumes. This is due to the rapid growth of natural gas consumption, which was caused by China's energy sector shifting from coal and the transfer of the transportation system to natural gas (U.S. Energy Information Administration, 2015b; Independent Statistics and Analysis. U.S. Energy Information Administration (EIA)).

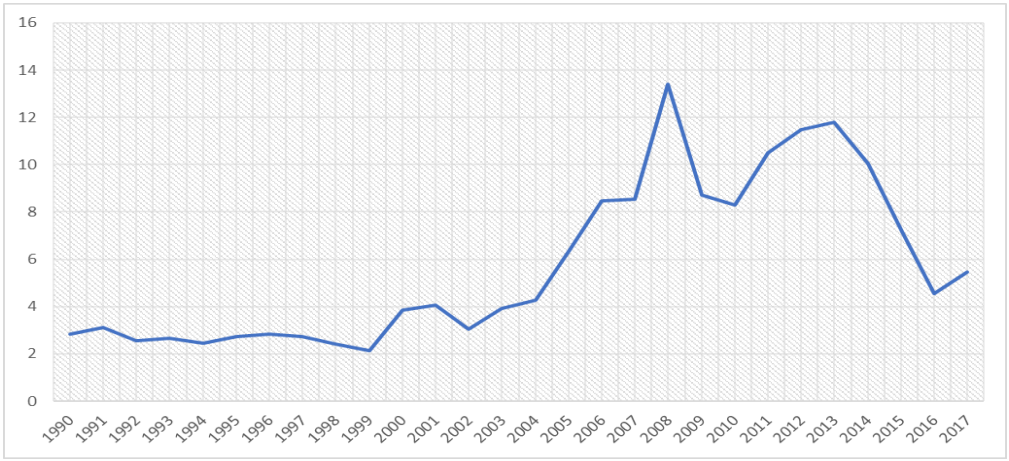
The USA is one of the main exporters and at the same time an importer in its region. This is since it actively uses natural gas in the power industry to produce electrical and thermal energy. Basically, the USA imports natural gas from Canada, and the southern US states export natural gas to Mexico (Independent Statistics and Analysis. U.S. Energy Information Administration (EIA)).

Canada is exporting large volumes of natural gas to the United States. However, at the same time it imports natural gas from the United States, which is mainly due to certain logistical reasons than the inability to totally cover the consumption with domestic reserves. Almost all of Canada's gas imports and exports involves the USA (U.S. Energy Information Administration, 2015a).

The export interchange of natural gas between the US and Canada results from the existing system of pipelines, and sometimes it is more cost-efficient for Canada to import natural gas from the US than to transport it inside the country (Independent Statistics and Analysis. U.S. Energy Information Administration (EIA)).

Having analyzed the previous studies, we showed the dynamics of world prices for natural gas for the period from 1990 to 2017 (USD / 1 MMBTU) that is represented in Figure 1. Average prices for natural gas estimated about USD 3-5, whereas in 2008 there was a sharp increase in gas prices to the level of USD 13.4, which is associated with an increase in world oil prices.

Figure 1. *Dynamics of world prices for natural gas from 1990 to 2017, USD / 1 MMBTU*



The cost of natural gas is affected by a number of factors, such as production cost, geophysical conditions, chemical composition of oil, macroeconomic and political factors.

Prices for natural gas largely depend on world oil prices. The Groningen pricing concept used in European countries implies that the price for natural gas is determined by its replacement cost. So, we conducted a correlation-regression analysis of world prices for natural gas and oil prices. It revealed that the correlation coefficient is equal to r = 0.97, which indicates a direct relationship between gas and oil prices. Considering the determination coefficient, which is equal to $r^2 = 0.94$, it can be argued that natural gas prices are 94% dependent on world oil prices. Dynamics of changes in prices for natural gas and oil are compared in Figure 2.

Figure 2. *Dynamics of changes in prices for natural gas and Brent Crude oil over 1990-2017*

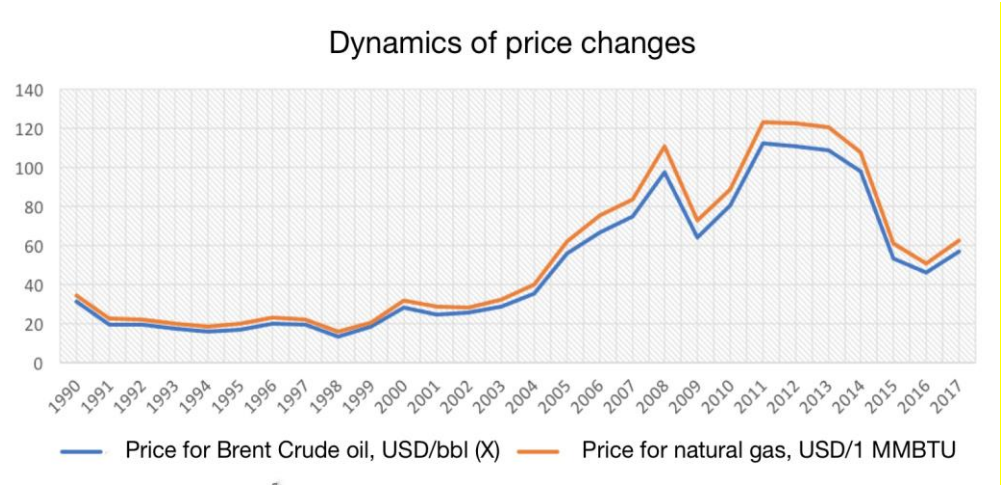
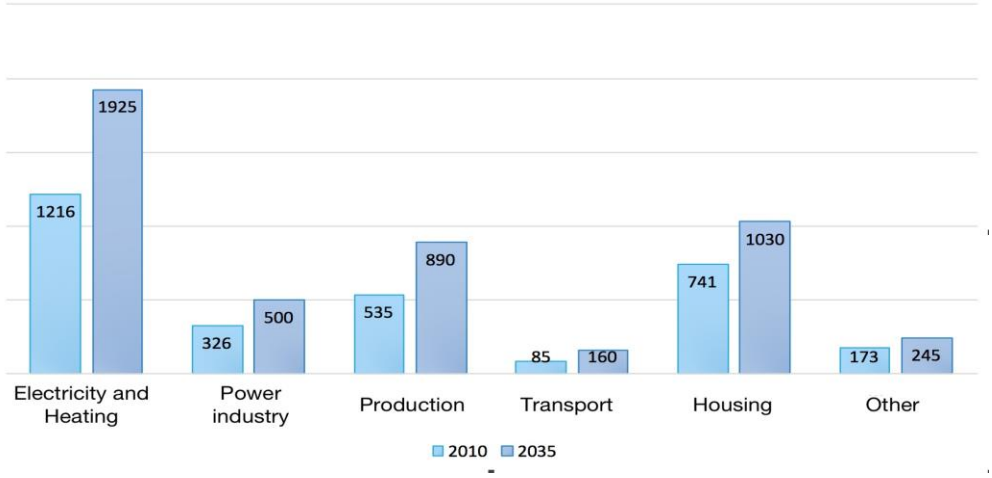


Figure 3 shows the forecast of natural gas consumption in different sectors of the economy up to 2035, according to which natural gas is to account for 24% in the fuel and energy balance. This is facilitated by carbon credit trading and high fees for carbon emissions into the atmosphere. The industrial sector will consume a large volume of gas, where it will be used to produce hot water and steam, to generate high temperatures for technological processes, and as a base raw material to produce synthetic organic materials. Industries producing metals and building materials (cement, brick, and glass) will consume the largest share of gas.

Figure 3. *Forecast of natural gas consumption in various sectors of the global economy up to 2035*



The production and consumption volume of these countries were forecasted by triple exponential smoothing of data covering the period from 1993 to 2014. The findings of this forecasting are presented in Tables 6 and 7, respectively.

Table 6. *Forecast volumes of natural gas production from 2015 to 2020, mln m^3*

Country	2015	2016	2017	2018	2019	2020
Russia	625 808	629 054	632 299	635 544	638 790	642 035
France	0	0	0	0	0	0
Germany	9 552	7 674	5 796	3 918	2 041	163
Netherlands	76 645	76 372	76 100	75 828	75 555	75 283
Norway	186 697	193 299	199 902	206 504	213 107	219 709
China	133 284	143 112	152 941	162 770	172 598	182 427
Canada	167 644	164 641	161 638	158 635	155 632	152 629
USA	764 198	771 781	779 364	786 947	794 530	802 113

Table 7. *Forecast volumes of natural gas consumption from 2015 to 2020, mln m^3*

Country	2015	2016	2017	2018	2019	2020
Russia	434 906	437 200	439 494	441 788	444 082	446 376
France	48 093	48 701	49 309	49 918	50 526	51 134
Germany	83 477	81 889	80 300	78 712	77 123	75 535
Netherlands	40 117	39 967	39 817	39 667	39 517	39 367
Norway	5 803	5 925	6 047	6 169	6 290	6 412
China	198 806	216 637	234 468	252 300	270 131	287 962
Canada	107 114	108 516	109 918	111 320	112 722	114 124
USA	704 275	709 599	714 922	720 245	725 568	730 891

According to the results of the forecast compiled by the authors for 2015-2020 which considers the production and consumption of natural gas, Russia and Norway will increase the volumes of natural gas production.

Germany and the Netherlands will reduce their own production. France will completely cease producing its own gas unless it lifts the ban on hydraulic fracturing of the reservoir.

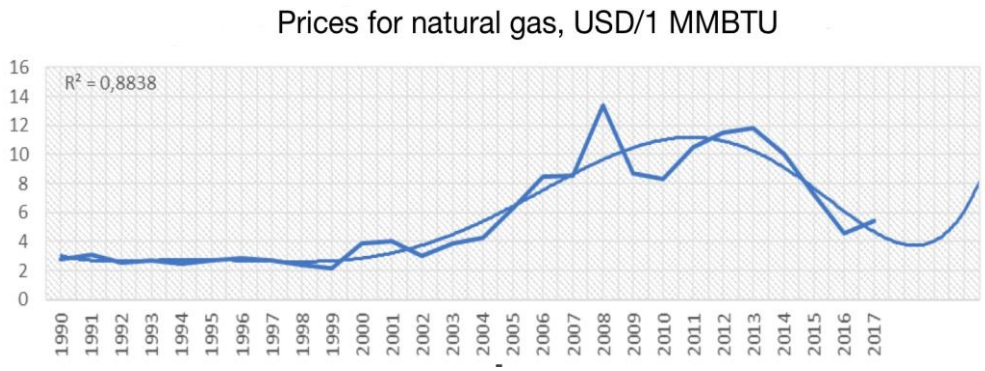
Canada will slowly reduce the volume of natural gas production, whereas the USA is expected to increase it. In China, both gas production and consumption are to go up. France will increase its consumption, as well as Russia, Germany and Norway. This can lead to serious changes in the gas market in Europe, given that domestic consumption will grow, and production volumes will not. This will lead to an increase in gas imports to Europe, which in the long run can mean an increase in exports for Russia.

Consumption in Canada will increase slightly; however, in the US, a rapid growth in gas consumption is expected. Nevertheless, if we consider the growth rates of production, the US may become a natural gas exporter not only in its region, but also on the world market.

To obtain the forecast of world gas prices, we carried out a historical trend analysis using the 6th order polynomial trend line presented in Figure 4. The approximation reliability is 88%, which is a relatively high figure. According to the forecast, natural gas prices will exceed USD 8/ 1MMBTU in 2020.

Production and consumption volumes directly influence world prices for natural gas. Knowing the approximate volumes of global demand and supply in the natural gas market, it is possible to adjust the historical trend analysis and make forecast scenarios for the dynamics of natural gas prices.

Figure 4. *The forecast of global natural gas prices up to 2020*



Using the historical trend analysis and volumes of gas production and consumption, we made forecast scenarios of world prices for natural gas. Scenarios were developed in accordance with the forecast values for oil quotations. The current Groningen concept implies that natural gas prices are linked with major commodity substitutes, namely, oil and petroleum products. In 2016 the authors conducted research that involved creating forecast scenarios based on the dynamics of oil price changes, and it confirmed the correctness of the base-line scenario and the price level for a barrel of oil ranging around USD 50-55 in 2017 (Elyakova *et al.*, 2016).

- The first– the baseline scenario: prices will rise, but at a moderate pace and by the end of 2017 it is expected to be around USD 4/MMBTU. By 2020, the price will reach USD 6.5-7/ MMBTU by 2020.
- The second – the best-case scenario: prices will continue to rise and will exceed USD 8.5 /MMBTU before 2020; this is justified by the growth in demand for gas in the world market, also due to China's active transition from coal to natural gas. In the future, by 2025, it is planned to settle the prices at the level of USD 8-9/MMBTU.
- The third – the worst-case scenario: prices in 2017 will remain at the current level of USD 3/MMBTU with a smooth fall to the level of USD 2/MMBTU by 2020. This might occur due to higher gas supply due to the growing number of gas producers, as well as increasing the efficiency of its associated production (methane-bearing coal seams, shale gas through fracturing, associated petroleum gas).

4. Conclusion

Having conducted the study, the authors proposed three forecast scenarios (base-line, best-case and worst-case) of changes in world prices for natural gas based on economic and mathematical modeling and historical trend analysis of the extraction, consumption, export and import of natural gas.

To create these forecast scenarios, the authors analyzed the volumes of production, consumption, export and import of natural gas in eight major countries in the gas market in Europe, Asia and North America (Russia, France, Germany, Netherlands, Norway, China, Canada, USA). In addition to that, the main causes and internal factors influencing the natural gas market of the studied countries were identified.

Prices for natural gas largely depend on world oil prices. The Groningen pricing concept used in European countries implies that the price of natural gas is determined according to the replacement cost. So, we conducted a correlation-regression analysis of world prices for natural gas and oil prices. The study revealed that the correlation coefficient is equal to r = 0.97, which indicates a direct relationship between gas prices and oil prices. Using the economic-mathematical modeling and historical trend analysis of the production, consumption, export and import of natural gas, we made forecast scenarios of gas price levels up to 2020, which can be used to determine the volumes of exports and imports, the price policy of the countries and oil and gas companies in the global gas market.

The obtained results, in our opinion, will allow countries to make more accurate strategic plans regarding the development of the gas industry and natural gas exports, which will consequently enable effective planning of tax revenues to budgets and improve the countries' welfare and balance of trade.

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