The relationship between energy policies and quality of life in Russia

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Abstract

This paper discusses general facts about energy policies and analyzes their relationship to the quality of life in Russia. Aspects of the sustainability and exploitation of energy sources in Russia are also discussed.

The aims of Russia's energy policy are the efficient use of natural energy resources, the increase in the potential of the energy sector allowing sustainable economic growth, the improvement of living standards of the population, and the enhancement of the economic position of the country.

This paper examines the relationship between energy policies and standards of living in Russia by using a production function integrated in an ARCH-model. Data on the production and export of energy resources in Russia from 1992 to 2012, for each of the forms of fuel (oil, gas, coal, uranium), was transferred to standardized units. Using the model, an analysis and a forecast of the Human Development Index (HDI), as well as the forecast of errors for the years 2013–2015, has been carried out. The results show that an increase in the production and export of energy is associated with an increase in HDI.
Keywords: energy policy, sustainability in energy sources, energy policies and quality of life, production function, ARCH-model.

1 Introduction

Fuel and energy resources include coal, lignite, oil, flammable gases, oil shale, peat, wood, and nuclear energy.

Currently, the main type of fuel and energy resource is oil, which provides 40% of energy production in the world. Furthermore, the oil can be easily transported and is therefore an important object of international trade. Over 65% of proven oil

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reserves are concentrated in the countries of the Middle East. There are also large oil reserves in Russia and in the Commonwealth of Independent States (CIS) – Kazakhstan, Azerbaijan and Turkmenistan. Natural gas provides 23% of the world's energy production, while the growth rate of consumption is the highest in the world. First place in natural gas reserves is Russia, where a third of the world's reserves are concentrated. Solid fuels (coal, lignite, peat) provide 27% of world's energy production. Typically, coal as a fuel is used only in countries that produce coal since the costs of its transportation are enormous. Fuel and energy resources also include uranium. Developing fields contain at least 0.1% of the uranium in the ore. The main producing countries are Australia, South Africa, Nigeria, Brazil and Canada. Five percent of the energy produced in the world is referred to as geothermal wind and solar power plants [1].

Energy resources are the most important product group for the Russian economy. The fuel and energy sector of Russia is a complex system involving the processes of production, material extraction, transformation, transmission, distribution and consumption of the primary or converted types of fuel and energy resources. Energy, fuel and electricity supplies all industries and enhances economic development. Fuel and energy is currently the main part of exports in Russia. The energy sector includes the extraction industries and the processing industries of different types of energy resources.

Energy is an essential structural component of the economy of Russia and is one of the key factors for the vital activity of the country. The energy sector produces more than a quarter of Russia's industrial output, thereby significantly affecting the formation of the country's budget.

Fully supplying itself with fuel and energy resources, Russia is a major exporter of fuel and energy, which makes up about 60% of its export potential.

Compared with global trends the structure of the Russian economy in the 1990s changed in the opposite direction. The importance of raw materials, including energy resources has steadily declined in the structure of world GDP. In Russia, the situation is reversed: the share of fuel and energy sector in Russia is increasing and is about 30% of industrial output, 32% of consolidated and 54% of the federal budget, 54% of exports, and 45% of foreign exchange earnings in Russia. At the same time in the last 10 years share of the sectors with high added value declined in the structure of industrial production.

2 Fuel and energy sector in Russia

2.1 Russian energy politics in context of world economic development

The aims of Russia's energy policy are the efficient use of natural energy resources, increasing the capacity of the energy sector for sustainable economic growth, improving the living standards of the population, and enhancing the external economic position of the country.

Russia had to adjust its strategy on the basis of changes in the domestic and world situation. The analysis reveals the following stages of the change in the energy policy.

The first stage dates to the late 1800s, when the Russian monarchy saw a huge potential for strengthening the empire, which existed in the development of the energy sector. The removal of restrictions on foreign investment and inviting European and American companies to develop oil fields in Baku and in the Volga region allowed the Russian Empire to produce 31% of world exports at the beginning of the 1900s [2].

The second stage began to emerge after the Second World War. In the period from 1950 to 1960, oil production in the USSR doubled and the Soviet Union became the world's second largest oil producer and a major supplier of fuel in Eastern and Western Europe. Revenues from oil exports accounted for nearly half of the total exports from the USSR. The amount of oil production was significant and the cost of labor was low. USSR sold oil at prices that were almost 50% lower than the Middle East. Oil has not been extracted efficiently and the fields have been depleted quickly. In the 1970s, oil prices have increased drastically due to crises that occurred mainly in the Middle East.

The third stage is dated to 1975, when the Soviet Union raised oil prices *to their customers from Eastern Europe*. Afterwards the USSR raised prices in line with world markets. By 1976, oil prices had almost doubled in the Eastern bloc.

The fourth stage is characterized by the development of the energy sector in Russia after 1992. In recent years, companies extract oil and gas from the deposits faster than the stocks are replenished. Thus, increasing the volume of exploration is very questionable. The current state of the fuel and energy sector and the growing needs of energy in the world demand urgent measures for the development of oil and gas industry. Therefore the Russian government has approved the "Energy Strategy until 2020". This is a public document that defines the country's program for the fuel and energy sector and the growth of the country's income due to oil and gas [3].

One of the main tasks of the Russian energy strategy is to ensure socio-economic development of regions on the basis of efficient, reliable and secured energy supply at the lowest cost of production, transformation, transportation, and energy consumption.

2.2 Dynamics of production and use of energy resources

The four essential and critical fuel types in the Russian energy sector are oil, natural gas, coal, and nuclear fuel (enriched uranium).

The Russian oil industry experienced a downturn from 1991 to the early 21st century. Production of oil and gas condensate decreased compared to 1990 by more than 40%. At the same time the industry has continued to provide both domestic demand and exports. Despite this crisis in the oil industry, Russia remains one of the world's largest producers, consumers and exporters of oil and continues to maintain an important position in the world market, occupying a high position in the world of oil production. The analysis shows only a positive dynamic in oil production in Russia since the beginning of the 21st century – as from that time innovative methods of extracting began to appear.

Natural gas production declined in the late 20th century and returned to the same level around 2006–2007. One may also notice a sharp recession in 2008, related to the global economic crisis. However, despite all of the above, Russia is still the world's largest producer of natural gas, which certainly has a very positive impact on the economy as a whole and the standards of living.

The dynamics of coal mining in Russia show a positive trend since 1998, and a sharply positive trend since 2009. However, prior to 1998, a clear decline can be seen. The global economic crisis in 2008 is also worth mentioning, in which there is a clear reduction of resource extraction.

Russia, with 5% of the world's uranium reserves, occupies one of the leading positions in the production of this resource. Starting in the 21st century one can see a sharp jump in the production levels because of new technologies for the extraction and production of nuclear fuel. In 2010 there was a decline. However, looking at the levels in 2011 and 2012, one can conclude that the trend remains positive.

The general trend of oil prices in 1992–2012 is upward, and from 2001 to 2012 the price of oil has increased by 4.5 times. In the crisis year of 2008 one could also see a sharp rise in oil prices. The prices almost doubled compared to the previous year of 2007.

A similar situation can be observed in the dynamics of gas prices. The general trend is upward from 2000 to 2012. Thereby the price of gas has increased by 4 times. In the crisis year of 2008, similarly to oil prices, one could observe a sharp increase by more than 50% compared to the previous year 2007.

The dynamics of coal prices looks a little different than the dynamics of the prices of the previously mentioned resources. However, there are also similar patterns. The general trend of price changes is still upward, and in the crisis year, similar to oil and gas, one can see a big jump in prices. The price of coal increased by nearly 60%.

Unlike the three abovementioned resources, the picture of the dynamics of prices for nuclear fuel is smoother. Steady rise in prices can be seen since 1999. The prices in 2012 are 4 times higher than in 1999. An important difference is the lack of a visible impact on the prices during the economic crisis of 2008, since in this year the prices have shown a steady and not an extraordinary level of growth.

2.3 The aspects of sustainability in energy sources and exploitation in Russia

The objectives of the Russian "Energy Strategy until 2020" are consistent with the objectives of the initiative "Sustainable Energy for All" at the UN General Assembly Resolution (June 5, 2014) which has been presented.

The priorities of the energy strategies are complete and reliable in their ability to supply the population and the economy with energy resources at affordable prices, in the use of energy-saving technologies and equipment, the minimization of impacts on the environment, the introduction of new technologies of production, processing, transportation, and in the sale and consumption of products [3].

The analysis shows that there are risks associated with the achievement of the objectives of the "Energy Strategy of Russia". The main ones are as follows. A high degree of depreciation of fixed assets (50%) and the possibility of accidents in the energy sector is an important issue that should be considered. Shortage of investments in energy industries (except for the oil industry) can result in an impediment to economic growth. The lack of competition between interchangeable energy resources and a policy for maintaining relatively low prices for gas and electricity may result in the future deficit of the respective energy resources due to the lack of economic incentives for investment in their production and overtaking demand growth. Lagging behind the world's scientific and technical level of the productive potential of the fuel and energy sector might also be a problem. A small proportion of renewable energy sources and therefore a negative impact on the environment is also critical. Another risk is the tendency to further increase the share of oil and gas in Russian exports.

3 Evaluation of life in Russia

The main indicators that represent the standards of living of the population are income (nominal and real per capita income, income inequality indicators, nominal and real average wage, average and real pensions, minimum subsistence level and proportion of the population with income below the subsistence level).

According to the World Bank ranking of countries in terms of standards of living in 2012, Russia is placed 59th out of 110 countries in the world.

Although, according to the UN, Russia is in the group of countries with an average value of the Human Development Index (HDI), and Russia's HDI is significantly above the average value. Furthermore in the period of 2005 to 2012, the world's average values and Russian values of HDI have been increasing.

4 Data and methods

4.1 Data

For the analysis and forecasting, four main types of fuel have been used: oil, natural gas, coal, and nuclear fuel (enriched uranium).

Statistical information about the extraction of fuel in Russia in the period from 1992 to 2012 was taken from the database of the Russian Statistics Committee. The proportion of fuel and energy sector in Russia's GDP was determined by the authors and was confirmed by an analytical report by the Moscow International Energy Forum.

Information about the volume of exports of the energy sector in the period from 1992 to 2012 was retrieved from the database of the Russian Statistics Committee and the analytical report by the Moscow International Energy Forum.

World prices for energy resources have been collected from various databases and analytical sources that are summarized in the industry overview about Russian nuclear power [4].

HDI values in the Russian Federation from 1992 to 2012 are taken from the database of the World Bank.

4.2 Evaluation of production and export of energy resources

In order to use the same dimension in the model, the production and export of fuel has been converted to a standardized unit. This conversion of fuel is used to compare the effectiveness of various fuels. One unit of standardized fuel represents one kilogram (kg) of fuel with a combustion energy of 7000 kcal/kg (29.3 MJ/kg). The ratio between the standardized fuel and the natural fuel is given by:

$$B_y = \frac{Q_k^p}{7000} B_k = Э * B_k \tag{1}$$

B_y – *mass of the standardized energy resource;*
B_k - *mass of the natural fuel in kg or cubic meters(m^3);*
Q_k^p- *lowest heat of the combustion of the natural fuel in kcal / kg or kcal/m^3;*
Э - *energy equivalent.*

The given fuel is converted into a standardized unit by using a coefficient that represents the ratio of heat content of 1 kg of the given type of fuel to heat content of 1 kg of standardized fuel.

The coefficient for oil is 1.43, 1.14 for natural gas, and 0.72 for coal [5]. As for uranium, 70 tons of uranium accounts for 1.08 million tons of fuel [6].

Using the explained approach, the production of energy resources during the period 1992–2012 is converted into standardized units. A similar approach is used to convert data for the export of energy resources.

The conversion provides two new time series – production and export of standardized energy resources in the period 1992–2012.

4.3 Methods

4.3.1 Power production function

To analyze the relationship between HDI and indicators assessing the activities of the energy sector the following multiplicative power production function is used [7].

$$y_t = \alpha_0 * x_{1t}^{\alpha_1} * x_{2t}^{\alpha_2} + U \tag{2}$$

y_t – *human development index in time t;*
x_{1t} – *rate of extraction of fuel and energy resources in time t;*
x_{2t} – *the exports of fuel and energy resources in time t;*
$\alpha_0, \alpha_1, \alpha_2$ – *coefficients that are determined using a regression analysis;*
U – *stationary noise.*

4.3.2 Stationarity of the time series

The time series Y_t, X_{1t}, and X_{2t} have been checked for stationarity. The results show that the mathematical expectation and variance of the series are constant, implying that stationary properties are met. To determine the significance of autocorrelation, Box-Ljung-statistics has been used. The values of autocorrelation are distributed evenly, confirming the autocorrelation property of stationary series. The autocovariance of the series is also constant. Thus, the results imply that the time series are stationary.

4.3.3 Derivation of the production function

Using ordinary least squares, coefficients $\alpha_0, \alpha_1, \alpha_2$ have been determined.

$$y_t = 0.506 * x_{1t}^{0.304} * x_{2t}^{-0.301} + U \tag{3}$$

To analyze the accuracy of the model and to define the parameters of the autoregressive conditional heteroskedasticity model (ARCH), Δy_t – the difference between the actual and estimated values for every period – was determined. The analysis of the new time series Δy_t showed that at all periods, except for one, of the actual values of the time series were larger than the estimated.

4.3.4 ARCH model

The general ARCH model is as follows:

$$\Delta y_t^2 = \gamma_o + \gamma_1 * \Delta y_{t-1}^2 + \cdots + \gamma_n * \Delta y_{t-n}^2 \tag{4}$$

Δy_t^2 – *square residual (error) at the time t*;
$\gamma_o, \gamma_1, \gamma_2$ – *coefficients of the ARCH model;*
n – *number of lags*.

Time series that are needed to create the ARCH model can be obtained by squaring the values of the previously found ΔY_t. For our case, we took two lags, i.e. the time series has been shifted by two lags. The resulting ARCH model is as follows:

$$\Delta y_t^2 = \gamma_o + \gamma_1 * \Delta y_{t-1}^2 + \gamma_2 * \Delta y_{t-2}^2 \tag{5}$$

The coefficients of the equations of the ARCH model are determined using the ordinary least squares method. To test the significance of the coefficients in the ARCH model a special a chi-squared test is used [8]. By making the assumption that the coefficients do not show any significance, the following null hypothesis can be set up:

$$H_0: \gamma_o = \gamma_1 = \gamma_2 = 0 \tag{6}$$

Looking at the chi-squared-test (180.34) one can reject the null hypothesis clearly (critical value for two lags is 12.01). Therefore the estimated coefficients are significant. By substituting the coefficients in equation (5) one gets the following ARCH model:

$$\Delta y_t^2 = 0.012 * \Delta y_{t-1}^2 + 2.25 * 10^{-10} * \Delta y_{t-2}^2 \tag{7}$$

5 Forecast of HDI

A forecast for 2013, 2014, and 2015 is determined using the following equation.

$$y_t = 0.506 * x_{1t}^{0.304} * x_{2t}^{-0.301} \pm (0.012 * \Delta y_{t-1}^2 + 2.25 * 10^{-10} * \Delta y_{t-2}^2) \quad (8)$$

In order to determine HDI for 2013, 2014, and 2015, all the parameters (x_{1t}, x_{2t}, Δy_{t-1}^2, and Δy_{t-2}^2) of equation (8) have to be estimated. The forecasts for the rate of extraction (x_{1t}) and the exports (x_{2t}) of energy resources in the years 2013, 2014, and 2015 have been determined using the following linear trend of the form

$$x_t = \beta_0 + \beta_1 * t \quad (9)$$

The results are shown in table 1.

Table 1: Forecast results.

	β_0	β_1	t_p	t_m
Rate of extraction (x_{1t})	0.977	$1.18 * 10^{-9}$	20.224	6.332
Exports (x_{2t})	0.211	$1.16 * 10^{-11}$	33.04	4.521

The forecasted values for HDI are as follows:

$$y_{2013} = 0.802545096 \pm 0.0143321486$$
$$y_{2014} = 0.802545102 \pm 0.0015700094$$
$$y_{2015} = 0.802545105 \pm 0.0001719861$$

One can check the precision of the forecast for the year 2013 since the actual data is already available. The actual value for HDI in 2013 is 0.778. Therefore the difference is less than 0.01.

6 Conclusion

Analysis of the fuel and energy sector of the Russian Federation showed that the sector is of strategic importance for the Russian economy, accounting for 25% of GDP and about 33% of tax revenues in the budget. Furthermore, the tendency for an increasing share of the fuel and energy sector in the total industrial production and a reduction of the share of industries with high added value can be seen. The analysis has also shown that there are risks for the sustainable development of the energy sector. Depletion of basic production assets, shortage of investments into the energy industry, low share of renewable energy sources in the energy balance of the country, and increasing share of oil and gas in Russia's exports are the main risks that could impede sustainability.

The results indicate a significant relationship between HDI and the volume of production and export of fuel and energy resources. A distinctive feature of the analysis is the conversion of production and export of oil, gas, coal, uranium in standardized units and implementation of the ARCH-model in addition to the production function to determine the forecasted values of HDI. The applied model allows us to assess the impact of the energy sector on the standards of living in Russia and make the forecast for three years.

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