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Article

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Directions To Improve The Effectiveness Of Russia's Energy Export Policy

Gennady Osipov[1]*, Svetlana Karepova[1], Elena Chizhevskaya[2], Maxim Gnatyuk[3], Alexander Semin[4], Oksana Mikhayluk[5]

[1]Institute for Socio-Political Research, Russian Academy of Sciences, Moscow - 119 991, Russian Federation, [2]Tyumen Industrial University, Tyumen - 625 000, Russian Federation, [3]Samara State Transport University, Samara - 443 066, Russian Federation, [4]Ural State University of Economics, Yekaterinburg - 620 219, Russian Federation, [5]Ural State Mining University, Yekaterinburg 620 144, Russian Federation. *Email: professor-osipov@mail.ru

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ABSTRACT

The importance of a fuel and energy complex (FEC) of the Russian Federation for the economy together with volatility of the global energy market conjuncture updates the need to develop scientific approaches to improving the effectiveness of energy export policy. Key factors destructive to an energy balance in the context of the current state and development of the FEC in Russia have been identified. Using the regression method, the article rationalizes the nature of dependence of Russia's gross domestic product (GDP) on energy balance indicators taking into account the factors of the current economic and geopolitical situation. Based on simulation modeling, values of a favorable ratio of exports to production and consumption of oil and gas that would contribute to an increase in the growth rates of Russia's GDP have been calculated. A quantitative estimation of the GDP growth and the level of energy intensity reduction in the national economy have been presented, while observing favorable ratios of the exports to the production and consumption of oil and gas. A set of focus areas to increase the effectiveness of Russia's energy export policy has been proposed.

Keywords: Energy Export Policy, Energy Resources, Energy Exports, Energy Balance, Energy Intensity of the Economy, Export Potential, Oil, Gas
JEL Classifications: L520, O110, O470

1. INTRODUCTION

The Russian economy is characterized by a significant dependence on oil and gas exports with the share of 13% of the gross domestic product (GDP) (Federal State Statistics Service, 2018). Energy revenues account for 19.24% of the consolidated revenues and 39.37% of the country's federal budget (Ministry of Finance of the Russian Federation [RF], 2018). This is largely due to the fact that Russia's fuel and energy resource potential is one of the largest in the world: About 13% of the world's explored oil reserves and up to 34 % of the natural gas reserves are concentrated in 13% of the earth's territory, in a country with <3% of the world's population (BP Statistical Review of World Energy, 2018). In this regard, it is Russia's effective energy export policy that contributes to optimizing the fuel and energy balance of the country and lays the foundation for progressive development of the national economy. A reliable fuel and energy balance as an instrument of state regulation makes it possible to avoid structural disparities and price distortions in the domestic energy market, to create an effective mechanism for managing the formation and use of the national economic reserves, and to reduce the energy intensity of the country's economy (McCalman, 2018). The growth of commodity dependence of the Russian economy by 10% in 2017 (Federal State Statistics Service, 2018) as compared to 2015 and the downward trend in the world energy market prices over the past six years (by 36%

for oil and 44% for natural gas) have significantly complicated the provision and implementation of Russia's effective energy policy (Energy Prices, 2018), (Paltsev, 2014; Andreassen, 2016; Kapustin and Grushevenko, 2018). Despite diversified Russia's hydrocarbon export destinations and the introduction of state programs to develop new oil and gas fields (the Energy Strategy of Russia Until 2035 [2015], The Concept of the Long-Term Social and Economic Development of the RF for the Period until 2020, [2008]), there is a slowdown in growth rates of the Russian economy (6% over the past six years) (Federal State Statistics Service, 2018). The development of long-term strategies for the energy exports does not have the desired effect in the short term. There is a need to adopt tactical approaches to achieving the effective energy export policy based on macroeconomic models, taking into account the factors of the internal and external conjuncture of the energy market.

The scientific priority of this research was to develop an approach to determining optimal quantitative parameters of the ratio of the exports to the production and the consumption of oil and gas that would enhance the GDP growth in Russia. Such an approach could contribute to flexibility in managing the volume of the national energy exports and improving the effectiveness of energy export policy in the short term.

2. LITERATURE REVIEW

Scientific research in the field of energy export policy has developed in the context of evolving scientific approaches to ensuring the effectiveness of the state's foreign economic policy. In the economic literature, what is initially meant by the energy export policy is a package plan aimed at regulating the economic relations in terms of the energy exports from the customs territory of the country and is based on international division of labor (Xia et al., 2015). Despite obviously inadequate interpretations of the energy export policy in the national economic context, this approach has a large backing today (Zheng-Xin et al., 2017; Picciolo et al., 2017). In spite of the fact that the modern understanding of the essence of this concept has become more complicated, this perspective has a significant impact on scientists' and politicians' views (De Avila et al., 2014; Akhmetov, 2015). The problem of energy export policy is dominated by the idea that it is primarily related to the issue of supplies. This scientists' position reflects in the optimal welfare-maximizing tariff theory, the generalized theory of distortions, and the theory of domestic divergences (Giannellis and Koukouritakis, 2017; Soderbery, 2018).

The export policy that maximizes the foreign trade earnings differs from the foreign trade policy that maximizes the national welfare. Eased foreign trade restrictions, all other things being equal, contribute to the growth of any country's national welfare (McCalman, 2018). Based on Ricardo theory and productivity theory, this scientific position can be supplemented with the fact that exporting companies achieve greater manufacturing productivity than those that produce only for the domestic market and, accordingly, an increased number of exporters ultimately results in the country's GDP growth (Montalbano and Nenci, 2018).

It should also be noted that there is a perspective of the energy export policy as a triple-component structure, including ensuring the efficiency of exports, transit, and consumption of energy resources (Alipour et al., 2018). Such an approach goes beyond one country and is based on the idea that all parties "must share responsibility and risks for the smooth functioning of global energy."

The abovementioned theoretical aspects in many respects closely echo the views on the energy export policy from the international organizations' perspective of this concept. Thus, the experts of the Organization for Economic Cooperation and Development (OECD) have identified three key characteristics they consider to be the core of the energy export policy problem: A risk and uncertainty in the continuity of supply and stability of hydrocarbon prices, a non-critical level of prices, and the psychological sense of export risks (OECD Economic Surveys: RF, 2014). The International Energy Agency has defined the "continuous availability of energy sources at an affordable price" as the main criterion and focuses on the time aspects of this concept - long-term and short-term (International Energy Agency, 2017). In the long term, the energy export policy effectiveness means the possibility to ensure the energy supplies in the volume that would meet the country's economic needs, while respecting reasonable environmental constraints (Proskuryakova, 2018). In the short term, it stands for the ability of the country's energy system to respond quickly to unexpected changes in the supply and demand balance (Noor et al., 2018).

According to the authors, the export policy should also be viewed from the standpoint of ensuring the energy security not only within the framework of one country, but also within the global security framework. In other words, there are geopolitical, military, economic, technological, social, environmental, and other dimensions of the energy export policy problem to consider in the framework of ensuring the energy security. Given the latest research by Rodrik, and other scholars, it becomes clear that the state policy to support the energy exports should be based on the creation of multifactor macroeconometric models to determine the degree of impact of these factors on the domestic market and the country's GDP (Rodrik, 2015; Burakov, 2016).

Given the above, the purpose of this research was to develop approaches to improving the effectiveness of Russia's export policy, taking into account the factors of the internal and external hydrocarbon market development.

As a result of the research, the following tasks were solved: The problems of the energy export policy effectiveness were analyzed; the functional aspect of interdependence of the country's energy balance and the GDP was reasoned; the levels of the ratio of the exports to the production and the consumption of energy resources, contributing to the country's GDP growth, were identified; the directions that would contribute to improving the effectiveness of Russia's energy export policy were substantiated.

3. MATERIALS AND METHODS

The following scientific cognition methods served as a methodological basis for the research.

An energy balance function was used within the framework of the study to determine the main factors affecting Russia's GDP (equation 1) (Paoli et al., 2018):

$$P'+Imp'=C'+Exp' \quad (1)$$

Where *P'* is the production (extraction) of energy resources;
Imp' is the imports;
C' is the consumption;
Exp' is the exports.

Regression analysis is a method of statistical analysis of the dependence of random variable *y* on the variables $x_1, x_2, \ldots, x_n$, (Mishra and Datta-Gupta, 2018). It was used to determine the type of the dependences between Russia's GDP, the country's energy balance indicators and the factors that affect them.

In general terms, the multifactor linear regression model has the following form (equation 2) (Mishra and Datta-Gupta, 2018):

$$y=b_0+b_1*x_1+b_2*x_2+.+b_n*x_n \quad (2)$$

Where *y* is the dependent variable;
x1,…,n are the independent variables;
b_0 is the intercept term;
$b_{1,\ldots,n}$ are the independent variable held constants;

The regression model parameters ($b_0, b_1, \ldots n$) are estimated by the method of least squares. Its principle is to select model parameters, whereby the sum of squared deviations of actual values of the dependent variable from the predicted ones is minimized (equation 3) (Mishra and Datta-Gupta, 2018):

$$\sum_i^N (y_i-\overline{y_i})^2 \rightarrow min \quad (3)$$

Where y_i is the actual value of the dependent variable in the *i*-th period;

$\overline{y_i}$ is the predicted value of the dependent variable in the *i*-th period;

$i = 1, 2, \ldots, N$

The use of data of different dimensions when building regression models of the dependence between the energy balance and Russia's GDP indicators (value, physical, index, and structural) necessitated standardization of data in order to reconcile them. They were standardized according to equation 4 (Anysz et al., 2016):

$$X_{st} = \frac{X_i - \bar{X}}{\sigma} \quad (4)$$

Where X_{st} is the standardized value of an indicator;
X_i is the actual value of an indicator;
$\bar{X}$ is the average value of an indicator;
σ is the standard deviation of an indicator.

Also, the regression analysis method was used to determine the elasticity of Russia's GDP and the energy exports of the energy intensity of the national economy. The coefficient of elasticity (K_e) was calculated by building single-factor linear regression models of the dependence of the GDP and the energy exports on the energy intensity of the economy using equation 5 (Guidolin and Pedio, 2018):

$$K_e = b * \frac{\bar{x}}{\bar{y}} \quad (5)$$

Where *b* is the regression model constant held by the independent vartiable for which the effect on the resulting indicator is estimated;
$\bar{x}$ is the average value of the independent variable for the period under study;
$\bar{y}$ is the average value of the dependent variable for the period under study.

Based on the relationships between Russia's GDP, the indicators of the country's energy balance and the factors that influence them, a simulation model was built to find a favorable ratio between the exports and the production, the exports and the consumption of energy resources that would maximize the GDP growth.

Simulation modeling is a method of modeling the aggregate of structural links between the elements of the system under study. A simulation model is represented by a system of differential equations (equation 6) (Wu et al., 2018):

$$\frac{dy}{dt} = F(x(t), v(t), h(t), t) \quad (6)$$

Where *F* is the vector function of a system functioning law;

x, v, h, y are the vectors of input, internal, and output actions, respectively.

The operation principle of a simulation model is to conduct experiments with the system and to investigate the influence of control variables (indicators of the ratio of the exports to the production and of the exports to the consumption of energy resources) on the dependent variable (the GDP). Those values of the control variables are taken as optimal that contribute to the achievement of target values of the dependent variable to the maximum extent.

In order to predict the volume of energy production, neural networks were used. An artificial neural network is a mathematical model representing a system of simple processors (neurons) and the interconnections between them. The neural network principle is a neuron converting the impulse received at the input into a post-synaptic function, the value of which is calculated by equation 7 (Wang et al., 2018):

$$net_j = w_0 + \sum_{i=1}^{n} x_i w_{ij} \quad (7)$$

Where net_j is the post-synaptic function;
w_0 is the threshold value of the function;
x_i is the input message of the i-th neuron;
w_{ij} is the strength of the synaptic connection between the i-th and j-th neurons;

$i,j=1,2,\ldots N$

The resulting value of the post-synaptic function is converted into an output message, using an activation function (equation 8) (Wang et al., 2018):

$$y_j = f(net_j), \quad (8)$$

Where y_j is the output message;
$f(net_j)$ is the activation function.
Historical oil and gas production values were used as input messages of the neural network, the predicted values of these indicators were used as output messages.

4. RESULTS

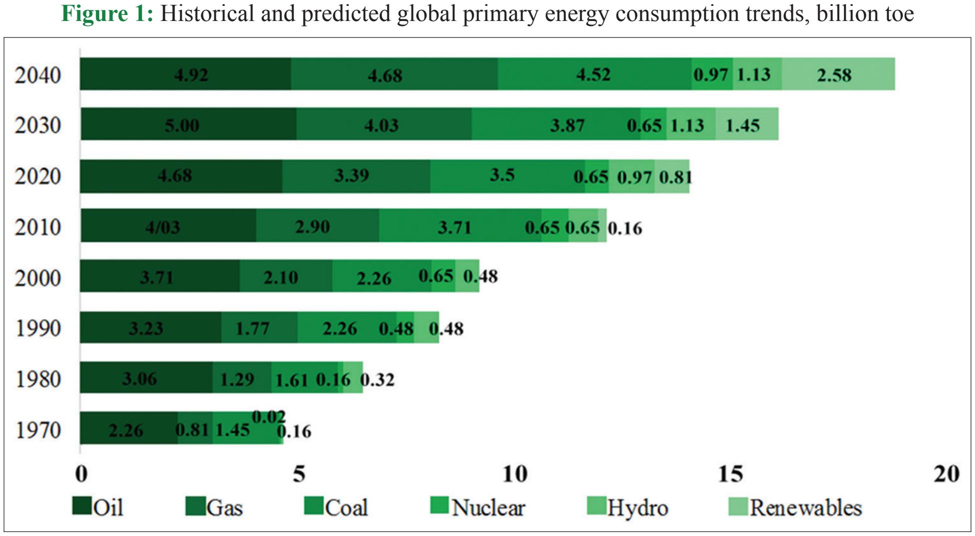
A growth of primary energy consumption in the world is conditioned by a world economic growth and an increase in the urban population. According to the projections of the International Energy Agency, the global energy demand will increase by 37% by 2040. Despite the fact that the consumption of renewable energy resources is projected to rise to 2.58 Billion toe in 2040, the bulk of consumption will also be provided by oil, gas, and coal - over 75% of the total primary energy consumption [Figure 1] (BP Statistical Review of World Energy, 2018).

The RF that positions itself as the top exporter of energy resources, in particular gas and oil, plays a significant role in meeting the growing demand for energy resources in the world. Thus, as of 2017, the country ranked second in oil exports - 13% (145.6 million tons) of the world exports. It is also the absolute world leader in the natural gas exports - 29% of the world export (215.4 billion cubic meters) (BP Statistical Review of World Energy, 2018). The country's leading positions in the world energy market are premised on a significant level of the natural reserves available and the production of energy resources. In 2017, Russia ranked fifth in the world in the proved oil reserves that amounted to 6.1% of the world's oil reserves, that is, 14.5 thousand million tons, and third in the oil production - 12.6% of the world crude oil production, that is, 554.4 million tons. It has a world lead in the natural gas reserves - 18.1% of the world reserves, that is, three trillion cubic meters, and ranks second in the gas production - 17.3% of the world reserves, that is, 635.6 billion cubic meters. It ranks second in the coal reserves - 15.5% of the world reserves, that is, 16,036.4 million tons, and sixth in its production - 5.5% of the global production, that is, 206.3 million tons. It is fourth in the world in the electrical power generation - 4.3% of the global volume, that is, 1,091.2 terawatt-hours (BP Statistical Review of World Energy, 2018). The export of hydrocarbons from Russia amounts to 12.5% of the GDP (Central Bank of the RF, 2018).

Trade in energy resources forms the backbone of Russia's exports, accounting for 59%, with only 28% of the exports accounting for the crude oil sales. It should be noted that, despite a growth in the absolute volume of the Russian oil exports in 2008–2015, its growth rates lagged significantly behind the growth rates in the oil production and consumption in the country, and since 2016 the oil export volumes are characterized by a downward trend (Figure 2) (BP Statistical Review of World Energy, 2018).

Also, the energy revenues account for the lion's share of the federal budget revenues. At the end of 2015, the share of oil and gas revenues in the federal budget fell to 30%, however, by the end of 2017 it was about 40%. For a particular federal budget, this figure has exceeded 70% (Ministry of Finance of the RF, 2018). The significance of the mining sector in the industrial production development has also increased essentially. Together with the oil refining sector, this economic segment accounted for more than 70% of the total growth of the national industrial production in 2017 (Ministry of Energy of the RF, 2018). This has been the highest share over the last five years. Despite the fact that the Ministry of Finance of the RF has balanced the federal budget at

Figure 1: Historical and predicted global primary energy consumption trends, billion toe



the oil price level of $ 55 per barrel in 2018, given the downward trend in the volume of Russian oil exports and the decline in the oil prices in the world energy market, a more complex task arises to balance the budget in 2019 with the oil price of $ 40–45 per barrel (Ministry of Finance of the RF, 2018).

The Russian economy highly dependent on the oil exports can encounter financial problems associated with the technical difficulties of oil production, which is already observed over the influence of geopolitics on the economy as a whole and on the oil industry in particular.

A stable trend of a high level of energy content (energy intensity) of the national economy also seems to be a destructive factor in the energy policy of Russia's exports. In 2017, the level of energy intensity of Russia's economy amounted to 0.211koe/$ 2015 p and has remained the highest in the world (75% above the global average and 55% above that of the Middle-East countries) (Global Energy Statistical Yearbook, 2018). In addition, despite the fact that the energy intensity of the economy decreased by 31% in 1991–2017, it has been characterized by a dynamic increase over the past three years. Today, Russia ranks second in the world after Ukraine in the energy intensity of the economy (Figure 3) (Global Energy Statistical Yearbook, 2018).

The growing energy intensity of the economy has had a negative impact on the GDP growth, and, therefore, on the energy export performance. Thus, as a result of the regression analysis algorithm implementation (equations 2–3), models of the GDP and exports dependence on the energy intensity were constructed in the framework of the research. The constructed models allowed the authors to assess the elasticity of Russia's GDP and energy exports of the energy intensity of the economy (equations 9,10):

$$GDP=3651.1-10194.3*GEI \quad (9)$$

$$E=21250-10193*GEI \quad (10)$$

Where GDP is the GDP expressed as billions of US dollars;

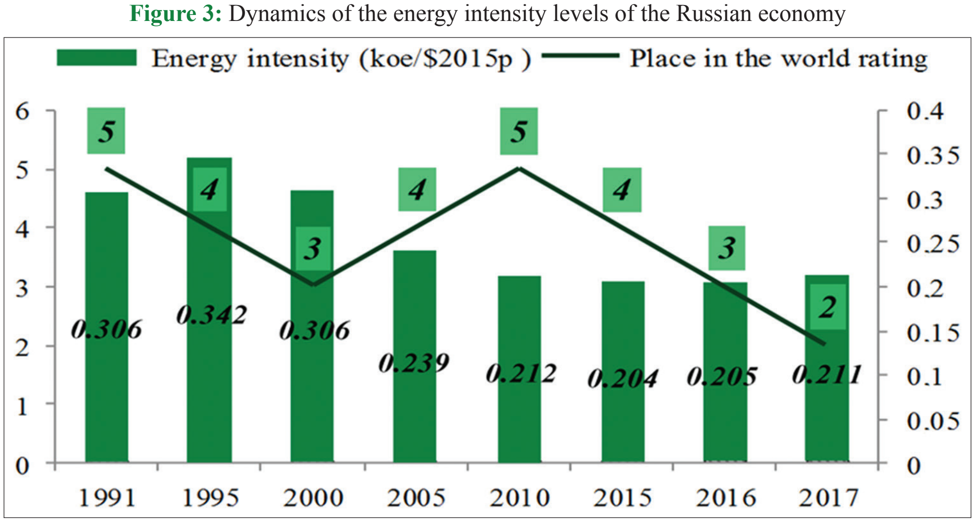
GEI is the global energy intensity index (the total energy consumption per unit of GDP).

E is the energy exports.

Calculated by equations (5), (9)–(10), the elasticity coefficients (K_e) testified that with an increase in the energy intensity by 1%, Russia's GDP would drop by 2.9% on average, while the energy exports would decrease by 7.5%.

Figure 2: The growth dynamics of the production, consumption, and exports of crude oil and oil products in the Russian Federation, %

Figure 3: Dynamics of the energy intensity levels of the Russian economy



The energy intensity of the Russian economy as of today even exceeds China's by 35%, while Russia's population is only 11% of China's population. The high energy intensity of the national economy in terms of specific energy consumption per capita places Russia on a par with states where the GDP per capita exceeds that of Russia by times. Moreover, when the energy intensity of the Russian economy is compared to other countries in transition, it becomes apparent the energy intensity of such economies has decreased by 25–35% over 20–25 years, since 1991 (Hungary, Estonia, Latvia, and Lithuania), and in some countries - twice or more (Armenia, Poland, and Kazakhstan) (Global Energy Statistical Yearbook, 2018).

It is impossible to rationalize this factor from the standpoint of the "climatic theory" as a consequence of the climatic pattern of the RF regions. Countries like Canada, Norway, Sweden, and Finland, countries with climatic conditions similar to those in Russia have a fairly competitive level of the energy intensity of the economy: 0.173, 0.085, 0.099, and 0.033 koe/$2015p, respectively (Global Energy Statistical Yearbook 2018, 2018).

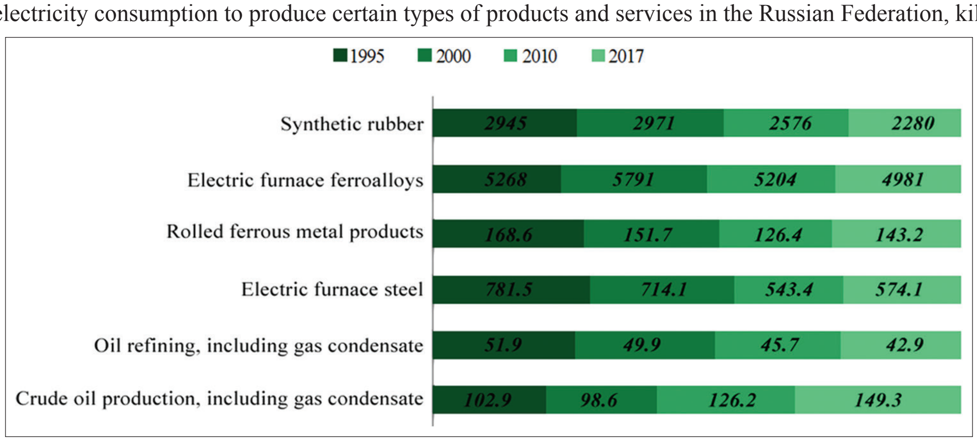
Thus, the Russian economy in terms of efficient energy use is uncompetitive in the modern conditions. The actual cause of the high energy intensity is the economic structure inherited from the USSR era (the power-consuming industry, insufficiently isolated buildings and structures, energy-intensive household appliances, cars, etc.). According to the official statistics, the total specific electricity consumption for manufacturing the main product types by Russia's industry reduced only by 12% in 1995–2017 (Figure 4) (Industrial production in Russia, 2017). Consequently, the energy-intensive nature of industrial production in Russia has not undergone any essential changes over the past 22 years, which dramatically reduces the export potential of Russia's energy resources and contributes to the disruption of the country's energy balance.

A key factor that reduces the effectiveness of Russia's energy export policy in the modern context is the Russian oil quality. The main export oil grade is Urals, a Russian export oil blend obtained by mixing a number of varieties in the Transneft pipelines, which accounts for the largest share in the export of hydrocarbons - 55% (The Main Development Trends of the World Oil Market Until, 2030, 2018). Urals oil is believed to be inferior to Brent, a North Sea mixture, in its properties. In addition, its processing is accompanied by more significant costs; therefore, Urals usually costs $ 1–3 less than Brent (Why the average Urals Oil Price Increased by Almost 27% in 2017, 2018). The main problem has been a growth of sulfur in the oil that Russia supplies to oil refineries in Germany, the Czech Republic, Slovakia, and Hungary. According to the metering station data provided by three European companies, Russia sold oil through the northern line of the Druzhba pipeline in 2017 with the sulfur content up to 1.81–1.85%–0.15 percentage points higher than the average over the last year (Europe Drastically Reduced the Purchase of Russian oil, 2018). Traders in the Urals market were unable to process oil of this quality. In addition, today Urals is characterized by a deterioration in such crude oil quality as density, which deteriorated from 870 to 871–875 in 2017 (Oil Urals, 2018). In this regard, there is a problem of reducing the amount of oil purchased by Europe from Russia or a reduction in its purchase price.

The problem of Russia's energy export policy effectiveness is also exacerbated by the sanctions imposed against it (Sidorova, 2016; Nureev and Busygin, 2017, Russian Council on Foreign Affairs, 2018) to limit the supply of Western technologies and equipment for exploration and development of new gas and oil fields in Russia, a rise in the cost of supplies of equipment and components for regasification and further use of natural gas. The change in the economic and political course of countries with large reserves of natural gas and other hydrocarbons and their entering into contracts with Western companies who possess efficient technologies could contribute to the rapid growth in the gas and oil exports on better terms than with Russia. The current situation is causing a decrease in the competitiveness of Russian projects, in particular, against the Middle East countries.

The Russian energy exports are also adversely affected by a significant change in the situation in the liquefied natural gas supplying countries, which contributes to the growth in gas exports or substitute energy sources on more favorable terms. In addition, it is necessary to take into account changes in the regulatory framework of the European Union - the most important importer of Russian gas. At the present time, according to the requirements of the EU's third energy package to eliminate monopolization and to promote competition in the world energy market, one supplier can use no more than 50% of the pipeline capacity (South Stream,

Figure 4: Specific electricity consumption to produce certain types of products and services in the Russian Federation, kilowatt-hours per ton



Project History, 2016). Consequently, Gazprom is prevented from using half of the capacity of the inland gas pipelines branches of the offshore gas pipelines Nord and South Streams.

Account must be taken of underdeveloped port facilities, a branched trunk pipeline network, and the geographical position of the RF, which determines the dependence of the energy exports on transit through other countries. Thus, for example, the direct export of Russian gas is estimated at 5.5%, as of today (BP Statistical Review of World Energy, 2018). As a comparison, in such countries competing with Russia as the Netherlands and Norway, the direct gas supplies to importers exceed 70% (BP Statistical Review of World Energy, 2018).

Thus, the above factors could trigger a violation of the energy balance and a slowdown in the country's economic development. This causes the need to reach an optimal level of exports, taking into account the state-of-the-art in the FEC in Russia, as well as necessitates changes in the world energy market conditions to ensure the maximum GDP growth rates.

The economic energy needs should be ensured by domestic production (extraction) of the respective goods. In case the demand exceeds the domestic supply, the deficit is covered by imports; in case the supply exceeds the demand, the merchandize surplus is sent for export. Uncovered deficits hamper the economic development, since they lead to a reduction in the production due to a shortage of manufacturing resources (energy resources), whereas a constant surplus leads to a deficiency in energy revenues. Further accumulation of energy resources would lead to a decrease in the GDP and a deterioration of the socioeconomic situation in the country.

When comparing the volumes of production, consumption, exports, and imports of energy resources, the authors revealed a lack of balance: There was a surplus in the oil and oil product market in 2008–2010 and 2013–2014, in contrast to a deficiency in 2011–2012 and 2015–2017. The total balance of oil and oil products in 2008–2017 was +20.3 million tons, which at the current price of oil (60–80 dollars per barrel) (SM Group, 2018) inflicts to losses of 8–11 billion dollars. For natural gas, there was an annual surplus of 140–190 billion cubic meters in 2008–2017. Therefore, in order to implement an effective policy for the energy exports, it is necessary to strike a delicate balance between the exports and the production, the exports and the consumption that would ensure the energy balance, and hence Russia's economic development in the short and long term.

Energy balance is a factor of ensuring the performance of any economy (Paoli et al., 2018). In this regard, it seems expedient to determine how the energy balance components impact changes in Russia's GDP. What is meant by the energy balance is a balance of production and consumption of hydrocarbons, taking into account foreign trade (Chomakhidze, 2016). The main energy balance indicators are: Production, import, consumption, and export of energy resources (equation 1). To determine the type of the dependence between Russia's GDP and energy balance, the study uses the expenditure method and the production method to calculate the GDP, including the energy balance indicators. The dependence functions are developed by building a multifactor regression model based on the values of indicators of 2008–2017, using the software package Statistica 10.0.

The advantage of using regression analysis is that it determines statistically significant factors that affect the independent variable, assess the constraint force between the indicators, and determine the nature of the relationship (Mishra and Datta-Gupta, 2018).

Based on the GDP calculations by the expenditure method ($GDP=C+1+G+XN$), it can be argued that GDP is directly proportional to consumption (C), investment (I), government expenditure (G), and net exports (XN) (Lyu et al., 2018). Since the amount of public expenditure in Russia in the form of subsidies to ensure the production of energy resources is not significant (Ministry of Finance of the RF, 2018), this indicator was not used to develop the regression models.

The GDP regression models were developed based on equations (2)–(3) differentiated according to the energy resources categories in terms of consumption (C'), investment in the extraction and processing of the energy resources (I'), and net exports (XN') as the difference between the exports and the imports (Table 1).

The developed models confirm that the consumption and investment in the oil and gas production sector directly impact the country's GDP. The net exports have a direct or an adverse effect on the GDP, depending on their volumes. A constant increase in the net exports with permanent production volumes could lead to a reduction in the consumption and production, which would negatively affect the GDP.

According to the method of production, the dependence of GDP on the energy production volumes is expressed through a system of single-factor models presented in Table 2.

According to the production method, GDP is defined as the sum of added values created in all sectors of the economy. The larger production volumes, in particular, the energy production volumes are, the higher the GDP is.

Table 1: Multifactor regression models of Russia's GDP as function of the energy resources category, according to the expenditure calculation method

Energy resources category	Dependence function
Oil and oil products	$GDP=0.34+0.35*C_o+0.19*I_o, g+0.38*XN_o$ (11)
Natural gas	$GDP=-0.51+0.61*Cg+0.10*I_{(o, g)}+0.27*XNg$ (12)

C_o is consumption of oil and oil products, C_g is consumption of natural gas, $I_{o, g}$ is investment in fixed assets aimed at reconstruction and modernization (the oil and gas production industry), XN_0 is net exports of oil and oil products, XN_g is net exports of natural gas. GDP: Gross domestic product

The energy balance is affected by a variety of economic factors that should be taken into account. In this regard, the study determined the relationship between the main economic factors and the energy balance indicators using the regression models.

The rate of exploitation is significantly influenced by the factors of production: the availability of minerals ("land"), workforce ("labor"), investment ("capital"), and technology (Christophers, 2014). As of 2017, the volume of oil reserves in Russia was 26.6 times as high as the production and that of gas reserves - as high as 417 times (BP Statistical Review of World Energy, 2018). Therefore, there are currently no restrictions on the production volumes, depending on the availability of natural resources. A model of the energy production volume (extraction) dependence on the production factors is presented in Table 3.

The developed models demonstrate a direct impact of the investment volume, the employment rate, and the innovative technology adoption index on the production volumes. The higher the level of investment in the industry is, the more financial resources are available to support the production operation of the industry players. The direct impact of the employment rate on the economic output is explained by the fact that an increase in the employment rate leads to a greater degree of human resource endowment, an increase in the economic output, and an approximation of the actual GDP to a potential one. Introduction of innovative technologies increases the production efficiency by reducing the labor, stock, energy, material intensity of products and the time spent on production, thereby an increase in the innovative technology adoption index contributes to an increase in production.

The exports are influenced, in addition to the physical indicators that are involved in the energy balance (volumes of production, consumption, imports), by price indices: The oil and gas world market price levels and the national currency exchange rate (Benkovskis and Wörz, 2018) (Table 4).

The export policy is aimed at maximizing profits; therefore, the price directly influences the decision-making on the expediency of exporting goods. An increase in the oil and gas world market price levels leads to an increase in the exports, which is confirmed by the results of the model development (17) and (18). The devaluation index has a positive effect on the exports: ruble devaluation stimulates the exports, since the exporters' revenue grows in the rubles equivalent, when a foreign currency is shifted into the national currency. The impact of the export potential indicators (logistics and intellectual potential, human resources) (Wang and Ma, 2018) on the exports is expressed through energy balance indicators, therefore, they are not separated in the models (17)–(18).

Table 2: Single-factor regression models of Russia's GDP as a function of the category of energy resources, by the production calculation method

Energy resources category	Dependence function
Oil and oil products	$GDP=-1,3+0,1*P_o$ (13)
Natural gas	$GDP=-1,1+0,5*P_g$ (14)

P_o is production of oil and oil products, P_g is production of natural gas. GDP: Gross domestic product

Out of the factors that affect the consumption volume, the energy intensity indicator (Ang and Goh, 2018) as one of the major destructive factors to Russia's energy policy revealed during the analysis is taken into account when building the models (Table 5).

The energy consumption volume is determined by the economic structure (Tang et al., 2018). Since the simulation is aimed at improving not the economic structure, but rather the export policy, it is only the energy intensity indicator as one of the main destructive factors to the energy policy is taken into account. Energy intensity directly affects the consumption volumes: the higher the energy intensity is, the more energy resources are required to produce a unit of output.

The adequacy of the above regression models is verified by the multiple correlation coefficient value that tends to 1.0, the determination coefficient that exceeds 0.8, the F-test, the calculated values of which are greater than the critical ones, and the *p*-error level not exceeding 5% (Mishra and Datta-Gupta, 2018).

All the dependence models of indicators for a favorable ratio between the exports and the production, the export and the consumption of energy resources are based on the standardized values for them to be commensurate in the form: Value indicators (GDP, investment volume), physical indicators (production, consumption, exports, imports), index numbers (the innovation technology adoption index, the price and devaluation index numbers), and structural indicators (employment rate) (Anysz et al., 2016). The use of indicators of different dimensions is conditioned by the following:

1. The use of all index numbers is possible when studying the dynamics of a certain process. Since the goal of the research is to find a favorable ratio, the use of exclusively index numbers in the modeling process will not determine the balance between the export and the production, the export and the consumption of energy resources. At the same time, index numbers are necessary to identify the response of the energy exports to the price and the exchange rate behaviors, since the exports change with price-level changes;
2. To determine the balance of energy resources, physical indicators are needed: Production, consumption, exports, and imports. The

Table 3: Regression model of energy production in the RF, taking into account the production factors

Energy resources category	Dependence function
Oil and oil products	$P_o=0.04*I_{o,g})+0.81*Emp+0.33*It$ (15)
Natural gas	$P_g=0.71*I_{o,g}+0.64*Emp+0.28*It$ (16)

P_o is production of oil and oil products, P_g is production of natural gas, $I_{o,g}$ is investment in fixed assets aimed at reconstruction and modernization (the oil and gas production industry), *Emp* is employment rate; *I* is the innovation technology adoption index (the oil and gas production industry)

Table 4: Regression model of energy resources export in Russia given the price factors

Energy resources category	Dependence function
Oil and oil products	$Expo=0.10*I_d+0.23*IP_o$ (17)
Natural gas	$Expg=0.22*I_d+0.31*IP_g$ (18)

Exp_o is exports of oil and oil products, Exp_g is exports of natural gas, I_d is the national currency devaluation index, IP_o is the free market oil price index (Brent Crude), IPg is the free market natural gas price index

Table 5: Regression models of energy consumption given the energy intensity factor of the Russian economy

Energy resources category	Dependence function
Oil and oil products	$C_o=0.24*GEI$ (19)
Natural gas	$C_g=0.37*GEI$ (20)

C_o is consumption of oil and oil products; C_g is consumption of natural gas; GEI is the global energy intensity index (total energy consumption per unit of GDP). GDP: Gross domestic product

use of value indicators in this case would not reflect the resource balance, since these indicators take into account different price levels: The domestic energy prices for consumption and production, international prices for exports and imports;
3. Out of the structural indicators, the employment rate is used, since this indicator characterizes the availability of labor resources, as well as the GDP gap (the deviation of the actual GDP from the potential one to show the amount of the GDP underproduction as a result of unemployment).

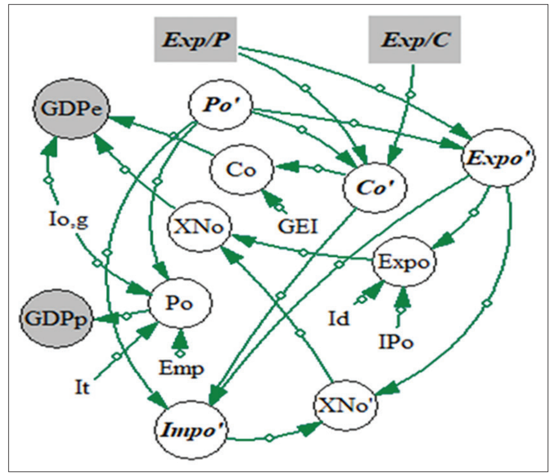
Standardized indicator values are calculated by equation (4).

To create a favorable ratio between the exports and the production, the exports and the consumption of energy resources that would maximize the GDP and enhance the energy export policy effectiveness, simulation modeling (equation 6) was used in the research. Its advantages are the ability to reflect the fundamental properties of a real-world process or phenomenon. The use of simulation modeling makes it possible to track and analyze the system behavior - A change in the resulting indicators when the control parameters are changed (Wu et al., 2018). Vensim Software was used for simulation modeling.

The parameters of the export to production ($\frac{Exp}{P}$) and the export to consumption ($\frac{Exp}{C}$) ratio are the control parameters of the simulation model for ensuring the energy export policy effectiveness; the resulting parameters are the GDP calculated by the production method (GDP_p) and the GDP calculated by the expenditure method (GDP_e). To build a simulation model, the control and resulting indicators must be interrelated through a system of functions. For this, the energy balance indicators were expressed through $\frac{Exp}{P}$ and $\frac{Exp}{C}$ (equations 21–23):

$$C' = Exp' \div \frac{Exp'}{C'}; \quad (21)$$

Figure 5: Simulation model for determining optimal values of Russia's energy balance to maximize the GDP



(grey ellipse) is resulting indicators;
(grey rectangle) is control parameters of the model;
GDP_p is the GDP calculated by the production method;
GDP_e is the GDP calculated by the expenditure method;
$\frac{Exp}{C}$ is the indicator of the ratio of oil and oil product exports to consumption;
$\frac{Exp}{P}$ is the indicator of the ratio of oil and oil product exports to production (extraction);
P_o' is the production (extraction) of oil;
C_o' is the consumption of oil and oil products;
Exp_o' is the export of oil and oil products;
Imp_o' is the import of oil and oil products;
XN_o' is the net exports of oil and oil products;
P_0 is standardized values of the production of oil and oil products;
C_0 is standardized values of the consumption of oil and oil products;
Exp_0 is standardized values of the exports of oil and oil products;
Imp_o is standardized values of the imports of oil and oil products;
XN_o is standardized values of the net exports of oil and oil products;
I_d is the national currency devaluation index;
IP_o is the free market price index (Brent Crude);
$I_{o,g}$ is the investment in fixed assets aimed at reconstruction and modernization;
I_t is the innovative technology adoption index;
Emp is the employment rate;
GEI is the global energy intensity index.

$$Exp' = \frac{Exp'}{P'} * P' \quad (22)$$

$$C' = \frac{Exp'}{P'} * P' \div \frac{Exp'}{C'} \quad (23)$$

A visual representation of the simulation model for balancing the oil and oil product market is shown in Figure 5. The model aimed at striking the balance in the natural gas market has an identical structure with the respective indicators for natural gas.

The following were used as elements of the simulation model: The control parameters $(\frac{Exp}{P}, \frac{Exp}{C})$ the energy balance indicators - production of oil and oil products $(P_o^{'})$, consumption $(C_o^{'})$, exports $(Exp_o^{'})$ imports $(IMp_o^{'})$; the resulting indicators (GDP_p, GDP_e); the factors affecting the energy balance indicators and included in the GDP calculation: $XN_o^{'}$, I_d, IP_o, I_t, Emp.

Since the energy balance is determined by the absolute indicators ($P_o^{'}, C_o^{'}, Exp_o^{'}, Imp_o^{'}$), and the regression models of the connection between the indicators are built on the basis of standardized values, the standardized balance indicator values (P_o, Co, Exp_o, Imp_o) were also used as elements of the simulation model. These indicator values are necessary for a transition from the control parameters to the indicators forming the basis for the regression model (11)–(20) development.

All the simulation model elements (Figure 5) are connected to each other through a system of dependences (equations 1, 11–23). The independent variable of the model is at the basis of the arrow, while the dependent one is at the vertex; the arrow points to the indicator influence directions.

To build a basic simulation model, the values of the indicators that are the model elements of 2017 were taken. The model principle is to find such values of the control parameters of the energy balance, whereby the GDP maximum value would be reached.

Subsequent to the experiments with the simulation model for balancing the oil, oil product, and natural gas market, optimal values of the ratio of the exports to the production and the exports to the domestic consumption of energy resources were determined (Table 6).

According to the simulation model calculations, it was revealed that the values of the ratio of the export and production volumes at the level of (0.77–0.80), as well as of the exports and consumption (3.5–3.7) contributed to the GDP maximization for the oil and oil product market; and for the natural gas market, they were (0.36–0.38) and (0.57–0.60), respectively. The actual values reflect the average values of the respective indicators in 2008–2017.

5. DISCUSSION

Based on the empirical research, it may be concluded that in order to improve the effectiveness of Russia's energy policy under the given conditions for the energy industry performance and the global energy market trends, it is advisable to increase the ratio of the export to production volumes from 0.74 to 0.77–0.80 for oil and from 0.31 to 0.36–0.38 for gas. For the ratio of the export to consumption volumes of hydrocarbons, it is advisable to increase it from 2.75 to 3.5–3.7 for oil and from 0.44 to 0.57–0.60 for gas.

The expediency of observing optimal ratios of the exports and production, the exports and consumption is estimated by performance indicators. The principle of calculating performance indicators is to compare the GDP at the actual values of $\frac{Exp}{P}, \frac{Exp}{C}$ and at the optimal values. The actual GDP is calculated by plugging in the simulation model the predicted values of the energy production volumes and the actual values of the $\frac{Exp}{P}$ and $\frac{Exp}{C}$ indicators. The optimal GDP is calculated for the lower and upper limits of the optimal values of by plugging them in the simulation model (Figure 5).

The calculations used the predicted values of the production volumes. This indicator formed the prediction basis, since exports and imports depend on production. Production is the upper limit for possible volumes.

Effectiveness is calculated as the arithmetic mean value of the ratio of the optimal to actual GDP for the period 2018–2022.

To ensure a reliable prediction, the values of oil and gas production volumes in 1985–2017 were used (BP Statistical Review of World Energy, 2018). The predicted indicators were obtained using the technology of neural networks (equations 7–8). Neural networks can be used to model relationships between the indicators of different degrees of complexity expressed through linear, logistic, hyperbolic, exponential, sinusoidal, and step functions (Wang et al., 2018). Therefore, this prediction tool promotes the highest accuracy and reliability.

To calculate the predicted values of oil production in Russia for 2018–2022, the neural networks of a multilayer perceptron class with 2, 3, and 6 hidden neurons were used: MLP 1–2–1, MLP 1–3–1, MLP 1–6–1; production of natural gas - MLP 1–2–1, MLP 1–4–1, MLP 1–7–1, respectively. The use of these neural network types is contingent on their highest performance (>0.98) and the lowest error level: Training <0.04, test <0.07, control <0.09.

The average predicted values of the energy production in Russia for the next 5 years, obtained with the use of neural networks are given in Table 7.

In 2018, the oil production is projected to increase by 3%. With a production change of + 3%, in order to achieve optimal ratios of the exports and the production, the exports and the consumption,

Table 6: Actual and optimal values of indicators of the ratio of the exports to the production and the exports to the consumption of energy resources

Energy resources category	Ratio of exports and production		Ratio of exports and consumption	
	Actual value	Optimal value	Actual value	Optimal value
Oil and oil products	0.74	0.77–0.80	2.75	3.5–3.7
Natural gas	0.31	0.36–0.38	0.44	0.57–0.60

Table 7: Predicted volumes of the energy production for 2018–2022 in the context of Russia's energy export policy optimization

Energy resources category	Predicted values				
	2018	2019	2020	2021	2022
Oil and oil products, million tons	569.5	585.0	617.5	643.9	762.6
Natural gas, billion cub. m	639.4	639.7	640.7	641.7	644.9

the consumption standard should decrease by 16%, while the exports should increase by 7% in 2018.

In the natural gas market in 2018, the production will increase by 1%. At the same time, the consumption should decrease by 10%, while the exports should increase by 17%.

The volume of oil and gas imports should remain approximately at the level of 2017 in order to maintain the energy balance.

With these changes in the consumption volumes and the GDP growth of 2.3% for the oil and oil product market, according to the calculation of performance indicators, the GDP energy intensity will decrease by 18%. For the natural gas market, with the GDP increasing by 1.1% and the consumption reduced by 10%, the energy intensity levels will decrease by 11%.

Also, the energy balance in the country and the contemporary energy export policy effectiveness will be facilitated by implementation of the following package plan in a number of areas.

The energy intensity of the Russian economy can be reduced by:
- Development and implementation of an energy management system aimed at improving the energy performance in various economic sectors;
- Creation of modern innovative infrastructure of the fuel and energy complex, whereby oil pipelines would be modernized, the well performance mode would be optimized, the coefficient of process losses of oil upon the extraction would be reduced, the efficiency of deep oil processing would enhance, which would improve the quality of energy resources, reduce gas consumption for technological needs and for its processing, generation equipment with the performance coefficient of no <60% would be introduced, etc.;
- Modernizing and engineering the process of manufacturing in-house specialized equipment for the exploration, development, and production of hydrocarbons, which would significantly reduce the dependency on imports;
- Creation of domestic technologies aimed at the development of the Arctic hydrocarbon resources;
- Construction of traffic systems, main oil and gas pipelines, seaports, oil transshipment terminals, LNG terminals on a new technical basis, creation of belt and scraper conveyors with a digital control system for transportation of minerals, etc. Construction of pipelines to ensure delivery of energy resources to China and India;

  To reduce the resource dependence of the Russian economy, the priority areas should be the following:
- To take the oil production to the state of a managed recession that would meet the domestic economic needs and eventually exclude the exports of crude oil completely;
- A shift in the development priority from the oil industry into gas production and oil refining;
- Active development of non-hydrocarbon, alternative, and renewable energy, as well as local energy resources, etc.;
- An effective fiscal policy that would ensure such an amount of oil and gas short that could be financed in the long run from the oil and gas revenues with their optimal distribution in time and with a stable trajectory of the net public debt;
- Systematic system analysis and forecasting of trends in the development of global energy markets to be able to craft and timely adjust the economic development strategy for oil and gas fields, including with the world oil market price levels, the EU's energy saving programs, and a revival of shale gas production in North America, etc.

6. CONCLUSION

Solving the scientific research problems, the authors arrived at the following conclusions:
1. In the current context, the major destructive factors in Russia's energy export potential and energy balance, according to the study, are the following: The resource dependence and the high energy intensity of the national economy; deterioration in the oil production quality; the EU and the US sanctions to limit the transfer of Western technologies and equipment for exploration and development of new gas and oil fields in Russia; the absence of a branched main pipeline network for hydrocarbon transportation. The influence of these factors determines the effectiveness of the country's energy export policy by flexibly regulating the hydrocarbon exports, in particular, the oil and gas exports.
2. Based on simulation modeling, taking into account the factors of the current economic situation in Russia and the development trends in the world energy market, the optimal values of the ratio of the oil and gas export to the production and the consumption volumes were empirically determined. The indicator of the ratio of the export to production volume should increase from 0.74 to 0.77–0.80 for oil and from 0.31 to 0.36–0.38 for gas. For the indicator of the ratio of the hydrocarbon export to the consumption volume, it is advisable to increase it from 2.75 to 3.5–3.7 for oil and from 0.44 to 0.57–0.60 for gas. Provided that the optimal proportions are observed, the GDP growth of 2.3% is possible and the energy intensity of the Russian economy can be reduced by 18% for the oil market. With the increase in GDP by 1.1%, the decrease in energy intensity will be 11% for the gas market.
3. Possible ways of reducing the energy intensity and resource dependence of the Russian economy have been proposed. These measures, together with the proposed optimal values of the ratio of the exports to the production and the consumption of energy resources (oil and gas) will lay the

theoretical groundwork for increasing the effectiveness and target orientation of Russia's energy export policy. They will contribute to the stability of the country's energy security and accelerate the economic growth.

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