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Estimation of the Influence of Different Factors on the Change of the Energy Intensity of Russian Economy under the Sanction Pressure

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Abstract: The influence of various factors on the energy intensity of the gross domestic product in the context of the ongoing Western countries sanction pressure has been studied. It has allowed to identify the factors that have a decisive impact on the energy intensity value. The research made it possible to reveal that the change in the energy efficiency of the economy is mostly under the influence of the activation of innovative activity of Russian corporations as the result of the increased funding of their R&D activity and the growth of the final consumption of electric energy by households inside the country. On the basis of the economic and mathematic modeling of the influence of different factors on the change in the energy intensity of Russian economy, the estimation of possible consequences of the continuing Western countries sanction pressure on the dynamics of the energy efficiency of Russian economy.

Key words: Economic and mathematical modeling, scenario approach, energy intensity, sanctions, growth, estimation

INTRODUCTION

The decrease of energy intensity of national economies and the increase of their energy efficiency is one of the major development tasks in almost all countries of the world. The urgent character of its solution is reasoned by the lack of non-renewable energy resources and the necessity to provide national producers with competitive advantages on the basis of the most effective utilization of energy resources (Javied *et al*., 2015; Melnik *et al*., 2015; Moreno *et al*., 2014; Vikhorev *et al*., 2013). To estimate energy efficiency different indicators are used. They include the energy intensity of Gross Domestic Product (GDP), the relation of the economy growth rates to the energy consumption growth rates, the efficiency of utilization of separate kinds of energy resources (Bougain *et al*., 2015; Phylipsen *et al*., 1997; Sadriev *et al*., 2015) and the integral indexes, allowing to take into account the quality side of energy supply and energy consumption processes (Ahmad and Dhafr, 2002; May *et al*., 2015; GWEC., 2016).

Now a days, according to the level of the energy intensity of gross domestic product, Russia is related to a group of countries with the highest value of this indicator. Analysing the information, presented in Fig. 1, the following conclusion can be made. The four countries of the world including Russia, Ukraine, Ethiopia and Iceland have the biggest size of the energy intensity of GDP. In this case the following fact should be taken into account: while explaining the reasons, influencing the given situation, that are common for all these countries, their geographical position, the size of their territory, climatic peculiarities and other rather obvious characteristics that are traditionally considered in such cases cannot be used to make possible comparison.

In this situation it is possible to presuppose that the size of the energy intensity of GDP in each country is formed under the influence of different factors, determining the peculiarities of their functioning on a certain stage of its development. However, in any case, their influence appears either through the changes in the level of energy consumption in each country or through the changes in the volume of their gross product (Sadriev, 2014). All these facts refer to the conditions of the functioning of each country including Russia with the results of the activity being under the significant influence of the Western countries sanctions.

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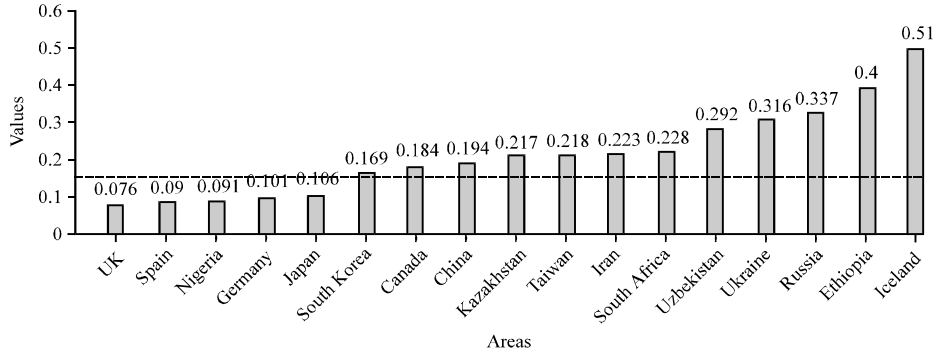

Fig. 1: Energy intensity of GDP (koe/$2005p), 2015 (made according to the information (GESY., 2016)) dotted line shows the size of the energy intensity of GDP, average in the world in 2015)

MATERIALS AND METHODS

To achieve the goal of the research, the economic and mathematical model, reflecting the dependence of Russian economy energy intensity on changes of different factors has been worked out. In its development the method of correlation and regression analysis which is broadly applied to reveal the interconnections between different economic occurrences and processes has been used (Alexeev and Weber, 2013; Isard, 1966). To build the economic and mathematical model, the official statistics information, reflecting the social and economic development of Russia in the period from 2000-2015 has been examined (MF., 2016). The utilized information satisfies the requirements for compatibility, completeness, homogeneity and sustainability of dynamic series. The study of the dynamics of change of indicators included in the economic and mathematical model that is developed was based on the scenario approach. Its utilization made it possible to estimate the size of Russian economy energy intensity under different scenarios of continuing Western countries sanction pressure. On the basis of the given modeling under different scenarios of Russian economy development, conditions that are necessary to keep its energy efficiency on 2015 year level in the case of the prolongation of external economic sanctions have been determined.

Main part: Figure 2 presents the dynamics of the Russian GDP energy intensity from 2000-2015. Analysing the changes that took place, the following conclusion can be made. The period of time, since, 2000-2008 is characterized by the positive dynamics that is accompanied by the decrease of the size of this indicator. The further analysis of the information, presented on Fig. 2, allows to state that the 2008-2009 financial crisis led to the troubles in the GDP energy intensity decrease that took place before. In the next years the dynamics of this indicator can be characterized as weakly volatile measured nearly 0.330-0.340 koe/$GDP.

However, the strengthening of the Western countries sanction pressure on Russia is able to worsen the situation that takes place in the sphere of energy efficiency. The background of this development scenario appears also through the decrease in the GDP volume. Thus, for example, from the point of view of analysts, the sanction regime decreases Russian GDP by 0.8-1% per year (Gros and Mustilli, 2015; Okhotsky, 2016). So, in the nearest future the worsening in the dynamics of the GDP energy intensity can be expected, taking into account the persistence in the current volumes of energy resources consumption under the decreasing GDP size.

All the facts, stated that can be considered as the background of the necessity to carry out the research, directed at revealing of the facts, influencing the size of the Russian GDP energy intensity in the conditions of further strengthening of the sanction pressure from the part of Western countries. With this object in mind, we have analysed more than 40 indicators, reflecting the influence of various factors on the Russian economy energy intensity. Official statistics information, covering Russian social and economic development in the period from 2000-2015 was used for this purpose. The calculation of the coefficients of the correlation between the chosen indicators and the GDP energy intensity made it possible to choose only the indicators with which the strong correlation dependence was stated, out of the whole complex (Table 1).

The results of the calculation showed that the energy intensity of the Russian GDP has the highest correlation dependence (>0.9) on a number of indicators including the size of the national revenue per capita, the share of the international export in GDP, the size of the inner R&D expenses, the share of R&D researchers per 1 mln. people,

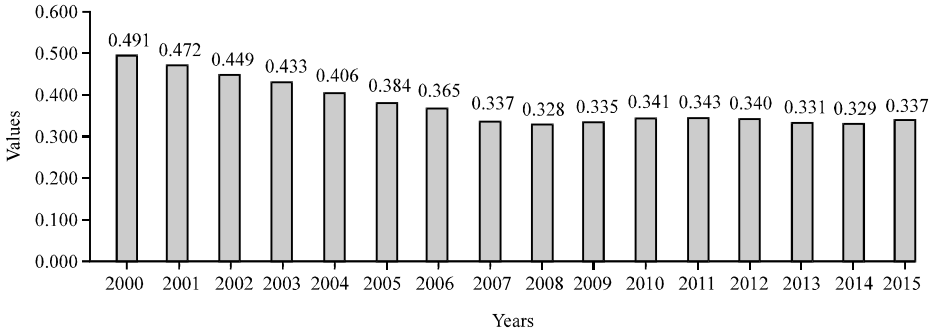

Fig. 2: The dynamics of energy intensity of Russian GDP, GDP energy intensity, koe/1$GDP in 2005 prices (made according to the information (FFSSS., 2016)

Table 1: Value of coefficients of the correlation between different indicators and GDP energy intensity*

Name of an indicator	Unit of measurement	Specification	Correlation coefficient
National revenue per capita	$	X1	-0.92494
Share of the international export in GDP	%	X2	0.91110
Inner R&D expenses	mln.$	X3	-0.93144
Share of R&D researchers per 1 mln. people	%	X4	0.97715
Quantity of advanced production technologies that are used	pcs.	X5	-0.97528
Russian trade balance	bln.$	X6	-0.88654
Foreign trade turnover	mln.$	X7	-0.78340
Export	mln.$	X8	-0.82100
Import	mln.$	X9	0.67240
Share of the international import in GDP	%	X10	0.76280
Foreign investment	mln $	X13	-0.79426
Direct foreign investment	bln.$	X16	-0.87830
Final consumption of electrical energy by households	kWh	X26	0.75010

*Worked out by the researchers

the quantity of advanced production technologies that are used, the employment in all spheres of activity and some others.

The further research of the degree of their influence on the GDP energy intensity demanded to carry out the analysis of possible multicollinear dependence. Its results and the final choice of indicators made it possible to build a model of influence of different indicators on the Russian GDP energy intensity (Y). This model included the size of the inner R&D expenses (X_3) and the size of the final consumption of electrical energy by households (X_{26}):

$$Y = 0.463-0.0092X_3+0.001492X_{26} \quad (1)$$

The determination coefficient $R^2 = 0.9613$ shows that the variation of the resultant indicator (Y) is explained by the dependence on the factor attributes X_3 and X_{26} by 96.13%. The statistics importance of the received equation is proved by the Fisher's ratio test F = 136.9, the value of which is higher than critical ($F_{crit} = 3.98$).

RESULTS AND DISCUSSION

The analysis of the received results proves that the size of the Russian GDP energy intensity is under the strongest influence of the factors of innovation development of the country which appear, first of all, through the changes in the inner R&D expenses. The calculated coefficient of elasticity shows that under 1% increase of their size the expected energy intensity decrease will be 0.72%. The received results specify the prior directions of the Russian economy development which can lead to the real changes in the sphere of its energy efficiency.

However, the situation is complicated because of the continuing Western countries sanction pressure, accompanied by the prohibition imposed on the new technologies import to Russia. Correspondingly, in case of the Western sanction prolongation the further reduction in the number of Western advanced technologies that are used should be expected. So, it is not incidental that the majority of analysts see the threat, coming from the sanctions in the possible limitation of new technologies transmission.

It should be noted that the tendency to reduce the procurement of new technologies became apparent before the worsening of relations with Western countries in 2011 and 2012. When the dynamics of the changes in the number of advanced technologies that are used is analysed, it is possible to note that in 2010 its increment

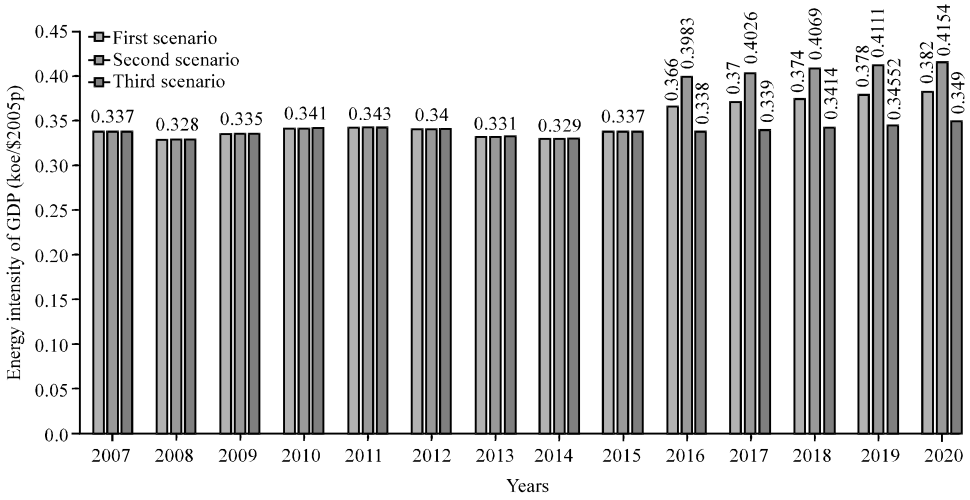

Fig. 3: The dynamics of the change of the Russian GDP energy intensity according to three scenarios of the situation development (worked out by the researchers)

in relation to that of the previous year is 0.8%. In 2011 and 2012, the 6% decrease of the given indicator was observed. In 2014, its size exceeded the similar 2010 measure only by 0.59%. In the given conditions the most important direction of the development of the country is the increase of inner expenses on the financing of domestic researches. So, it is not incidental that measures and programmes of imports phase-out, realized nowadays at different levels of domestic economy direction, are aimed at giving a new impulse for developing Russian advanced technologies in different areas and spheres of activity. The analysis of statistical information for a number of years that was carried out showed that the unstable dynamics of its changes is also characteristic for this indicator. Indeed in 2010 and 2011 its size decreased by 6% annually and in the next 2 years the retrieval only to the level, achieved in 2009 was observed (FFSSS., 2016). However, it is rather obvious that the changes in the situation that takes place nowadays are impossible without the serious increase in the financing of the advanced Russian scientific and technical researches.

The second indicator, entering the developed model is the final consumption of electrical energy by households. The calculated elasticity coefficient shows that its 1% increase is expected to result in 0.51% decrease of energy intensity. It should be noted that for the last years the dynamics of the indicator of electrical energy consumption in households has had a tendency to increase in a stable way, influencing greatly the size of the GDP energy intensity. So, the solution of the problem of Russian economy energy efficiency increase presupposes the necessity to research out a complex of measures directed at the stimulation of energy saving in households.

To model the dynamics of energy intensity of Russian economy three possible scenarios up to 2020 should be examined. With regard to the above mentioned, the following assumptions should be taken into account. Firstly, when the consumption of electrical energy by households is forecasted, its dynamics will be extrapolated in all the three scenarios on the level of the development tendencies that appeared in the previous years. Such approach is explained by the fact that the size of the change of this indicator does not depend on economic and political sanctions. So, the analysis that was made showed that since 2007 the steady growth averagely by 3% annually has been noticed in the dynamics of the changes of the quantity of electrical energy consumption by households. Secondly, possible consequences of the sanction pressure influence can be estimated through the change of the inner R&D expenses.

The first (basic) scenario of the change of the inner R&D expenses will be build on the basis of the hypothesis of the conservation of the existing trend. The second (pessimistic) scenario will take into account their possible annual 10% decrease under the influence of the continuing sanction pressure. The third (optimistic) scenario will be build on the basis of the hypothesis of the lessening of the sanction pressure on the Russian economy and the possible 10% increase of the inner R&D expenses.

Figure 3 presents the dynamics of the change of GDP energy intensity according to three scenarios of the situation development, built with the accordance of the dependences, revealed by the model that was worked out. The analysis of the information, presented on Fig. 3, makes it possible to assume that in all the three scenarios of the development the situation in the sphere of

energy efficiency will worsen. With regard to the above mentioned, the increase of the GDP energy intensity by 2020, compared to 2015 will be from 3.56% according to the third (optimistic) scenario up to 23.26% according to the second (pessimistic) scenario. In this case the prolongation of the economic sanctions according to the second development scenario will result in the largest increase of the GDP energy intensity, under which its size will decrease up to the level which existed 10-15 years ago. The situation development according to the third scenario is able to slow down the GDP energy intensity decrease a little. However, based on the calculations, that were made, even the 10% increase of the annual R&D expenses aimed at the increase of the innovation activity of enterprises that can be considered according to the optimistic situation development scenario is unable to increase the energy efficiency of the economy of the country. All these facts presuppose the necessity to spend more large-scale expenses to solve the arising problems.

When the reverse problem of the research was solved, the minimum annual accession in the size of the inner R&D expenses, under which it is possible to keep the size of the GDP energy intensity on the 2015 year level under the prolongation of economic sanctions against Russia was identified. According to the researcher's calculations, the minimum annual accession in the size of the inner R&D expenses should be 11.35% in 2017, 12.5% in 2018, 13.6% in 2019 and 14.75% in 2020.

CONCLUSION

The main results of the given research are the following. Firstly, when the economic and mathematical model of the influence of different factors on the size of the GDP energy intensity was built, a whole range of indicators, reflecting different aspects of the development of Russian economy were examined. As the result of the selection and elimination of the multicollinear dependence, 2 indicators, influencing greatly the size of the GDP energy intensity, entered the model that was developed. They are the size of inner R&D expenses and final consumption of electrical energy by households.

Secondly, on the basis of modelling possible changes in the energy efficiency of the economy of Russia under the different scenarios of the continuing sanction pressure on Russia from the part of Western countries were examined. It allowed to state that under all the three development scenarios that were examined, the situation in the sphere of energy efficiency will continue to worsen. Under this the increase of the GDP energy intensity by 2020, compared to 2015 will be from 3.56%, according to the optimistic scenario, up to 23.26%, according to the pessimistic scenario.

Thirdly, it was stated that the prior direction of the increase of the energy intensity of the economy of Russia is the increase of the innovation activity of domestic producers that presupposes the increase in the volumes of financing of innovation activities on different levels of the economy direction. The results of the calculations allowed to determine that to keep the size of the GDP energy intensity on the 2015 level under the prolongation of economic sanctions against Russia the minimum annual accession in the size of the inner R&D expenses should be 11.35% in 2017, 12.5% in 2018, 13.6% in 2019 and 14.75% in 2020.

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