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FEATURES OF INNOVATIVE AND TECHNOLOGICAL DEVELOPMENT OF RUSSIA IN THE SYSTEM OF THE FORMED TENDENCIES OF DEVELOPMENT OF THE HIGHER SCHOOL

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Abstract. The publication was prepared within the framework of the scientific project No. 16-06-00062 supported by the Russian Foundation for Basic Research.
The object of research is the innovative and technological development of national economy in the system of transforming mechanisms of development of the higher education. The subject of study are the mechanisms and methods of state regulation that form the basis for an efficient and adapted (to the emerging business environment) innovative and technological development of the national economy. We paid particular attention to the issues of econometric modeling, which justifies the dependence of innovation and technological development on a group of factors (number of higher educational institutions, number of patents granted, receipt of foreign investment for research and development; science funding from the federal budget; number of personnel engaged in research and development; number of organizations that have carried out research and development), which form the potential for intensifying the research and development followed by their commercialization.
The authors, based on the methods of econometric analysis, consider and analyze the key factors that affect the parameters of innovative and technological development of Russia. We have paid particular attention to determining the role of higher school in the process of creating advanced production technologies in the national economy, to highlighting key problems and directions of development that promote the innovative development of the national economy in the transforming environment.

Key words: innovative and technological development, higher school, interuniversity cooperation, innovative economy, multifactor analysis, measures of state regulation.

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1. INTRODUCTION

The innovative and technological development of national economy is a complex, multidimensional process of interaction of heterogeneous systems. Some of them have an obvious nature, while the other part has an implicit nature expressed in the system of organization and generation of mechanisms for stimulating and commercializing the innovations. At the same time, the latter is a multidimensional complex of administrative influences in the field of activation of the mechanisms under consideration, the measurement of the evaluation effectiveness of which is a very non-trivial procedure.

One of the most important mechanisms in the sphere of innovative and technological development of the national economy is the integration of higher education institutions into the system of scientific developments and their subsequent commercialization (Guerrero, Urbano, 2010). Unfortunately, it should be noted that these mechanisms require their significant development and activation in the Russian Federation at the moment. In accordance with the existing approaches to assessing the commercialization of R&D in the higher education system applied by the international and Russian rating agencies, the leading Russian higher educational institutions of the Russian Federation lag significantly behind their competitors abroad (Guerrero, Urbano, 2010) (*Report of the Company "Shanghai Ranking Consultancy"*, 2016) (QS Top universities, 2016) (Times Higher Education World University Rankings, 2016) (*Monitoring the Effectiveness of Innovation Activities of Russian Higher Educational Institutions*, 2016) (The Global Entrepreneurial University Metrics initiative, 2016). This lag formed a whole range of risks, expressed not only in the loss of competitiveness of the Russian higher school in the world market, but also in the growth of structural gaps in the national economy, which were escalated in 2012-2013 when the most acute signs of structural distortions appeared in the economy, expressed first of all, in the insufficient level of conformity of the productive forces with the growing process of changing the technological order in the world economy (a transition from the fifth technological order (dated from 1970-1980 to 2015-2020) to the sixth one based on the mechanisms for the development of ultra-high-speed digital telecommunications: creation of modern structural materials obtained with the help of nanotechnologies and technologies of a different level; creation of medical high-precision technologies; creation of clean energy technologies; creation of new synthetic materials and corresponding innovative technologies of nano- and micro-level; design and creation of flexible production systems, robotics of a wide range and purpose; creation of modern management technologies, etc.).

It should be noted that, despite the set of mechanisms and tools for process intensification aimed at integrating innovations into the system of macroeconomic generations implemented by the state, the share of science-intensive products was only 7.9% of the total volume of goods shipped, works performed and services rendered in the Russian Federation in 2015 (Rosstat, 2016), while the value of this indicator reached 70% in the USA, 65% - in the European countries and 40% - in China. At the same time, the current growth dynamics of the indicator under consideration (an increase of about 3 percentage points in the past five years) is clearly insufficient in Russia to change the paradigm of economic development, which requires the search and scientific justification of tools that facilitate the activation of the processes under consideration.

One of the main reasons for Russia's innovative and technological lag is the outdated model of approach to the higher education, where, in many ways, the higher educational institutions are assigned only a "service", infrastructural role in the socio-economic development. In fact, higher education in Russia lives in an industrial culture of the middle XX century, since the vast majority of higher educational institutions work exclusively as educational institutions that supply employees for the needs of national economy.

2. METHODS

The proposed assumptions, characterizing the features of innovative and technological development of the Russian Federation, may be confirmed by a multi-factorial analysis that reveals the peculiarities of influence of a set of parameters on the number of advanced production technologies created. Essentially, the econometric calculations implemented in the work enable us to identify the logic of innovative development of the Russian economy, including, taking into account the specifics of the development of such an important component of it as a higher school. We selected the indicator "The number of advanced production technologies created" as an indicator, having result in the model. This indicator in a concentrated form

reveals the effectiveness of functioning of the higher educational institutions that form the basis of innovative and technological development of the national economy.

To identify the factors that affect the number of advanced manufacturing technologies created, we designed a multi-factor regression model.

As a result of the complex analysis, we selected several factors to determine the degree of their influence on the resulting feature, namely:

X1 – number of higher education organizations, units;

X2 – number of patents granted, units;

X3 – foreign investment in research and development, mln. US dollars;

X4 – science funding from the federal budget, mln. roubles;

X5 – number of personnel engaged in research and development, ths. people;

X6 – number of organizations that have carried out research and development, units.

3. RESULTS

Selection of factors at the next stage of study begins with the identification of factors closely related to each other. If there are such links between the factor characteristics, one or more of them should be eliminated in such a way that there are no close links between the remaining factors (at that, the correlation ratio between the resulting sign Y and the factors should be high). This procedure enables us to avoid the negative effects of multicollinearity (Table 1). In the presence of multicollinearity, the accuracy of estimates of regression parameters decreases; hence we probably have an incorrect introduction of some variables into the analysis; the sensitivity of regression ratios to the peculiarities of the initial data increases sharply.

Table 1. Matrix of Pairwise Correlation Ratios

	Y	**X1**	**X2**	**X3**	**x4**	**X5**	**X6**
Y - advanced technologies created	1	-0.65	0.75	0.59	0.95	-0.73	-0.02
X1 – number of higher education organizations	-0.65	1	0.04	-0.13	-0.3	-0.34	-0.58
X2 – number of patents granted	0.75	0.04	1	0.21	0.88	-0.94	-0.47
X3 – foreign investment	0.59	-0.13	0.21	1	0.53	-0.4	0.45
X4 – science funding from the federal budget	0.95	-0.3	0.88	0.53	1	-0.9	0.78
X5 – number of personnel engaged in research and development	-0.73	-0.34	-0.94	-0.4	-0.9	1	-0.24
X6 – number of organizations that have carried out research and development	-0.02	-0.58	-0.47	0.45	0.78	-0.24	1

As a result of assessment implementation aimed at identifying the statistically significant factors (adequate) of the regression model, the number of higher education institutions, the number of patents granted and the receipt of foreign investments have been chosen as predictors, since these factors have the greatest impact on the resulting feature and have the least mutual correlation.

As a result of calculations, we obtained a regression model:

$$Y = 3093{,}5 - 2{,}97 \times X_1 + 0{,}03 \times X_2 + 0{,}765X_3$$

The non-random nature of the obtained values of regression ratios is indicated by the calculated values of the t-criterion, which have turned out to be more modular than its table value $t_{table} = 2{,}14$ (Table 3).

Table 2. Regression model statistics

Regression statistics	
Multiple R	0.945554104
R-square	0.894072564
The normalized R-square	0.848675092
Standard error	103.5399285
Observations	16

Table 3. Ratio values and their statistical significance

	Ratios	t-statistics
Y	3093.491377	3.93614763
X 1	-2.965677981	-4.224890087
X 2	0.032198144	4.248543291
X 3	0.765619553	3.213791872

The obtained results of calculations confirm in many respects the earlier estimates made by us regarding the features and factors that have developed in the Russian economy, which determine the innovation and technological development. For example, it is noteworthy that the indicator with a factor that estimates the impact of changes in the number of higher education institutions takes a negative value. This shows that the growth in the number of higher education institutions in Russia does not contribute to the activation of processes in the area of building up the advanced production technologies used in the creation of gross domestic product (the numerical value of the indicator with X1 factor is negative). The quantitative increase of the higher educational institutions contributes only to the implementation of the "University 1.0" model, which does not promote the activation of scientific and research processes, their commercialization, with the subsequent creation and replication in the markets of science-intensive products.

4. CONCLUSIONS

The hypotheses put forward and the estimates obtained may be confirmed by the observed period of active quantitative increase in the number of higher educational institutions in Russia in the period under review from 2000 to 2008. There were processes that were not characterized by the orientation of the higher education system for the intensification of scientific researches and their commercialization. On the contrary, it can be argued that the stagnating processes in the area of innovative and technological development took place during the period under consideration (Figure 1).

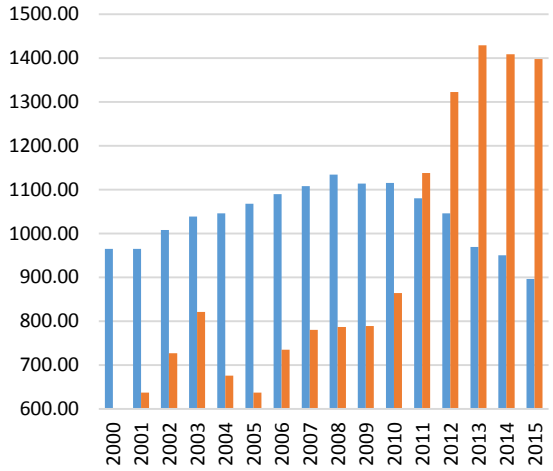

Figure 1. The ratio of the number of higher educational institutions and the number of advanced production technologies (units)

It would seem that an increase in the number of higher educational institutions should form an effect of scale, expressed, among other things, in building up the infrastructure, scientific and research, human and other kinds of potentials that contribute to the activation of innovation and technological development. However, it should be noted that the opposite happened in the modern history of Russia until 2008-2010 - as the number of universities increased, the innovative and technological activity decreased. This phenomenon can be explained on the basis of the formed logic of development of the higher education system in Russia in this period of time, oriented not primarily to the generation of scientific and technological breakthroughs and their commercialization, triggering mechanisms for changing the technological structures, but to the implementation of a diverse range of educational services. In other words, it can be argued that at that time the Russian higher education system was characterized by an outdated, inefficient model, where, in many ways, the higher educational institutions were assigned only a "service", infrastructural role in the socio-economic development (Safiullin, Safiullin & Safiullin, 2013).

Thus, returning to the results of econometric modeling, it is necessary to emphasize once again that the innovative and technological development generation institutions that have emerged in the Russian economy require their further development and improvement. Thus, in particular, it is necessary to reformat the development model of higher school from quantitative to qualitative, which, strictly

speaking, has been observed in recent years (there has been a quantitative decline in the number of universities in Russia in the period from 2009 to the present time). The growth of universities in Russia does not contribute to solving the problems of innovative development, the higher educational institutions do not become the basis for technological breakthroughs, and their quantitative growth leads to a decrease in the innovative potential of the economy on the contrary. This is convincingly evidenced by the results of econometric calculations implemented in the present study. An extremely topical issue at the current time is the definition of mechanisms for consolidation and cooperation of the system of higher educational institutions, since, in all likelihood, it is precisely this strategic vector of the higher school development that will allow solving a number of accumulated problems. This direction of development will allow combining the infrastructural and research potentials of the system of higher educational institutions, creating a synergetic effect that promotes the transition of higher school from the "service" model to the model of active generation of scientific breakthroughs and their subsequent commercialization. Moreover, not only the development of mechanisms for vertical integration and cooperation of higher educational institutions, but also the horizontal on, implying the merger and/or co-operation of specialized higher educational institutions or their separate areas of training, is a strategically important direction for the development of higher education system in the context of the problem of innovative and technological development. An important tool for the transition to the model of active generation of scientific breakthroughs and their subsequent commercialization is also the cooperation of higher educational institutions with the business sector of the economy. The search for such kind of configurations is a non-trivial task and requires its own comprehensive, comprehensive and systemic solution, as well as scientific and practical justification.

The indirect confirmation of the emergence of synergistic effects arising from the consolidation of the system of higher educational institutions and the withdrawal from the market of inefficient higher educational institutions is that the optimization of higher school, observed in the period from 2009-2010 up to the present, forms a system of positive effects, expressed, for example, in the process of activating the patents granted, which also have significant potential for the creation of advanced production technologies. So, for the period from 2009-2016, characterized by the policy of optimization of the higher school system, there was a significant breakthrough in the sphere of scientific inventions (Figure 2).

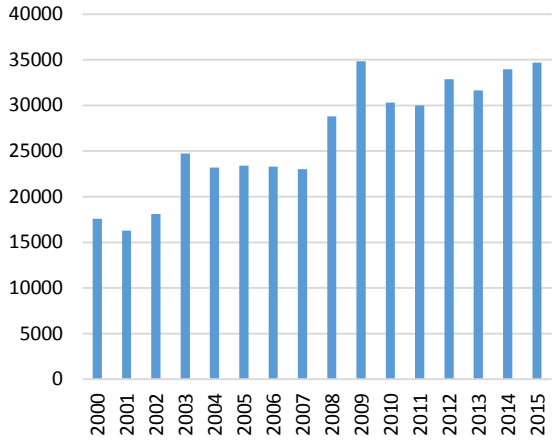

Figure 2. Number of patents granted in the Russian Federation, units

Taking into account that this factor, based on the results of econometric assessments, makes a significant contribution to the process of innovative and technological development of the national economy, it is necessary to state the effectiveness of state policy aimed at optimizing the higher school structure.

5. SUMMARY

Stating the foregoing assessments and directions of development, it is necessary to note that for a full-fledged transition to an innovation economy and a knowledge economy, it is necessary to revise the attitude towards the higher educational institutions as "service institutes", realizing their status as not only independent, but also the main drivers of economic growth of a new type and legislating them with necessary rights and resources for the implementation of the territory development potential laid in them. The most important instrument contributing to the activation of the processes of innovative and technological development of the national economy is also the intensification of public policy measures aimed at quantitative and qualitative optimization of the system of higher educational institutions, which implies the development of interuniversity cooperation and consolidation mechanisms. This way of development, due to the emerging synergetic

effects, forms a significant effect of activating the growth of the created advanced production technologies. This development mechanism is especially relevant in the conditions of resource constraints that have emerged in 2014 amid the aggravation of the geopolitical situation, which is reflected in the restriction of access of economic entities to the capital market and, as a consequence, in the reduction of investment activity by the foreign economic agents. Given that, based on the results of the implemented econometric analysis, this factor plays an important role in the generation of innovative technological development (elasticity ratio 0.75), the restriction of its impact, due to the reduction in foreign investment in research and development, should be offset by other factors. Undoubtedly, these factors should include the improvement of mechanisms for the higher school development, based on the principles of cooperation and consolidation of interuniversity space (Salmi, 2009) (Gube, 2009) (Knight, 2011). This paradigm of development will significantly increase the level of global competitiveness of the Russian higher educational institutions and create sustainable bases for accelerated innovative and technological development of the socio-economic environment.

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