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STIMULATING THE CREATION OF NEW PRODUCTION TECHNOLOGIES AS A FACTOR OF TECHNOLOGICAL MODERNIZATION

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Abstract

The task of intensifying efforts to stimulate the process of creating advanced production technologies today is facing the modern economy. To this end, it is necessary to identify those factors that directly influence the creation of new national high technologies for production, regardless of regional specifics and regional policy and irrespective of technology imports. This was set as the research goal in this article.

The method of least squares was used to construct an econometric model. A semi-logarithmic model was obtained after all recalculations that best corresponded to the stated research task and the selected criteria for selecting variables.

As a result of the research, two factors were identified that are not related to each other, but have a direct impact on the creation of new national high production technologies - a patent issued for inventions and internal R&D expenditures. A purposeful impact on these factors will

allow ensuring the technological modernization of the country's production base, the development of the scientific and technical potential of key sectors and sectors of the economy, and the growth of the country's intellectual resources.
In the future, it is necessary to continue the factor analysis of the process of creating new technologies with the aim of activating and strengthening it. It is necessary to focus on stimulating the process of creating technologies that meet world standards and outrun them.

Keywords
Technological Modernization, New Technologies, Econometric Model, Factor Analysis, Sustainable Development, Import of Technology, Innovation Development

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1. Introduction

Economic development has two approaches to solving the problem of technological modernization:

1) Creation of domestic advanced technologies and their introduction into real production sector.

2) Acquisition abroad - import of technologies and their use at national enterprises.

The second way is simpler, faster and more efficient under conditions of free competition, division of labor, including scientific and research, and free trade. Many countries have made significant progress in modernizing their technological basis and creating advanced industrial production (the most striking example of such a breakthrough is the Japanese "economic miracle" (Montalvo & Yafeh, 1994; Narin & Frame, 1989) due to the import of foreign technologies.

Many scientists considered the import of technologies as an effective tool for overcoming the backwardness of the technological level of national innovative structures from the world level. To achieve this goal, "the large-scale import of technologies, licenses and patents is needed, followed by the servicing of these production facilities with domestic innovative potential" (Komkov, 2014, p.15). Other researchers prove the ambiguity of the influence of external technologies on competitiveness and production efficiency, in contrast to this: «Clearly, external technology acquisition is not a panacea and great care must be taken to ensure firm success» (Jones, Lanctot, & Teegen, 2001, p.256).

It was the import of technology that for a long time was the basis of Russia's technological development. The share of imported technologies in the total number of new technologies purchased by organizations was equal to 85.2% in 2012 and 87.3% in 2013 before the introduction of sanctions by the leading Western countries against Russia. An even larger share of the foreign advanced technologies used was in high-tech economic activities in Russia: in 2012 it was equal to 96.7%, in 2013 - 95.7% and in 2014 - 91% (respectively, the share of domestic technology was 3.3%, 4,3% and 9%) (Rosstat, Regions of Russia, 2017; Rosstat, Science and innovations, 2017). Thus, as noted by Russian researchers, "such a small number of advanced technologies being created in Russia have no influence on the modernization of the country" (Kasavina, 2015, p.263). The Russian experts speak about the extremely high degree of dependence of domestic production, especially high-technology types, on foreign technologies threatening national technological security. For example, I.V. Shulgina believes that the weak development of advanced technologies, the use of a large number of "yesterday's samples of foreign equipment, consisting of ... secondary kinds ... does not improve, but conserves the existing technical backwardness" of Russia (Shulgina, 2013)

All of the above sharply poses the task of intensifying efforts to stimulate the process of creating domestic advanced production technologies that not only meet international standards, but also outpace them.

2. Theory

Issues of technological modernization of industrial production are widely discussed in the world science. The first wave of research in this field falls on the 70-90s of the 20th century. Among the most famous works of that time, laying the foundations of entire research areas and scientific schools, one should mention works by G. Dosi (Dosi, 1982; Dosi, 1984), K. Pavitt (Pavitt, 1981; Pavitt, 1984) and N. Rosenberg (Rosenberg, 1976) devoted to researching the directions of technical changes, identifying technological development trajectories and developing a new technological paradigm, since "the history of technology is contextual for the history of industrial structures associated with this technology" (Dosi, 1982). And a large nomber of modern research continues these studies: it is the study of influence of technological Innovation for growth of small and medium firms (Al-Mubaraki, & Aruna, 2013), the research of the effects of innovation types on firm performance (Gunday, G., Ulusoy, G., Kilic, K., & Alpkan, L. (2011), the study of effects of innovation potential of industrial enterprises (Matejun, 2017; Danilina, & Mingaleva, 2013), the study of the innovation sources of large and small technology-based firms (Bommer, & Jalajas, 2004), the research of the bridging the innovation gap between small and large firms in the base of technological collaboration (Nieto, & Santamaría, 2010).

Another study that also led to a broad examination of five key issues concerning the impact of technological change on firms and industries was the work of Clayton Christensen and his colleagues devoted to the limits of traditional technologies and destructive technologies (Christensen, 1992a; Christensen, 1992b; Christensen, 1997; Christensen & Rosenbloom, 1995; Rosenbloom, & Christensen, 1994). The term "disruptive technologies" introduced by Christensen characterizes those technologies that initially do not correspond to the current technology, i.e. the technologies that are new to the industry. In this case, disruptive technologies usually offer greater flexibility in production, high convenience of the organization or a lower price. Christensen shows by examples that disruptive technologies can serve to create new markets, but it can also upset the balance of companies with good reputation and good products (Christensen, 2002).

The huge volume of the most diverse research in the field of technological development, technological discontinuities, technological innovations led to the expansion of the spectrum and areas of research (Kamin, Bijaoui, & Horesh, 1982; Lowe, & Taylor, 1998; Moon, 1998; Tidd, Bessant, & Pavitt, 1998; Tyler, & Steensma, 1995).

In the 2000s, the issues of comparing the effectiveness of innovation policy and the transfer of technology from public institutions were actively discussed in such developed countries as Germany, Great Britain, France, Japan and China (Angelino, & Collier, 2004; Hemmert, 2004; Jones, et al., 2001; Kim, & Kwon, 2011; Poon, & MacPherson, 2005). In a study by C.A. Di Benedetto, W.S. DeSarbo and M. Song, based on a study of 376 firms in the United States, Japan and China, it was proved that it was manufacturing technology and information technology that were most positively associated with radical innovative products (Di Benedetto, DeSarbo, & Song, 2008), while in the United States marketing opportunities are more significant, and in China manufacturing technology is the only opportunity that is significantly and positively associated with radical innovation.

Analysis of the results of innovative activity of 108 Chinese firms that purchased foreign technologies in 2001-2008 showed 1) improvement of the innovative performance of the acquiring firm; 2) the positive impact on the productivity of innovations of the absolute size of the acquired external technology; 3) the negative impact on the productivity of innovations of the relative size of the acquired external technology (Sun, 2014). Such dependencies do not coincide with those that are manifested in developed countries, which confirm the special situation with the import of technologies in developing countries.

Modern foreign research in this field is focused on the features, opportunities and problems of technological development in developing countries. Thus, in the process of analyzing the institutional environment of developing countries N. Chakroun concluded that institutional support for technological development in developing countries is necessary, since these countries cannot fully benefit from the transfer of technology due to the lack of experience necessary for technology transfer (Chakroun, 2017). To do it, it is necessary to create special organizations able to manage technological transactions and to develop an innovative strategy with adequate policy in the field of intellectual property.

Another source of technological development in developing countries is the research activity of local MNE production units in these countries, which makes it possible to overcome the complexity of the perception of foreign technologies and new strategy of multilocated firms.

An analysis by I. Ivarsson and C.G. Alvstam of the performance of local R&D divisions in developing countries of Swedish MNE production plants has shown that currently these units are mainly developing new co-location technologies with manufacturing plants, although they previously used locally adapted strategies. This situation is typical for China, India and other Asian countries with large and growing markets (Ivarsson, & Alvstam, 2017).

J. Alcácer and M. Zhao conducted their research in the field of technological development of various countries by analyzing the strategy of multilocated firms, changes in their internal organization in different clusters and their reaction to technological and market competition in clusters (Alcácer, & Zhao, 2012). As a result of research of the world semiconductor industry held by J. Alcácer and M. Zhao it was established that internal links between regions are strengthened by interaction between competitors - industry leaders in the direct market, and not in their interaction with innovators in the same technological area.

Great volume of foreign research of this period is built on the following logical chain:

"The creation of advanced production technologies" →
→ "The introduction of advanced production technologies" →
→ "The production of Innovative products based on advanced production technologies" →
→ "The impact of innovation on labor productivity, the creation and expansion of sales markets"

The problems of scientific, technical and innovation-technological development of the country and its regions are actively discussed by Russian scientists too. At the same time, the basic attitude of the research and conclusions made are rather pessimistic. All the studies note that Russia is seriously lagging behind foreign countries in terms of technological development according the contribution of science to the country's technological modernization and its innovative development, in terms of national advanced production technologies, in terms of the state funding of science and research, in terms of the grade of the interest of private business in research and developments, etc. Shortcomings in the implementation of scientific and technical policy of the country are particularly noted.

A number of authors express a pessimistic view on the possibilities of Russia's technological development now and in the future. E.L. Vodolazhskaya and V.V. Avilova argue that "it is possible to state a significant contraction in the innovation sphere and, in general, a crisis scenario for the development of the Russian economy as a result of recent events, a decrease in the degree of openness ... of the associated innovation systems and, as a consequence, an increase in the closeness of the domestic economy ..." (Vodolazhskaya, & Avilova, 2017, p.137).

Within the framework of the research task an econometric analysis of the factors in relating to the field of science and innovation was conducted of Russian Federation.

3. Data and Methods

We formulated the task of searching for such factors of technological development of Russia in modern conditions that would have a significant impact on the activity of technological modernization of Russia's industrial complex (Mingaleva, & Danilina, 2014). The requirement of complete independence between factors was an important criterion for solving the task. This is necessary to eliminate the problem of autocorrelation and the multiplier effect.

Spatial data for the econometric analysis were chosen from the statistic data on 80 regions of the Russian Federation, available in official statistics (Rosstat, Regions of Russia 2017). The analysis excluded the city of Moscow in the Central Federal District and the city of St. Petersburg in the North-West Federal District for the reason of their special status and economic structure, which are very different from other regions of Russia. Sevastopol and the Republic of Crimea were also excluded from the econometric analysis, because there is not a sufficient statistical base for this regions (official statistics on them have been presented in official reports only since 2014), as well as Nenets Autonomous District, data on which are taken into account in statistics within the Arkhangelsk region.

The following explanatory and dependent variables were chosen for econometric analysis.

The indicator “Elaborated high technologies for production” was adopted as a dependent variable (Y). According to the widely spread opinion, the indicator "Elaborated high technologies for production", selected as a result indicator, determines new sources of economic growth and development trends, reflects the potential of the country's technological development and its innovative state (David, 1975; Dosi, & Grazzi, 2005; Mingaleva, & Mirskikh, 2009; Saviotti, 1996).

Statistical data (42 indicators in total) grouped into the following groups were used as explanatory variables:

1) A group of indicators reflecting the number of personnel engaged in research and development, with the specification of the categories of personnel: researchers (including the allocation of the researchers having candidate and doctor degrees, and researchers without a scientific degree), technicians, support personnel, other staff categories;

2) A group of indicators reflecting the internal current costs of research and development, including costs differentiated by types of work (basic research, applied research, technical and technological development), by types of costs (wages, insurance contributions to the Pension Fund, Social Insurance Fund, Federal Compulsory Medical Insurance Fund, acquisition of equipment, other material costs, other current costs);

3) A group of indicators reflecting the filing of patent applications and issuing protection documents on the main industrial property objects (inventions, utility models, industrial designs), as well as indicators of the intellectual property usage (inventions, utility models, industrial designs, databases, computer programs, topographies of integrated microcircuits);

4) The number of organizations that carried out research and development, the number of organizations that conduct postgraduate and post-doctoral training;

5) The number of postgraduates and doctoral students, the indicators of admission and graduation from postgraduate and doctoral studies, including the defense of the thesis.

The total number of indicators accepted for analysis by groups is given in Table 1 (compiled by the authors) (Rosstat, Science and innovations, 2017; Indicators of Innovation in the Russian Federation, 2018; Science and Technology Indicators, 2018; Science, technology, innovation: a brief statistical compilation, 2017).

Table 1: *Grouping of indicators for econometric analysis*

Grouping of indicators	Number of indicators
The number of staff engaged in R&D	8
Intramural expenditures for R&D	9
Patents granted for inventions and issued patents	14
Number of organizations performing R&D and number of organizations conducting postgraduate and post-doctoral training	3
Results of postgraduate and doctoral studies	8

Source: own study based on the survey research

All the statistics related to these groups of indicators were processed using Microsoft Excel and Reviews programs.

The method of the least squares was used for the econometric study and construction of the econometric model. A semi logarithmic model was obtained after all the recalculations, that best corresponded to the stated research task and the selected criteria for selection of variables.

4. Model and Results

The aim of the econometric model construction was to identify and evaluate absolutely independent variables, but significantly affecting the dependent variable - the number of newly created domestic advanced industrial technologies. Such formulation of the research aim is motivated by the fact that the presence of autocorrelation between variables means the existence of a synergistic influence on all the related factors, when a change in one factor inevitably leads to a change in other factors, and, consequently, of the dependent variable. At the same time, the greater the relationship, the stronger this cumulative effect is. And if the positive influence is positive and necessary for development and achievement of the goal, then the negative impact leads to much larger aggregate losses under the influence of the synergetic effect from the action of each factor.

Thus, development is proceeding at a much slower pace than is necessary to create a modern technological base of the country, unfortunately, as a whole it traces the results of implementation in Russia's scientific, technical and technological policy. Despite the fact that the dynamics of the increase in the number of newly created domestic advanced industrial technologies is positive, nevertheless, the growth rates are absolutely insufficient to achieve the planned results of the modernization and re-industrialization processes taking place in the Russian economy, including the lagging behind the leading foreign countries which continues to be unacceptably large.

During the construction of the model, some variables characterized by the presence of autocorrelation, multicollinearity and heteroskedasticity were identified step-by-step and excluded from the analysis. Testing the model for multicollinearity was necessary in order to solve the problem of the close correlation dependence between regressors, which ultimately leads to a decrease in the accuracy of the parameter estimation and, accordingly, to the obtaining of unreliable regression estimates. Since the presence of multicollinearity in the model distorts the effect of each individual variable on Y, the presence of multicollinearity in the model chosen by us was verified by calculating Variance Inflation Factors.

Checking the model for heteroskedasticity, i.e. for the heterogeneity of observations (the variance of the error is not constant), the presence of which is another problem in the construction of an econometric model besides multicollinearity. The White test was used to check the regression for the presence of heteroskedasticity. All basic tests and model building were carried out in the Eviews program.

After excluding all those variables that do not meet the selected criteria in the framework of the task of econometric analysis of regressors, two independent variables were determined to test the hypothesis and construct the final model, which directly affect the explained variable, but which, at the same time, are not related to each other and the change in the effect on one of them does not affect the other.

They were the following variables:

- Number of patent applications (NPA);
- Internal costs for R&D (ICR&D).

The indicator "Elaborated high technologies for production" was adopted as a dependent variable (Y).

A detailed description of the process of econometric modeling and a full description of the data obtained will be given in another paper. In this article, we will analyze the resulting simulation results in the context of highlighting the most significant factors that affect the creation of new manufacturing technologies and which are completely independent of each other.

The main R-squared (R2) coefficient of determination and the adjusted coefficient of determination (R2adjusted) obtained in the process of the model construction are R^2 = 0,5547613; $R^2_{adjusted}$ = 0,5431966.

As it can be seen from model, the main and corrected coefficients of determination are low - slightly more than 50%. It means that almost half of the factors affecting the explained variable are not taken into account in this model. This is really so, because in accordance with the purpose of the study, we deliberately removed all factors that, although they affect the final result, but have an autocorrelation. It is important that the 2 remaining regressors (out of 42) provide more than 50% of the result, with a very high degree of influence on the indicator being studied.

The value of t-statistics for the factors "Number of patent applications" and "Internal costs for research and development" was: 3.340087 for the first one and 2.685573 for the second factor, respectively. This indicates the existence of a relationship between the explanatory and explanatory variables. The check of factors by standard error values (Std.Error) gave very low values (0.010659 and 1.392473 respectively), which indicates the high accuracy of the coefficients obtained.

The value of Prob. factors "Number of patent applications" (0.0013) and "Internal costs of research and development" (0.0089) less than 0.01; 0.05; 0.10, which indicates the importance of these variables, and at all levels of significance simultaneously, starting with 1%. This also confirms the quality of the model.

Checking the model for multicollinearity and heteroscedasticity showed the following. The values of Centered VIF for both factors = 2.081452, which indicates the absence of multicollinearity in the model under consideration. To test the regression for the presence of heteroscedasticity, a White test was used, the results of which showed that there is heteroscedasticity in the model (the value of Prob (F-statistic) = 0.0031 <0.05). Therefore, the standard errors were recalculated. After recalculating standard errors, the variable "Number of patent applications" still remained significant at 1%, 5% and 10% significance levels (Prob. (0.0010) <0.01), but the variable "Internal research costs and development "was significant only at 5% and 10% significance levels, since its recalculated value Prob. (0.0182)> 0.01, although in general this value is still closer to 1% than to 5%. Thus, the quality of the model remained high.

The general results of the constructed econometric model after all the checks are given in Tables 2-4. The Table 2 gives a summary of the characteristic of the econometric model. The

Table 3 gives a summary of determination coefficients in determining the relationship between the number patent granted for inventions, intramural expenditures for R&D, and the number of elaborated high technologies for production. The Table 4 gives a summary the results of the econometric model

Table 2: *The characteristic of the econometric model*

The characteristic	Content of the characteristic
Dependent Variable:	ELABORATED_HIGH_TECHNOLOGIES
Method:	Least Squares
Sample:	1 80
Included observation:	80
White heteroskedasticity	consistent standard error & covariance

Source: own study based on the survey research

Table 3: *Determination coefficients in determining the relationship between the number patent granted for inventions, intramural expenditures for R&D, and the number of elaborated high technologies for production*

Variable	Coefficient	Std.Error	t-Statistic	Prob.
ELABORATED_HIGH_TECHNOLOGIES	-21.46480	9.423338	-2.277834	0.0255
NUMBER_OF_PATENT_APPLICATIONS	0.035602	0.010403	3.422461	0.0010
Log(INTERNAL_COSTS_FOR_R&D)	3.739587	1.550431	2.411967	0.0182

Source: own study based on the survey research

Table 4: *The results of the econometric model*

R-squared	0.458316	Mean dependent var	12.42500
Adjusted R-squared	0.444246	S.D. dependent var	19.16535
S.E. of regression	14.28756	Akaike info criterion	8.193435
Sum squared resid	15718.35	Schwatz criterion	8.282761
Log likelihood	-324.7374	Hannan-Quinn criterion	8.229248
F-Statistic	32.57460	Durbin-Watson stat	1.637713
Prob.(F-Statistic)	0.000000	Wald F-Statistic	21.48586
Prob.(Wald F-Statistic)	0.000000		

Source: own study based on the survey research

The equations obtained confirm the hypothesis about the presence of at least two independent factors, which directly and significantly affect the number of newly created domestic advanced industrial technologies. The obtained results correlate with the results of studies obtained by other authors, for example, with the results of research by I.Bijoui, R.Horesh, J.Y.Kamin (Kamin, et al., 1982) H. Kim, Y.S. Kwon (Kim, & Kwon, 2011), Z. Sun (Sun, 2014), I.V. Naumov (Naumov, 2014) and other researchers.

5. Conclusions

Based on the approaches of foreign scientists, we set the task to identify those factors that most directly affect the creation of new national high technologies for production, regardless of regional specifics and regional policy and regardless of import of technologies.

Two factors were identified that are not related to each other, but which have a direct impact on the creation of new national high technologies for production - patent granted for inventions and intramural expenditures for R&D. A purposeful impact on these factors will allow to ensure the technological modernization of the country's production base, the development of the scientific and technical potential of key sectors and sectors of the economy, and the growth of the country's intellectual resources.

A clear selection of several "hub" points of influence will allow to concentrate the resources of the state and business on the creation of new production technologies, on the development of those already existing technologies that are necessary to strengthen Russia's technological security and accelerate its economic growth.

The results of the research can be used to develop a strategic planning processes of entrepreneurial organizations particularly focusing on new ventures enterprises (Baykal, 2015). Also it is very important for small enterprises created on the basis of ICT-technologies (Japang, Rosie, Nasah, Supinah, & Yoag, 2016) and for enterprises engaged in active scientific research (Sahut, & Peris-Ortiz, 2014; Danilina, Mingaleva, & Malikova, 2016).

The scope and prospect of further research in our opinion is seen in the continuation of the factor analysis of the process of creating new technologies with the aim of activating and strengthening it. It is necessary to focus on stimulating the process of creating technologies that meet world standards and outrun them.

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