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IMPACT OF THE INNOVATIONS ON REGIONAL GROWTH OVER TIME: DYNAMIC ECONOMETRIC MODELING

Svetlana Rastvortseva

Abstract

Technological change leads to the rapid growth of the knowledge-based economy and service industries, allowing those regions to increase their total factor productivity and to become more competitive in the global economy.

Innovations are key determinant of regional development but their impact becomes noticeable often over time. For regional policy it is important to understand in what period of time the results of innovative projects can affect on the social and economic indicators.

The role played by the innovations in economic growth was recognized and introduced into the neo-classical approach and R&D theories. We used a pooled regression model for panel data to look at the affects of innovations on regional growth over time. The empirical analysis based on a large sample of Russian regions from 2002 to 2014 supports the hypothesis that innovation can impact on economic development in just a few years.

The aim of the paper is to reflect the nature of innovation influence on economic growth in the region taking into account time factor.

It was determined that influence of patent activity on regional economic growth is positive and statistically significant with lagged value of two years, a share of highly educated employees has positive influence on the rates of economic growth after three years.

The findings of the research are useful for policy applications and policy-makers by providing them with a better understanding of the impact of innovation factors of regional growth and length of time needed for the general development.

Key words: innovations, regional economics, economic growth over time, dynamic econometric modeling, regions of Russia

JEL Code: O30, R11, O47

Introduction

Technological change leads to the rapid growth of the knowledge-based economy and service industries, allowing those regions to increase their total factor productivity and to become more competitive in the global economy.

Innovations are key determinant of regional development but their impact becomes noticeable often over time. For regional policy it is important to understand in what period of time the results of innovative projects can affect on the social and economic indicators.

The issues on regional economic growth have agitated scientists for more than hundred years. The scientific doctrines and theories which are considered to be classical require actualization and revision due to the environmental changes where the corresponding provisions shall be fulfilled. Separate factors of the economic growth, including the innovations to which significance was not given, develop momentum and require adjustments of economic models.

The earlier original study showed that such innovative factors as internal expenditures for research and development, expenditures for engineering innovations, personnel capacity, involved in research and development as well as volume of innovative goods, works, services, have positive effect on economic development of the territory (which was estimated by the gross regional product index). The results of the empirical analysis show that the most significant factors for development of economics are expenditures for engineering innovations and internal expenditures for research and development. Influence of innovative activity on GRP is not statistically significant.

The results of the research also revealed that the innovations have positive influence on economic development of the regions since 2012 only.

The aim of the paper is to reflect the nature of innovation influence on economic growth in the region taking into account time factor.

1 Theoretical background and bibliography

The role played by the innovations in economic growth was recognized and introduced into the neo-classical approach and R&D theories.

Up-to-date theories of growth focus on determination of factors through aggregate modeling. From such standpoint economic development shall be considered as growth of income per capita in equilibrium. From these models, based on capital allocation, of the Harrod–Domar model type to neoclassical models of growth (the Solow model, 1957), economic development

was considered as a linear process. It was assumed that it was possible to influence on it by changing existing resources and factors both in theory and in practice. Later, in 1980s the theories of endogenous growth disputed the priority of engineering factors and underlined importance of human capital assets (Romer 1990, Lucas 1993, Grossman and Helpman 1993). At the same time neglect of engineering factors of economic growth does not allow to reflect influence of non-market processes and social and institutional indices on economic efficiency. Let us consider the manner in which innovation factors of economic growth are represented in economic literature (Table 1).

Table 1 Basic economics approaches deals with innovation and economic growth

Authors	Theory
Solow, 1956 and Swan, 1956	Diminishing returns to capital imply that in the absence of technological change, growth would stop. As empirically long-run growth does not stop, technological progress was assumed to be exogenous.
Arrow, 1962 and Sheshinski, 1967	Discoveries immediately spillover to the entire economy as knowledge is non-rival
Romer, 1986 and Lucas, 1988	Competitive assumptions can be maintained and determines an equilibrium rate of technological progress but the growth rate is not Pareto optimal. At the end, growth and knowledge can increase boundlessly.
Romer, 1987, 1990 Aghion and Howitt, 1992	R&D activities reward firms through monopolistic power. The equilibrium is not Pareto optimal, but rather one with monopolistic competition. The stock of human capital determines growth, but too little human capital will be devoted to R&D. Also, integration into world markets increases growth rates, and large populations are not sufficient to generate growth.
Gordon, 2012	The industrial revolution from 1870 to 1900 was more important than the others and was largely responsible for 80 years of relatively rapid productivity growth between 1890 and 1972. Once the spin-off inventions from the industrial revolution (airplanes, air conditioning, interstate highways) had run their course, productivity growth during 1972-96 was much slower than before. Many of the original and spin-off inventions of the industrial revolution could happen only once - urbanization, transportation speed, the freedom of females.
Promoting Growth in All Regions, 2012	Innovation can have a positive impact on long-run (ten years or more) growth.

2 The innovations and regional growth over time

At present Russian economy faces a range of external challenges. There is high dependence on global prices of *Brent* oil – it correlates with the national currency rate, complication of the

conditions of access to foreign capital markets for Russian companies − appreciation credit resources, reduction in influx of foreign direct investment in economy and many other phenomena. In this connection search for internal (endogenous) reserves of economic growth assumes critical importance.

For further consideration of the indices of economic growth it is necessary to take into account inflation factor and to put GRP into comparable prices (for example into prices of 2002). Note that the price index varies significantly among the regions. Thus, in 2002 the highest inflation rate was observed in the Krasnoyarsk Territory (18.4 %), and low one – in the Republic of North Ossetia-Alania (7.8 %). In 2013 maximum price advance took place in the Kaliningrad Region (15.6 %), minimum price advance – in the Chukotka Autonomous District (4 %). For further work we will suggest the indices of GRP, GRP per capita, labor efficiency to comparable prices – prices of 2002.

For period of 2002-2014 Russia's real total GRP was increased by 7.16 % per year on average. In 2014 the highest index of real GRP was observed in Moscow (22.32 % of total GRP of the Russian regions), the Khanty-Mansijsk Autonomous District (5.29 %), the Moscow Region (4.54 %), Saint Petersburg (4.23 %), the Republic of Tatarstan (3.07 %), the Yamalo-Nenets Autonomous District (3.03 %). In 2014 42.49 % of total production was accounted for six country-subdividing regions.

Let us consider economic growth of the regions by some indices (Table 2).

Table 2 – Real GRP, GRP per capita and labour productivity in Russian regions, 2002-2014

	Change in real GDP	Change in real GPD per capita	Change in GRP per worker (labour productivity)
Minimal growth	2,1 % (Magadan region)	3,8 % (Magadan region)	11,7 % (The Republic of Buryatia)
Maximum growth	15,8 % (Sakhalin region)	16,9 % (Sakhalin region)	in 4 times (Sakhalin region)
Range	13,7 pp	13, pp	288,3 pp
For comparison: regions of OECD countries, 1995-2005*			
Minimal growth	-1,7 % (Berlin, DEU)	-1,8 (Adana, TUR)	-3,8 % (Champagne-Ardenne, FRA)
Maximum growth	8,5 % (Southern and Eastern, IRL)	7,1 % (Southern and Eastern, IRL)	7,1 % (Podlaskie, POL)
Range	10,2 pp	8,9 pp	10,9 pp

Note: pp refers to percentage points, DEU- Germany, TUR – Turkey, FRA – France, IRL – Irland, POL – Poland.

** Source: How Regions Grow: Trends and Analysis. Paris. OECD Publishing. 2009*

High indices of economic growth are observed in the Sakhalin Region (on average for 2002-2014 – 15.8 %), the Republic of Ingushetia (15.6 %), the Nenets Autonomous District (13.62 %), the Republic of Dagestan (12.76 %), the Tyumen Region (12.66 %). For the period of analysis 38 regions of Russia had the higher rates of economic growth than average one on an aggregate basis, 45 regions – lower that average one. Falling of the mentioned regions within the leaders can be explained by two reasons. Firstly, in a number of the regions extractive industry grows rapidly which provides high rates of growth. Secondly, the regions which had poor development have a high rate of growth.

Initial level of economic development is an important factor of growth. Up to the last decade of XX century the concept of convergence of economic growth trajectories was very popular. The conclusion from this concept consists in the fact that poor regions shall grow faster than rich ones as at a modern rate of diffusion of technologies intensification of production shall have similar rates and therefore capital-labor ratio in the regions with a low initial level shall grow faster. This assumption often comes into conflict with empirical research. Let us consider relationship between the rates of economic growth of the Russian regions and initial level of region development (let us represent if as GRP per capita) (Fig. 1).

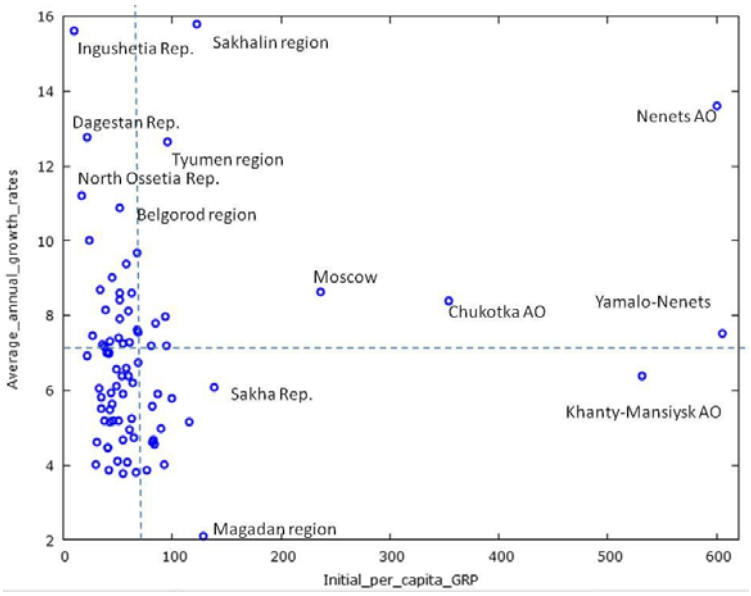

Fig.1. Initial GDP per capita and annual average growth rates in real GDP among Russian regions, 2002-2014

Quantity of obtained patents for inventions and for useful models can be considered as innovation factor in the region. Creation and patenting of inventions and useful models is the most important result of research and development. A patent for invention or useful model is a

protection document certifying the priority, authorship and exclusive right to utilization of intellectual property for the patent duration. The main source of information on submission of patent applications and issue of protection documents for inventions and useful models in Russia is the Federal Service for Intellectual Property (Rospatent).

Note that in the Russian regions inventions much oftener than useful models are patented. A share of inventions in 2002 is 73.54 %, and in 2014 it was reduced to 65.28 %. In 2014 we can qualify Moscow (33.27 % of total number), Saint Petersburg (6.85 %), the Moscow Region (6.62 %), the Republic of Tatarstan (4.57 %), the Samara Region (2.38 %) and the Sverdlovsk Region (2.37 %) as regions with maximum number of patents. Thus they are not only leading economic but also industrial centers of the country. In 2014 56.05 % of total number of issued patents is accounted for six regions.

In 2002 the geographical coverage of patent activity was more diversified – 47.83% is accounted for a share of six leading regions. As per the index the leaders were Moscow (22.9 %), Saint Petersburg (8.81 %), Moscow (6.74 %), Sverdlovsk (3.32 %), Samara (3.25 %) and Nizhny Novgorod Region (2.81 %). At large, for the analyzed period, number of patents is increased by 71.61 %, which indicates weakness of this trend of innovative development.

A share of higher education employees is one more index characterizing innovations and quality of labor. In this sphere the situation is much better: if in 2002 22.7 % of employees in Russia had higher education, then in 2014 their percent was increased up to 32.2. The most educated human resources are in Moscow – it was 50 % (2013), as well as in the Republic of North Ossetia-Alania (42.2 %), the Moscow Region (41.5 %), Saint Petersburg (41.1 %), the Yamalo-Nenets Autonomous District (39.8 %). The lowest share of highly educated employees takes place in the Jewish Autonomous Region (20.3 %) and the Chechen Republic (19.4 %).

It is worth mentioning that if across Russia a share of highly educated employees steadily grows, then in terms of regional make-up the dynamics of this index is variable. This fact evidences migration of educated population to more attractive regions.

3 Research methodology

We can distinguish three approaches to research of influence of innovations on economic growth. The first approach consists in linear modeling. In case of linear modeling we proceed from the fact that innovations and inventions stimulate increase in labor productivity and result in economic growth. Empirically, at such approach relationship between research and

development and patent activity shall be studied and then influence on economic growth shall be evaluated. The higher volume of expenditures for research the higher innovative capacity and rates of economic growth, by extension. Thus a linear model allows us to determine the key innovative factor of economic growth.

The second approach consists in overall evaluation of regional innovation system. In case of such approach innovations shall be considered as an integral part of regional development. Here, interacting institutes created in the region can attract, or vice versa, deter, generation of innovations. Capability of these institutes to act as catalysts depends on social and structural conditions created in the region. In separate literary sources a combination of such conditions is called "social filter". To the number of institutes which enable innovations in the region, we can relate arrangement of interaction between companies and institutes, finance, engineering subdivisions, legal services, research establishments, as well as relations with the regional authorities. Major drawback of such approach consists in complexity of rating of institutes to carry out empiric studies.

The third approach is also complex enough for empiric implementation. It covers diffusion and assimilation of knowledges and assumes that we can observe such spillovers in both quality and quantity. This approach is implemented at microlevel inside innovation establishments – companies, universities, research centers, regional institutes, between entrepreneurs. Internal and external interaction results in knowledge transfer and its diffusion.

We used a pooled panel data model to observe the effects of influence of the above mentioned factors on regional growth in the course of time. A panel specification has some advantages as compared to cross-sectional specification consisting in measurement of annual influence of independent variables on economic growth considering interregional interrelation and time effects.

Panel data approaches allow for lagged effects on the phenomenon to be explained, so if a particular variable, say infrastructure, takes time to have an impact because it needs to be built and used, these models allow us to pinpoint the time needed for that impact to emerge.

To use lagged values we applied the Tinbergen and Alt approach (distributed lag model). Such approach allows to determine balance between accuracy of the model (value of lag variables) and assessment quality (multicollinearity). It assumes sequential assessment of models:

$$y_t = a_0 + b_0 x_t + \varepsilon_t$$
$$y_t = a_0 + b_0 x_t + b_0 x_{t-1} + \varepsilon_t$$
$$y_t = a_0 + b_0 x_t + b_0 x_{t-1} + b_0 x_{t-2} + \varepsilon_t \ldots..$$

Termination of process is recommended when any of the factors at lagged variables changes the sign or becomes statistically insignificant, which is a consequence of multicollinearity. Besides, such situation, when observations are not enough for further increase of number of lagged variables, is unlikely but possible.

4 Model specifications

To assess the impact of innovation on regional economic growth over time, we will use a power-mode regression model with constant elasticity:

$$\hat{Y}_{i,t} = \alpha \prod_{i=1}^{m} x_{i,t-1}^{b_i}, \quad (1)$$

where $\hat{Y}_t$ is average growth of gross regional product (GRP), predicted in the time period *t*;

α is absolute term of equation;

x_i is innovative and other factors, included in the regression model;

b_i is equation parameters - regression coefficients, particular elasticity coefficient of GRP growth on investigated factors;

i is serial number of the factor;

m is number of factors, included in the model.

In linear representation the model looks in the following way:

$$\ln\left(\frac{\hat{\hat{Y}}_{i,t}}{Y_{i,t-1}}\right) = \ln\alpha + \sum_{i=1}^{m} b_i \ln x_{i,t-1}. \quad (2)$$

As a productive indicator we denote the average growth of gross regional product for 2002-2014. Let's define factor indicators (Table 3).

Table 3 Factors of economic growth used in analysis

Factor	Theory	Indicators

Initial level of GRP per capita	Convergence hypothesis Neo-classical	GRP per capita for the previous year
Human capital	Endogenous growth	High attainment rate: the share of the labour force with high education
Innovations	Endogenous growth	Patent intensity: the number of patents granted

Source: Own research, 2016

Basic factors which are considered to be included into the model are initial level of GRP (for 2002), number of issued patents, share of highly educated employees in aggregate number of employees involved in economy. It is also important to note that economic growth is not achieved only by means of the mentioned factors – their influence will be insignificant. Including such variables as infrastructure development level, fixed investment, human resources, etc. into the model will allow increasing determination coefficient, but at that we cannot catch the value of innovation factors for economic growth of the territory. Thus, following the task assigned in the study, we accept the following as independent variables:

Initial GRP – initial GRP in region *i* in 2002;

Patent – number of issued patents in region *i* for time period *t*;

High Edu – share of highly educated employees in aggregate number of employees involved in economy.

Value of innovations will be reflected in the model by number of patents and level of education of human resources. Value of labor will be reflected only by the index of share of highly educated employees. Value of capital was purposely not included into the model due to complexity of regional infrastructure development level assessment. Preliminary assessments show that such indicator as road density is not statistically significant at analysis of economic growth. This can be explained by immense territory of the country – in many regions roads are not basic element of transport infrastructure. Railway, sea and air transport is preferred for shipping in the regions of Siberia and Far East. Consequently, degree of the infrastructure development shall be assessed by an integral index, development of which is not included into the tasks of this study.

The data used in this study comes mainly from a Russian Federation Federal State Statistics Service, Statistical Data Book *Regions of Russia. Economic and Social Performance* for 2002-

2015. The data has been collected in 83 regions, with the exception of the Republic of Crimea and Sevastopol.

5 Interpreting the results

The results of the conducted analysis regarding modeling pair regression are presented in Tab.4.

Table 4 The results of the empirical analysis-characteristic of pair regression models

	Initial GRP per capita	Patent	High Education
b	-0,024***	-0,0007	-0,069***
R^2	0,028	0,0001	0,0198
Adj R^2	0,027	-0,0009	0,0188
F	28,08	0,14	20,01

** Significant at the 5% level*

The results of the empirical analysis prove that the most significant factors for the economic growth initial GRP per capita. In order to determine the best combination of effective factors, we carry out a distributed lag model (Tab.5).

Table 5 Results of the empirical analysis (distributed lag model)

	Model 1	Model 2	Model 3	Model 4
Constant	0.19 *** (0.025)	0.18 *** (0.056)	0.17 *** (0.058)	0.22 *** (0.056)
Initial GRP per capita	-0.032 *** (0.006)	-	-	-0.028*** (0.006)
Patent – lag 1	-0.025*** (0.009)	-	-0.035*** (0.009)	-0.034*** (0.009)
Patent – lag 2	0.026*** (0.009)	-	0.034*** (0.009)	0.034*** (0.009)
High Education – lag 1	-	-0.102** (0.034)	-0.061* (0.035)	-0.045 (0.035)
High Education – lag 2	-	-0.017 (0.035)	-0.034 (0.036)	-0.028 (0.035)
High Education - lag 3	-	0.082** (0.032)	0.060* (0.033)	0.057* (0.032)
R^2	0.047	0.020	0.033	0.065
Adj R^2	0.043	0.016	0.026	0.057
F	12.83	5.14	4.78	8.0
n	783	744	706	706

** Significant at the 5% level*

Thus, we constructed 4 models. Low determination coefficient takes place due to insignificant influence of the factors, selected for the analysis, on economic growth. Initial level of Gross Regional Product per capita is reflected adversely on economic growth rates. At stable statistical significance of the factor we can conclude that richer regions have indeed lower rates of economic growth than poor ones.

Such factor of innovative development, as issued patents, has no significant influence on economic growth without regard to time lags (model 2), but in case of more detailed study we can see that positive influence of the factor is significant with two-year lag. Here we shall note that patent activity of the Russian regions is at low enough level. Patents are only becoming a significant index of innovative development in the Russian regions, as procedure of patenting is only starting to take roots.

The level of population education is a significant factor of economic growth. However, we see that high share of highly educated employees positively reflects only after 3 years.

Increase of share of highly educated employees by 1 % will add 0.057-0.082 % to the rates of economic growth after three years. Increase of patent activity of a region by 1 % will add 0.026-0.034 % to the rates of economic growth already after 2 years.

Conclusion

This paper shows the nature of innovation influence on regional economic growth with respect to time factor. To use lagged values we applied the Tinbergen and Alt approach (distributed lag model). The model includes such factors as initial level of GRP (for 2002), number of issued patents, share of highly educated employees in aggregate number of employees involved in economy. Initial level of GRP per capita is statistically significant, but has an adverse effect on regional economic growth. This allows us to reach the conclusion that richer regions have indeed lower rates of economic growth than poor ones (which confirms the concept of convergence of economic growth).

Influence of patent activity on regional economic growth is positive and statistically significant with lagged value of two years. Therefore, the patents for inventions and useful models issued in the region contribute in economic growth only after two years.

The level of population education is weighty factor of economic growth, and a share of highly educated employees has positive influence on the rates of economic growth after three years.

The factors considered in the paper are not exhaustive, but the carried out analysis is enough for reflection of the fact that positive influence of innovations on economic growth of territory is not instantaneous, but takes place after 2-3 years. This allows to pursue a regional policy aimed to all-round innovative development

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Contact

Svetlana Rastvortseva
Belgorod State National Research University
308015 Russia, Belgorod. ul. Pobedy, 85
SRastvortseva@gmail.com