Econometric Estimation of Economic Growth by Purchasing Management: Neovlassical Models to the Analysis of Qualitative Changes

Ekaterina Ivanovna Kadochnikova[1], Liliaj Faridovna Zulfakarova[2], Darja Alekseevna Drozdova[3], Abdulaev Hawaj-Baudi Salaudiyevich[4]

Kazan Federal University

kad-ekaterina@yandex.ru

***Abstract*— Based on the review of theories of economic growth, attention is focused on the sources of regional economic growth by purchasing management. Using linear regression models, a sample of data from 83 Russian regions from 2010 to 2016 reflects the short-term dynamics of regressors influence on the gross regional product growth. On the basis of partial elasticity coefficients, it is empirically revealed that the greatest influence on the gross regional product is exerted by investments in fixed capital, in contrast to the costs of technological innovations. The conclusion about the statistically significant difference in the impact of the volume of investment in fixed capital and the cost of technological innovation on the gross regional product is formulated on the basis of a comparison of the modular values of the boundaries of confidence intervals: if the intervals intersect, there is no statistical difference between the coefficients. It is possible to recommend to apply the results to regional authorities in the development of regional economic policy in the field of investment and innovation. The assumption that the growth of investment in fixed capital and rising costs of technological innovation increase the gross regional product is empirically confirmed. Investment in fixed capital has a greater impact on gross regional product than the cost of technological innovation. In 2015, 2016 compared to 2010, 2011, 2012, 2013, the impact of investments in fixed assets in the direction of increase, relative to the impact of costs on technological innovation is statistically different. In further studies, to eliminate the bias in the estimates of regression coefficients, it is advisable to expand the range of regressors of the gross regional product, to use econometric models for the analysis of panel data.**

Keywords*— *gross domestic product, fixed investment, regression analysis, purchasing management, linear multiple regression model.

1. Introduction

Economic growth is the ability of an economy to produce more and more goods and services from year to year to meet the growing needs of society. In other words, it is a steady process of growth of the economy's productive capacity and the resulting increase in national income. Traditionally, economists identify four major factors of economic growth: natural resources, human capital, physical capital, and production technologies. In addition to these factors, external shocks have a greater impact on economic growth (for example, world oil prices, interest rate levels that cause large capital movements. The question of achieving regional economic growth through investment is still debatable. At the time, A. Smith pointed out such key sources of growth as the division of labor, capital accumulation and technological progress. In the modern digital economy, these sources of growth are given great attention in the development of modern theories, exploring the process of transforming economic growth factors, such as technological progress and human capital, into endogenous factors. The Harrod-Domar model [1] uses a production function in which the amount of capital and labor consumed in the production of one unit of product is fixed and exogenous. In the neoclassical model of economic growth of Solow-Swan [2;3] the factors of economic growth are interchangeable, with a variable technological coefficient, capital and labor automatically adapt to balanced growth. Although the Solow-Swan model considers technological progress as the main, in fact, the only exogenous factor for economic growth in the long term. According to F. Knight, F. Ramsay, R. Solow [3], without technological changes, the growth of investments cannot lead to long-term economic growth. New growth theories have proposed models with an endogenous factor of technological progress. Kenneth J. Arrow [4] suggested that technological progress or productivity growth is a by-product of capital accumulation, an effect caused by investment and the accumulation of human capital through learning. As a result, arrow showed technical progress as an endogenous variable defined by the economic system. In the 1980s, P. Romer [5;6;7-17], F. Aghion and P. Howitt [8] presented an endogenous theory of economic growth based on the dissemination of knowledge among producers as a result of deliberate research and development.

Therefore, technological progress is both an expression of human capital accumulation and an improvement in the quality of invested capital. The internal quality of invested capital increases with the level of technology created through the use of human capital. In addition to the accumulation of human capital, the deepening of capital specialization can also contribute to the deepening of the division of labor and the formation of a monopoly competitive advantage, which makes economic growth more stable and sustainable and leads to an increase in the marginal return on invested capital in purchasing management. The review of theories of economic growth allowed us to formulate the purpose of work - on the example of economy of Russia to check the assumption that growth of volume of investments in fixed capital and expenses on technological innovations increase the made gross regional product measuring economic growth.

2. Methods

Thus, at present, theories of economic growth are developing around three aspects [3]: technological innovations, the promotion of which contributes to the deepening of the division of labor; the accumulation of human capital, which is directly expressed through technological progress; the materialization of technology into innovations, which are manifested in the accumulation of capital. Based on the above review of growth theories, the main sources of regional economic growth are technological progress, investment, the accumulation of human capital through technological progress, and the accumulation of capital quality through technology.

In the study according to the collection according to the collection "Regions of Russia. Socio-economic indicators. 2017". The linear model of multiple regression, which provides a clear economic interpretation of the parameters and allows for the given values of the regressors to find the theoretical values of the regressant [9;10;11]:

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \varepsilon_i$$

where, Y_i – gross regional product, thousand rubles, X_{i1} – volume of investments in fixed capital, thousand rubles, X_{i2} – costs of technological innovations, thousand rubles, β_0 , β_1, β_2, – regression parameters estimated by the usual least squares method, ε – random deviation (error). For comparability of indicators calculations were made per capita, according to the population in the regions.

The main purpose of multiple regression is to build a model with multiple representatives, defining the influence of each of them individually, as well as the cumulative impact on the modelled indicator. The classical approach to estimation of linear regression parameters is based on the least squares method. The least squares method allows to obtain such estimates of the regression parameters β_j, in which the sum of the squared deviations of the actual values of the regressant y from the calculated (theoretical) y_x is minimal, and the regression parameters β_j are partial derivatives of the regressant y on the corresponding factors x_j. On the example of the Russian economy, we check the assumption about the impact of investment in fixed assets and the cost of technological innovation on the produced GRP, using a linear model of multiple regression and partial elasticity coefficients estimated from a sample of 83 regions in the period from 2010 to 2016, per capita, in thousand rubles (official website of the Federal state statistics service): GRP - Y, the volume of investment in fixed capital - X1, the cost of technological innovation - X2.

3. Results and Discussion

Expediency of inclusion of regressors X_{i1}, X_{i2} in multiple regression is confirmed by the correlation analysis carried out by means of the tool "Correlation" in Microsoft Excel (tab.1).

Table 1. Results of correlation analysis of GRP regressors in 2016

	Y	*X1*	*X2*
Y	1		
X1	0,85	1	
X2	0,48	0,12	1

According to the Chaddock-Snedecor scale there is a close statistical relation between the produced GRP and the volume of investments in fixed capital (R_{yx1} = 0,85), and also moderate direct statistical correlation between the produced GRP and the cost of technological innovation (R_{yx2} = 0,48). At the same time, the statistical relationship between the factors (R_{x1x2} = 0.12) is practically absent, which indicates compliance with one of the requirements for the construction of multiple regression: the equation includes regressors that are not interconnected.

Table 2. Results of regression estimates of GRP in the amount of investments and costs of technological innovation from 2010 to 2016

Regressors	Dependent variable - GRP						
	2010	2011	2012	2013	2014	2015	2016
X1	0,266***	0,304**	0,23***	0,31**	0,35**	0,41**	0,46**
X2	21,52**	17,31**	21,12**	12,62**	13,59*	13,64*	15,42**
Free coefficient	142,97	174,22	186,20	227,09	248,98	279,55	290,102
R^2	0,65	0,72	0,74	0,69	0,71	0,73	0,68
Elasticity X1	0,26	0,24	0,18	0,22	0,22	0,24	0,24
Elasticity X2	0,01	0,23	0,31	0,20	0,21	0,18	0,20

Note: *** - significance with a probability of 99%, ** - significance at a probability of 95%, * - significance with a probability of 90%.

Thus, in 2016, an increase in fixed capital investment by 1% led to an increase in GRP by 0.24%, and an increase in the cost of technological innovation by 1 % led to an increase in GRP by 0.20%. The dynamics of private elasticity coefficients for 2010 – 2016 shows that investments in fixed capital have a more significant impact on GRP than the cost of technological innovation (except in 2012, where E1<E2). It is obvious that the assumption that the growth of investment in fixed capital and the cost of technological innovation increase GRP, received its empirical confirmation.

The paper also defines confidence intervals for regression coefficients, which allowed comparing the impact of investments and costs of technological innovations on GRP (Table 3).

Table 3. Value of elasticity coefficients and confidence intervals

Year	Multiple regression equation	Elasticity coefficient	Confidence intervals for regression coefficients
2010	$Y_x=142,97 + 0,266X_1 + 21,52X_2$	$Э_1 = 0,26$ $Э_2 = 0,01$	$98,92^{***}<\alpha<187,02^{***}$ $0,24^{***}<\beta_1<0,29^{***}$ $13,37^{***}<\beta_2<29,68^{***}$
2011	$Y_x =174,22+0,304X_1 + 17,31X_2$	$Э_1 = 0,24$ $Э_2 = 0,23$	$114,55^{***}<\alpha<233,89^{***}$ $0,27^{***}<\beta_1<0,34^{***}$ $9,25^{***}<\beta_2<25,37^{***}$
2012	$Y_x =186,20+0,23X_1 + 21,12X_2$	$Э_1 = 0,18$ $Э_2 = 0,31$	$114,46^{***}<\alpha<257,94^{***}$ $0,19^{***}<\beta_1<0,28^{***}$ $11,24^{***}<\beta_2<31,01^{***}$
2013	$Y_x =227,09+0,31X_1 + 12,62X_2$	$Э_1 = 0,22$ $Э_2 = 0,20$	$151,24^{***}<\alpha<302,95^{***}$ $0,28^{***}<\beta_1<0,36^{***}$ $5,54^{***}<\beta_2<19,72^{***}$
2014	$Y_x =248,98 +0,35X_1 +13,59X_2$	$Э_1 = 0,22$ $Э_2 = 0,21$	$162,51^{***}<\alpha<335,45^{***}$ $0,29^{***}<\beta_1<0,41^{***}$ $5,92^{***}<\beta_2<21,27^{***}$
2015	$Y_x =279,55 +0,41X_1 +13,64X_2$	$Э_1 = 0,24$ $Э_2 = 0,18$	$184,01^{***}<\alpha<375,12^{***}$ $0,36^{***}<\beta_1<0,47^{***}$ $5,3^{***}<\beta_2<21,98^{***}$
2016	$Y_x =290,102 + 0,46X_1+15,42X_2$	$Э_1 = 0,24$ $Э_2 = 0,20$	$188,01^{***}<\alpha<393,4^{***}$ $0,39^{***}<\beta_1<0,52^{***}$ $5,94^{***}<\beta_2<24,91^{***}$

Note: ***, **, * – significance at 1%, 5%, and 10% respectively.

According to 2016 data, confidence intervals for regression coefficients are: 188,01<α<393,4; 0,39<β1<0,52; 5,94<β2<24,91. Note that the range of confidence interval boundaries for the regression coefficient should preferably not exceed 3. In our case, for the coefficients α and β_1 this condition is satisfied (the right boundary is greater than the left one by 2,09 and 1,33 times, respectively), and for the coefficient β_2 this value exceeds the set maximum and is 4.19 times. This tendency for confidence intervals of regression coefficients is observed in all considered time intervals. This suggests that the actual effect of the coefficient β_2 in the variable x_2 (cost of technological innovation) varies in large intervals than the actual values for α and β. Therefore, the quality of the fit is recommended to improve.

The conclusion about the statistically significant difference in the impact of the volume of investment in fixed capital and the cost of technological innovation on the gross regional product is proposed to formulate on the basis of a comparison of the modular values of the boundaries of confidence intervals: if the intervals intersect, there is no difference between the coefficients. Thus, in 2015, 2016 compared to 2010, 2011, 2012, 2013 the impact of investments in fixed assets in the direction of increasing relative to the impact of costs on technological innovation is statistically different. Statistically different influence of costs on technological innovations on the gross regional product is not revealed, modular values of the boundaries of confidence intervals are crossed in all pairwise comparisons.

4. Summary

On the basis of the presented results it is possible to formulate several General theses concerning endogenous factors of economic growth.

According to the analysis, the assumption that the growth of investment in fixed capital and the increase in the cost of technological innovation increase produced GRP received empirical confirmation. The calculated regression coefficients and their confidence intervals, as well as partial elasticity coefficients characterize the degree of influence of factors on the effective indicator and determine the boundaries of its variation. The regression analysis deepens the understanding of the nature of the relationship and more accurately proves the statistical significance of the selected indicators. Note that a significant difference between growth theory in the 1960s and 1990s is that recent studies have focused on the empirical implications and the relevance of the theory to real data. However, in most of these applied works applications of empirical hypotheses from the old theory are considered, in particular we are talking about such a consequence of the neoclassical model as conditional convergence (convergence) of growth. A significant part of the research in the 1990s. statistical regressions were built on the basis of neoclassical growth models to study the impact of various macroeconomic indicators on growth. However, there is some discussion about the robustness of such estimates. Other empirical studies are more relevant to recent theories of endogenous growth, including the role of increasing returns, research, human capital, diffusion of technology. Neoclassical theories of growth are limited by the assumption that technological progress is exogenous, depends only on time and is really weakly related to the processes within the simulated system. The disadvantage of these models is that they do not provide information about the causes of growth, do not contain recommendations on possible ways to accelerate technological progress, and hence the growth of the economy as a whole. The theory of endogenous economic growth to overcome the deficiency of neoclassical theories. First of all, they reject the neoclassical assumption of declining marginal capital productivity, allow for economies-of-scale economies of scale, and often focus on the impact of externalities on return on investment. The key factor of endogenous growth in the theory of Paul Romer is a variable called "knowledge" or "information". The basic idea of Romer's theory is: "there is an exchange between consumption today and knowledge that can be used to expand consumption tomorrow." He formulates this idea as a "research technology" that produces "knowledge" from past consumption. Thus, the rate of economic growth is in Romer's theory directly dependent on the size of human capital concentrated in the field of obtaining new knowledge. It follows from Romer's theory that countries with large accumulated human capital will have higher rates of economic growth. In further studies, to eliminate the bias in the estimates of regression coefficients, it is advisable to expand the range of regressors of the gross regional product, to use econometric models for the analysis of panel data.

5. Conclusions

It should be noted that the theory of growth is entering a new phase of its development — with great opportunities [12-16]. Being initially rather narrow discipline, the section of mathematical economy, the theory of growth and development expands the subject and methodological area, entering into cooperation with other branches of Sciences (political economy, evolutionary biology, economic history, etc.). The reasons for the changes are natural: on the one hand, more and more attention is paid not to proximate causes of growth, but to its fundamental reasons (biogeographic, historical, institutional, cultural),

the study of which has received a new impetus within the framework of theoretical and empirical models. In addition, the expansion of data and methods of empirical analysis allows testing hypotheses, the verification of which was not possible until recently. Finally, a new class of models in growth theory allowed us to move away from the traditional concept of balanced growth path — the state typical for developed countries in the short period of time (XX century), to the analysis of qualitative changes in the economy and corresponding to different phases of its development. All this greatly expands the understanding of the causes of differences in living standards between countries and also leads to the creation of a new class of growth models. Along with this, a significant expansion of instrumental capabilities for testing existing theories leads to the emergence of new growth empirics.

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