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THE GROWTH AREAS OF REGIONAL ECONOMY AND REGRESSION ASSESSMENT OF SECTORAL INVESTMENT MULTIPLIERS

The article develops the methodology for using the investment multipliers to identify the growth areas of regional economy. The authors discuss various options for assessing the multiplier effects caused by investments in specific sectors of the economy. All calculations are carried out on the example of economy of the Republic of Tatarstan for the period 2005–2015. The sectoral and cross-sectoral investment multipliers in today's economy of the Republic of Tatarstan, as well as the elasticity of the gross output of the region and its individual sectors in terms of investments in various sectors of the economy, are assessed on the basis of regression modeling by using the least squares method. The results of calculations are used to identify the growth areas in the economy of the Republic of Tatarstan. They are mining industry, manufacturing industry and construction. The success of a particular industry or sub-industry in a country or a region should be measured not only by its share in macro-system's gross output or value added, but also by the multiplicative effect that investments in the industry have on the development of other industries, on employment and on general national or regional product. In recent years, the growth of the Russian was close to zero. Thus, it is crucial to understand the structural consequences of the increasing investments in various sectors of the Russian economy. In this regard, the problems addressed in this article are relevant for a number of countries and regions that find themselves in a similar economic situation. The obtained results can be used to make similar assessments of investment multipliers, as well as multipliers of government spending, and other component parts of the aggregate demand in various countries and regions in order to identify the growth areas. Investments in these growth points will induce the greatest and the most evident increment of the outcome from the macro-system's economic activities.

Keywords: multiplier effect, sectoral investment multipliers, elasticity of gross output, regional economy, growth areas, regression modeling, production function, factor analysis, sectoral structure of economy, Republic of Tatarstan

Introduction

The question of the impact made by investments on economic growth is not as transparent as many people usually think.

The theoretical constructs found in macroeconomics textbooks often assume that there is some investment multiplier that increases the amount of investments in the economy and ensures a many-fold increment of gross output in the macro-system (a country or a region).

In this case, in accordance with the Keynes theory, it is taken for granted by default that the increment of gross output in the macro-system is exclusively the result of the investment process. Meanwhile, each part of the aggregate demand in the macro-system generates its own multiplier effects, and the values of their multipliers are different. This simple idea expressed in the 1930's by A. Pigou was forgotten for a long time, and the interest in it has been revived only recently in connection with the reinterpretation of results obtained by Trygve Haavelmo [1, 2] and his followers [3–6], who demonstrated the essential role of government spending in the increment of gross output in modern macro-systems and, thereby, provided the theoretical rationale for the existence of the so-called "Scandinavian" model of economic growth.

However, in the assessment of investment multipliers, there are many problems associated with the fact that their value varies greatly depending on the specifics of the sectors and territories, in which the investment process takes place. Actually, this fact allows to define the problem of growth areas in modern macro-systems, while the theoretical constructs (including those in quantitative models) sometimes feature the "average" values of investment multipliers.

When we turn to the origins of the theory of multiplier effects, one can notice that, generally speaking, such effect can emerge in any field when an increment of any type of costs generates more significant (multiplied) quantitative results. In the economy, the effect of this type was first identified by R. Kahn. Moreover, it was determined by the ratio of change in domestic investments to variations in the number of employed [7].

According to this understanding, when describing the standard investment multiplier, J. M. Keynes raises the question of its quantitative increase rather than the one on the origin of public wealth. In his theory, the gross output of macro-systems is generated by investments [8], but where do they come from? On the one hand, the savings are "pumped" into investments. However, on the other hand, the investment multiplier is tied to consumption rather than to savings. This implies the so-called "paradox of thrift" and other paradoxical (though maybe less well-known) theoretical constructs [9]. All these paradoxes exist only in the minds of people who write textbooks on economic theory, and partly in the minds of those who read them, but, in the real life, these paradoxes do not exist.

We can say that, from the point of view of the Keynesian doctrine, the separation of the gross domestic product of a closed macro-system into consumption and savings makes sense only in the short-term horizon. But, in the long run, yesterday's savings will sooner or later turn into consumption, be it personal or investment. However, this observation explains (although partly) the same paradox of thrift (which, as we know, expresses the contradiction between the short- and long-time horizons), but it does not make more accurate the explanation provided for the origin of investments in the short term.

Before moving on to practical calculations, we need to present a number of other theoretical considerations.

1. Two things often not mentioned in the textbooks of economics are required in order to ensure work of the investment multiplier (i.e. to ensure that the volume of investments really becomes a constituent part of the aggregate demand).

First, the macroeconomic system must have a certain volume of idle resources (the current volume of GDP should be sufficiently less than its potential volume). If any public resources are close to exhaustion, then the higher investment spending can only cause the inflationary overheat rather than the increase in the current level of GDP. This is essential for successful application of "Keynesian" measures to stimulate the GDP growth by influencing the aggregate demand.

Secondly, the investments in the economy must be accompanied by the creation of real goods that are adequate in terms of their value. If the investments or consumption expenditures (in this case, regardless whether they are private or public) go into thin air without bringing any positive results, the macroeconomic system experiences the cost inflation instead of any multiplier effect.

2. Like in the times of growth, the economy in crisis also has its investment multiplier. The only difference is that it works in the opposite direction. While the healthy, growing economy has the investment multiplier, the economy in crisis enables the multiplier of non-payments. For example, in the mid-1990's, every ruble of domestic public debt in Russia (delayed wages and social transfers from the state budget) led to the loss of 5–6 rubles in the aggregate volume of GDP. But in the growing Russian economy of the mid-2000's, every ruble of government spending brought a little more than 2 rubles of short-term GDP growth.

We should note that in times of crisis, with the declining living standards, there is a higher marginal propensity to consume (MPC) and, therefore, a higher value of investment multiplier. As a result, the multiplier has its maximum value in the period when the impact of the multiplier effect the economy is the most destructive. This "asymmetry" of multiplier effects is one of the key reasons why the decline in physical volumes of production always takes place faster than the post-crisis recovery of the macroeconomic system.

As for other types of multipliers, the cyclical "pulsations" of investment multiplier are usually not reflected neither in theoretical constructs nor (and even more so) in the elaboration of macroeconomic policy measures. However, when these facts are not taken into account, counter-cyclical regulation of the economy ceases to be scientifically valid. It is because the cyclic dynamics of multipliers are the central point that allows to understand the modification of the current industrial cycle and adopt the appropriate practical solutions aimed at cushioning the adverse effects of economic crises.

The Russian economy is fluctuating near the zero growth mark over the recent years. Therefore, it would be interesting to understand how investment process impact on the economic growth of the country and its regions; and what are the growth areas (the groups of sectors, the investments in which ensure the maximum multiplier effect); and what is the impact of investments in individual sectors of the economy on the dynamics of the gross output in other sectors (as the calculation of the so-called "cross-multipliers" is associated with that impact)

For calculations, we considered the case of the economy of the Republic of Tatarstan, for which we obtained well verifiable long-term time series of statistical indicators.

Empirical Data

The Republic of Tatarstan has a diversified structure of the economy. The main natural wealth of Tatarstan is its oil, as there are more than 120 discovered fields with the estimated time of exhaustion of 30–40 years. The Republic is also producing natural gas, brown coal, building materials, and other natural resources. In addition, the fertility of soils allows developing the agriculture. The industrial sector and a powerful construction base play a special role in the economy of the Republic. The structure of gross value added by economic activity in 2015 is presented in Figure 1.

The industrial sector is very diverse and largely focused on processing of oil and agricultural products. However, among the manufacturing sectors, a significant share is held by the chemical industry (including the enterprises of Tatneft Group), manufacturing of vehicles and equipment, rubber products and plastics, etc. (Fig. 2).

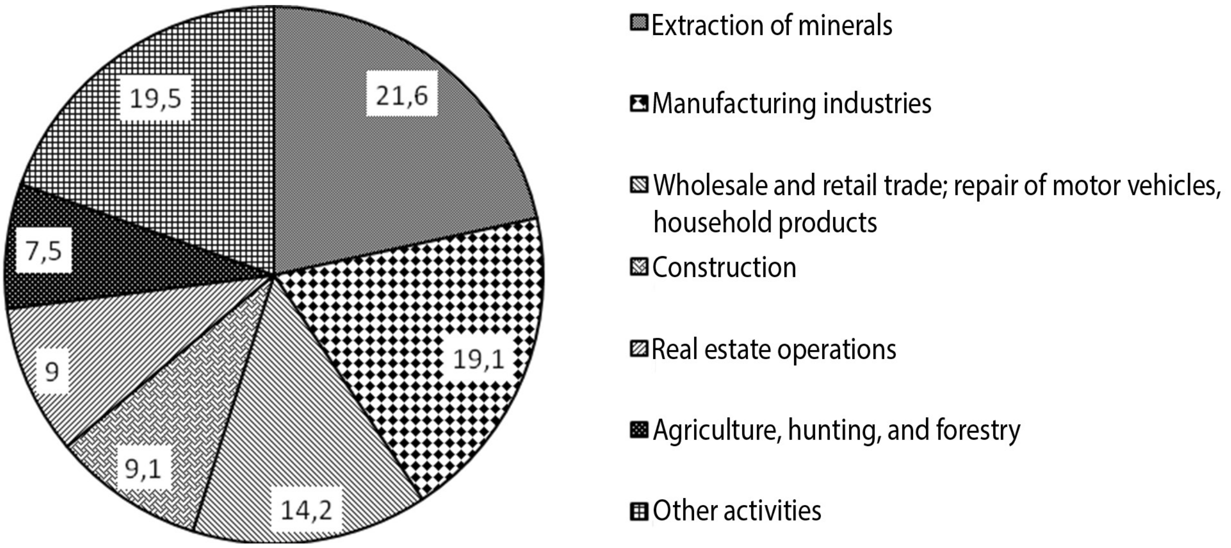

Fig. 1. *The structure of gross value added of the Republic of Tatarstan in 2015, % (compiled by the authors with the data provided by the Regional Authority of the Federal State Statistics Service in the Republic of Tatarstan. Retrieved from: http://tatstat.gks.ru/wps/wcm/connect/rosstat_ts/tatstat/ru/statistics/grp/ [date of access: 11/28/2017])*

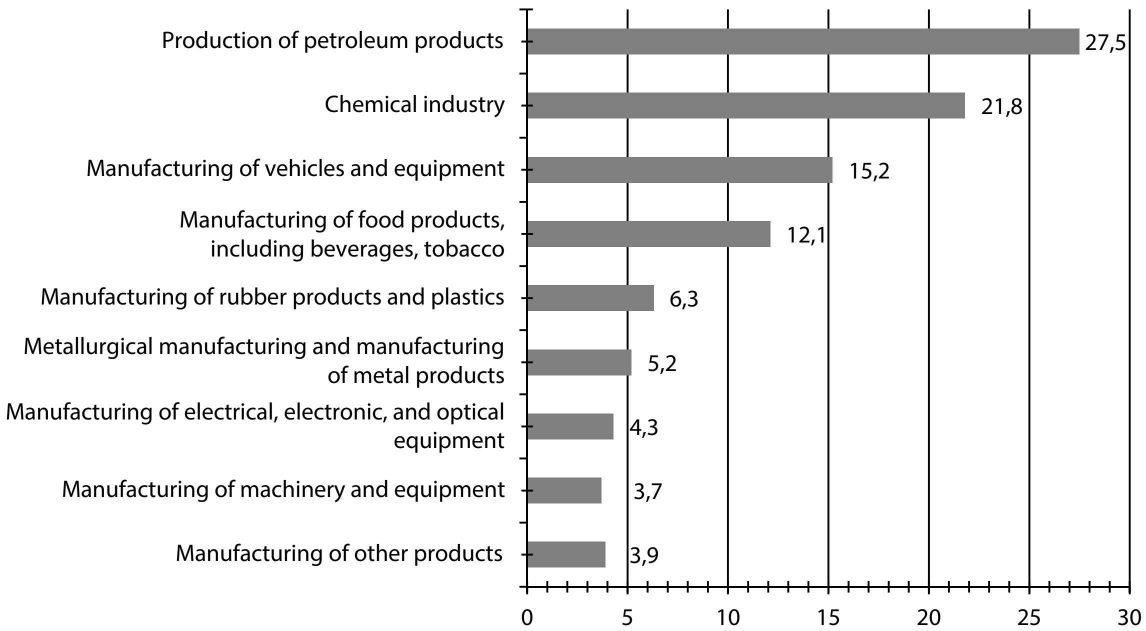

Fig. 2. *The structure of manufacturing sectors in the Republic of Tatarstan in 2015, % (source: State program "The Development of Manufacturing Sectors of the Republic of Tatarstan in 2016–2020." Retrieved from: http://anticorruption.tatarstan.ru/rus/file/corrupt/corrupt_19657.pdf [access date: 11/28/2017])*

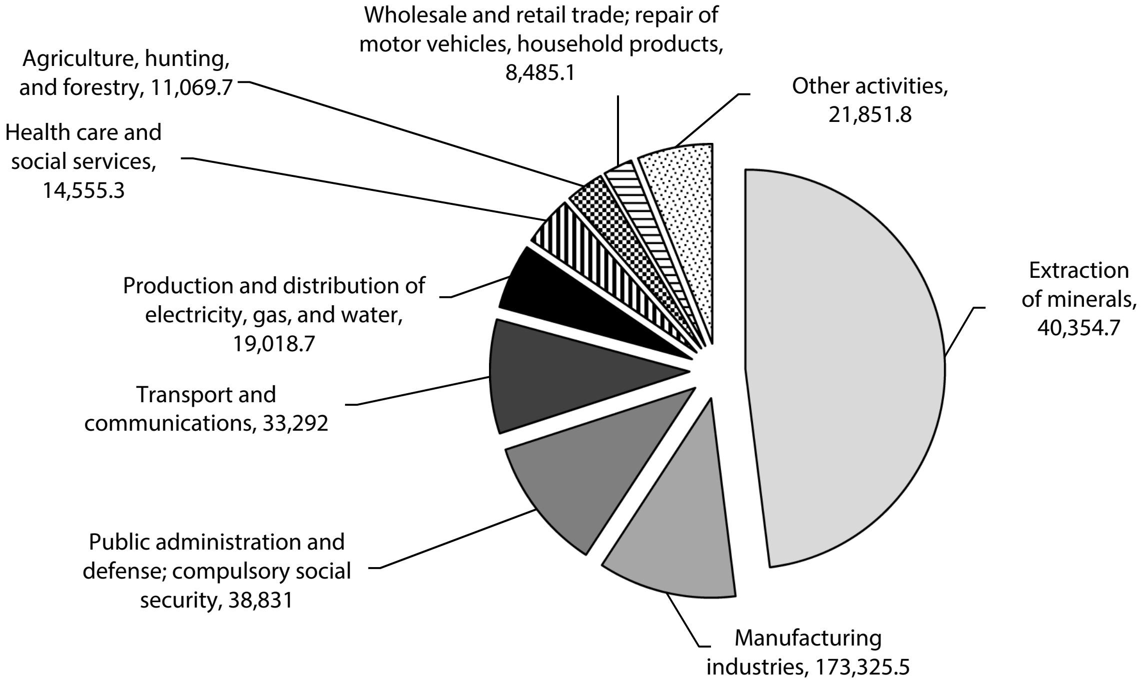

Fig. 3. *The structure of investments in fixed capital by economic activities of the Republic of Tatarstan in 2015, % (source: prepared by the authors based on data from the statistical compilation "Regions of Russia. Socio-Economic Indicators. 2016." Federal State Statistics Service. Moscow, 2016, pp. 1262–1263)*

Figure 3 presents the structure of investments in the fixed capital of the Republic of Tatarstan by economic activities.

As we can see, most investments are made in manufacturing industries. The second rank in terms of investments in fixed capital is held by mining and public administration; the third rank is held by transportation and communications. Nevertheless, the large volume of capital investments does not guarantee a proper level of development in the relevant sectors. In particular, the investments in the social sphere often fail to bring any value added. At the same time, the investments in lagging technology may be of dissipative nature [10]. Spontaneous investing, which is not based on scientific approaches and preliminary analysis of return on investment, including by specific sectors, can lead to the ineffective economic structure of the region. This article actually discusses the measurement of potential effects related to investment processes.

Theory of Multipliers and Methods of Measurement of Multiplier Effects

Any investment impulse generates the impacts which, by their nature, point to different directions. Investments may be viewed as the tools for allocation of resources to specific areas in the development of macro-system. However, amid the limited availability of certain types of resources (in cases, when the assumption on their limited availability should be recognized as likely), the development of some areas depletes the others by depriving them of the necessary capacity.

In this case, the multiplier effects, like all other effects measured in increments, express the short-term impact, even if this impact is averaged over a number of years. This is associated with the fact that the quantitative assessment of multipliers is always performed by using the linear functions — whatever is the global dependence between the studied variables, any smooth curve can be locally (in a sufficiently small neighborhood of each of its points) approximated to a straight line.

Therefore, in recent years, there has been a natural increase of interest to the assessment of sectoral multipliers, namely, to the measurement of the impact of investments in a particular sector on the gross output of macro-systems, level of employment, personal income, and total value added (national income). It is often emphasized that, along with the direct effects, it is also necessary to discuss and quantify the induced, indirect effects [11].

In strict accordance with the described methodology, there are papers that assess the multiplier effects of investments in a particular sector on the economy of the region. For example, L. V. Kievsky, in his article, [12] uses simple algebraic calculations to establish the assessment of impact made by the construction sector of the city of Moscow on the gross output of other sectors, employment, and *GRP* of the entire region.

The cross-sectoral investment multipliers are most often determined by using balance and pseudo-balance input-output models of W. W. Leontief; sometimes, such cross multipliers are called "matrix multipliers" (see [13–15], etc.).

To algebraic calculations, we prefer econometric (in particular, regression) models which, in a certain sense, act as a universal tool for data mining. Pseudo-balance models and calculations made on their basis rely on the assumption that all data involved in the calculation are absolutely accurate (as if there were no errors of measurements and calculations), and all factors involved in the model make a significant impact on the variation of the considered variable. In addition, within the balance methodology, it is impossible to check the exact accuracy of discussed results. There is some irony in the fact that supporters of pseudo-balance models are often convinced that their conclusions are correct and, at the same time, have absolutely no apparatus to confirm that.

This shortcoming can be successfully overcome by econometric models. In this case, for any '*N*' unknowns, we (usually) have at least $1/2\ (N^2 + N)$ equations and, along with the best approximation, we get an approximate (stochastic) answer to the question about the accuracy of such approximation which is, of course, much more valuable. Moreover, the statistical characteristics of the model allow to make sure that the built model is adequate and meaningful, and provide an opportunity to make at least a rough estimate of the contribution made by each of these factors of the model to the final result — i.e. the variation of the considered variable. The regression models allow to determine the accuracy of a particular result and, when necessary, to include or exclude explanatory variables until obtaining a model with an acceptable level of adequacy.

This is why, in recent years, there have been the papers using pseudo-balance approaches based on regression analysis. As an example, we can mention a preprint [16] that calculated the cross-multipliers reflecting the impact of investments in the energy sector on the development of other sectors. Moreover, in this case, the assessment is based on regression models using the improved input — output matrices or the so-called "Social Accounting Matrices" (SAM). For more details on SAM, see [17].

From the point of view of assessing the mechanism of the accelerator multiplier in terms of stimulating the demand and calculating the total increase in investment caused by initial investment impulse, there are also interesting papers written by V. V. Eremin [18, 19].

In the past 15–20 years, the researchers paid much attention to multiplier effects caused by investments in the defense sector of the economy. Moreover, this included the assessment of the indirect impact on the gross output of other sectors and macro-system in general, as well as on the employment. For today's US economy, including at the different phases of the industrial cycle, this issue is fairly well researched [20, 21].

This generates the logical questions on the value of government spending multiplier in the economy in general and also by various areas of government spending, including the state contracts (procurement) and social transfers. The assessments allow to understand the answers to not-so-obvious questions, such as whether the government spending in the US economy during the crisis contributes to higher employment, and whose welfare actually improves as a result of growing social transfers. In this regard, we should mention the classical works of Robert Barro and Charles Redlick [22], as well as L. Cohen, J. Coval and C. Malloy [23], and their colleagues [24–26].

We should note that the multiplier effect describes the short-term impact of government spending on economic growth of countries and regions, while the medium-term effects of this type (applicable to time horizons that are commensurate with the duration of industrial cycle) are expressed by nonlinear dependencies, namely, the Armey — Rahn curve, and there are many substantive papers on this issue assessing the parameters of relevant curves by using the regression models for the economies of various countries at different time periods [27–29].

The neoclassical Cobb — Douglas model [30] is often used to identify the relative indicators reflecting the impact of investments involved in the production.

The standard Cobb — Douglas production function is a power function:

$$Y = r \times K^{\alpha} \times L^{\beta}, \tag{1}$$

where *Y* is the result of economic activity, such as *GRP*, *r* is the scale factor expressing the dependence of *Y* from all other factors of production which are not the capital (*K*) and labor (*L*).

In some cases, the role of variable '*K*' in this formula is assumed by the volume of investments in fixed capital rather than the value of applied fixed capital. In that case, the exponent at this parameter reflects the elasticity of output in terms of investments in fixed capital.

Recent years have seen the spread of various modifications of Cobb—Douglas production function which, in addition to the cost of fixed capital and live labor, include a number of other factors, such as the R&D or R&D and innovation expenditure [31]:

$$Y = r \times K^{\alpha} \times L^{\beta} \times I^{\gamma}. \tag{2}$$

The application of these models by using the regression analysis allows to assess how the volume of gross output depends on various factors, including those with distributed lags, and excluding insignificant factors, and to identify the set of them, on which actually depends the variation of the variable to be explained. This methodology allows to make meaningful conclusions regarding the behavior logic of macro-systems and to forecast their dynamics depending on changes in certain parameters.

A similar methodology was used in this article. It is necessary to identify a set of industries, on the investment to which actually depends the dynamics of regional *GRP* (to do this, we need first to group the relevant sectors), and then we can calculate the sectoral and intersectoral multipliers and the elasticity of various macro-parameters in terms of investments in specific groups of sectors.

The problem of assessing the elasticity of gross output in macro-systems or individual sectors of the economy in terms of investments in other sectors is also being actively discussed and studied [32, 33]. In this case, the assessment of the impact made by investments in information technology is usually interpreted by taking into account the indirect, induced effects, which are called in that specific area the "spillover effects" [34, 35].

We should mention the paper [36], in which the regression models with distributed lags are used to calculate the elasticity of both the gross output in China and cross-elasticities caused by the transition to new energy sources and their impact on the dynamics of the transportation sector in the country.

The Production Functions of Regional *GRP* Built Based on Investments in Individual Sectors

Before calculating the indicators of investment efficiency, we will build the production functions. They designed to answer the question of what exactly are the sectors where the investments in fixed capital are significant for the Republic of Tatarstan in terms of changing its gross regional product. Under the sectors, we mean the economic activities as defined in OKVED (All-Russian Classifier of Economic Activities), because the information in statistical compilations "Regions of Russia" is presented in this context (Table 1). The sample size includes the period from 2005 to 2015; the information for later periods is not provided in the official sources.

To exclude the effect of inflation on the relationship between the indicators, we used the regional price indices of manufacturers of industrial products for the period of study to bring all data in Table 1 to the prices of the base year of 2005, which was relatively stable for the economy of Russia in general and the one of Tatarstan, in particular.

Given the significant number of sectors compared to the sample size, at the beginning of the study, all sectors were grouped and, after eliminating the accumulated parameters with no significant effect on the volume of regional *GRP*, we obtained the following production function:

$$Y = \underset{(19.228)}{1812.277} \times \underset{(5.790)}{(I_4 + I_6)^{0.166}} \times \underset{(1.948)}{(I_3 + I_5)^{0.082}} \times \underset{(3.577)}{(I_7 + I_8 + I_9)^{0.056}}. \tag{3}$$

Its coefficient of determination is equal to 97.3 %; the *F*-criterion is significant at the significance level of 0.01; the parameters are significant at the significance level of at least 0.1 (*p*-values for each regressor do not exceed 0.1). The parentheses under the values of coefficients contain values of *t*-statistics for each regressor.

The coefficients of the model (3) indicate that the aggregate investments in the following sectors make a significant impact on the volume of *GRP* in the Republic of Tatarstan:

— manufacturing industry and construction (elasticity of output in terms of aggregate investments is on average 0.166 during the period of study);

— mining, production, and distribution of gas and water (elasticity of *GRP* in terms of investments in fixed capital in these sectors is 0.082);

Table 1

GRP of the Republic of Tatarstan and investments in fixed capital by sectors of the economy for 2005–2015, mln rub.

	GRP, Y	**Investments by sectors***							
		I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8
2005	482,759	3,673	12	11,117	18,699	4,183	1,574	5,327	97
2006	605,912	9,406	27	13,537	30,418	3,833	1,687	2,841	1,406
2007	757,401	18,688	18	16,496	43,851	4,976	2,401	3,215	194
2008	926,057	11,134	13	22,810	57,539	7,632	6,866	6,240	271
2009	884,233	12,408	5	18,825	73,124	9,775	3,182	3,177	213
2010	1,001,623	16,209	2	2,1920	75,098	9,796	3,368	4,883	523
2011	1,305,947	14,928	2	25,518	72,947	11,603	6,774	4,928	546
2012	1,437,001	14,711	—	32,740	84,044	13,514	5,343	7,480	701
2013	1,551,472	12,209	—	40,633	116,182	22,321	4,743	6,656	1,067
2014	1,661,414	8,883	—	37,849	161,674	16,084	5,417	9,457	872
2015	1,833,215	11,070	—	40,355	173,326	19,019	4,379	8,485	1,271

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	GRP, Y	**Investments by sectors***						
		I_9	I_{10}	I_{11}	I_{12}	I_{13}	I_{14}	I_{15}
2005	482,759	21,156	1,409	12,582	1,626	3,396	4,956	7,488
2006	605,912	14,363	1,808	13,249	1,235	2,445	3,553	6,112
2007	757,401	17,617	2,293	21,668	2,614	3,319	4,085	5,026
2008	926,057	21,150	2,377	27,033	2,402	4,270	3,260	4,348
2009	884,233	21,960	1,898	17,049	3,143	2,669	4,375	15,776
2010	1,001,623	33,667	1,311	26,409	2,819	5,871	4,221	7,531
2011	1,305,947	55,463	2,415	22,973	2,076	6,549	7,232	13,029
2012	1,437,001	52,027	2,175	27,139	4,269	8,220	8,046	18,404
2013	1,551,472	54,971	2,626	29,547	3,227	6,263	6,610	15,273
2014	1,661,414	32,105	5,855	2,781	41,460	2,869	10,944	4,015
2015	1,833,215	33,292	4,351	3,635	38,831	4,259	14,555	3,958

* The sectors correspond to OKVED classifier of economic activities and are numbered as follows:

1 — agriculture, hunting, and forestry; 2 fishing and fish farming; 3 — mining; 4 — manufacturing; 5 — production and distribution of electricity, gas, and water; 6 — construction; 7 — wholesale and retail trade; repair of motor vehicles, motorcycles, household goods, and personal items; 8 hotels and restaurants; 9 — transport and communications; 10 — finance activities; 11 — operations with real estate, leasing and provision of services; 12 — public administration and defense; compulsory social security; 13 — education; 14 — health care and social services; 15 — other utility, social, and personal services.

Source: Regions of Russia: Statistical compilations "Socio-Economic Indicators" for 2006–2016 published by Rosstat (Federal State Statistics Service).

— trade, repair of vehicles and household appliances, hotels and restaurants, transport and communications (elasticity is 0.056).

Since the aggregate elasticity of *GRP* in terms of investments in these sectors is just slightly over 0.3, and the intercept is also significant and fairly large in absolute terms, we can (despite the high explanatory power of the model) state that the gross output is largely dependent also on other resources involved in production, and not only on the amount of capital invested in these groups of sectors.

As the formula (3) contains the accumulated indicators, let's move to the factors reflecting investment in individual sectors by using the method of inclusion/exclusion of variables:

$$Y = \underset{(9.712)}{747.529} \times \underset{(3.720)}{I_{30.461}} \times \underset{(2.745)}{I_{40.152}} \times \underset{(2.016)}{I_{60.095}}. \quad (4)$$

Therefore, 95.6 % of the variation in *GRP* can be explained by the change of investments in three indicated sectors (mining, manufacturing, and construction). With a probability of 0.99, we can assert that the model adequately describes the initial data. The parameters are significant at the significance level of at least 0.1 (p-values for each regressor do not exceed 0.1).

Translation

For mining, the elasticity of *GRP* in terms of investment in fixed capital is 0.461; for the manufacturing sector, 0.152; and for construction, 0.095.

The value of the intercept dropped by more than half, and the total elasticity by model (4) factors is more than 0.7.

Such a marked improvement in the quality of the model compared to model (3) can be explained by the fact that three selected sectors (mining, manufacturing, and construction) together bring half of the gross value added in the region (see Fig. 1).

It should be noted that the investments in agriculture, service sector, financial sector, public administration, and social sphere do not make a particular impact on the change in volume of *GRP* in the Republic of Tatarstan. In contrast to formula (3), in (4), there are no investments in such activities as wholesale and retail trade, repairs, transport and communications, hotels and restaurants because, in the remaining set of regressors, the coefficients turned out to be insignificant following the investments in these sectors.

But the resulting models (3) and (4) only indirectly indicate the potential impact of investments on the volume of *GRP* as a whole. It is much more interesting to determine the impact of investments in the individual sector on the gross output of the same sector and its related sectors.

Determining the Elasticity of Sectoral Value Added in Terms of Investments

To determine the volume of gross output for each activity, we used the data on the sectoral structure of gross value added (Table 2).

After calculating the absolute value of the gross value added for each activity during the period of study, we can determine the elasticity of output in terms of investments in individual sectors.

By using the regression analysis tools, we obtained several significant models with high explanatory power and presented them in Table 3. Unlike the methodology described earlier in [37], in this study, we have not abandoned the use of intercept, which emphasizes the impact of other independent variables, that are not investments in the fixed capital, on the gross output of the sector.

Thus, with a moderate explanatory power of the models (5)–(8), when the change of investments in the sector only by 52–60 % causes the variation of the value added created in that sector, they adequately describe the initial data, since the Fisher criteria exceed the critical value of 5.11 at a significance level of 0.05. In these formulas, the exponent is the elasticity of the sector's value added in terms of investment made in that sector:

— when the investment in fixed assets used in mining increases by 1 %, the value added in the sector will increase on average by 0.34 %;

— the increase of investments in manufacturing by 1 % will lead to the increase of value added in the sector by 0.36 %;

Table 2

The sectoral structure of gross value added by economic activity in the Republic of Tatarstan in 2005–2015, %

	Number of industry*														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
2005	7.8	0	30.6	16.7	2	10.3	11.7	0.6	6.9	0.5	4.8	1.8	2.6	2.3	1.4
2006	7.9	0	27.8	20.2	2.3	6.9	12.4	0.7	7.8	0.3	6	2	2.4	2.3	1
2007	7.1	0	25.3	21.7	2.7	7.9	12.1	0.8	7.6	0.4	6	2.5	2.6	2.3	1
2008	7.3	0	21.9	19	3	10.5	13	1.2	8.3	0.5	7	2.6	2.7	2	1
2009	7.3	0	22.9	15.4	3	9	13.5	1.2	8.2	0.3	9.9	3.2	2.8	2.2	1.1
2010	5.1	0	21.6	17	3.3	9	14	1.2	8.4	0.5	11.3	2.8	2.4	2.3	1.1
2011	7.1	0	22.2	17	2.9	10.3	13.7	0.9	8.2	0.5	9.2	2.5	2.4	2.1	1
2012	6	0	21.8	18.3	2.5	10.4	14.7	1	7.5	0.4	8.9	2.9	2.5	2.1	1
2013	5.1	0	20.4	18	2.9	10.7	14.2	1	7.7	0.3	9.9	3	2.8	2.4	1.6
2014	7	0	19.8	18.6	2.4	9.2	14.8	1	7.8	0.3	9.4	2.9	2.9	2.5	1.4
2015	7.5	0	21.6	19.1	2.5	9.1	14.2	0.9	6.5	0.3	9	2.7	2.8	2.5	1.3

* For numbers of sectors, see Table 1.

Source: Regions of Russia: Statistical compilations "Socio-Economic Indicators" for 2006 — 2016 published by Rosstat (Federal State Statistics Service).

Table 3

The power models of relationship between the value added and investments in fixed capital of sectors in the Republic of Tatarstan for 2005–2015

Model number	Model*	R^2	*F*-criterion
(5)	$Y_3 = 5582.3 \times I_3^{0.34}$ (8.133) (3.110)	0.52	9.67
(6)	$Y_4 = 2{,}527.8 \times I_4^{0.36}$ (6.499) (3.199)	0.53	10.23
(7)	$Y_5 = 115.6 \times I_5^{0.58}$ (3.465) (3.660)	0.60	13.40
(8)	$Y_6 = 1{,}211.1 \times I_6^{0.51}$ (6.073) (3.357)	0.56	11.27

* Y_i is the volume of value added in *i*-th sector.
Source: prepared by the authors.

— in the production and distribution of electricity, gas, and water, the elasticity of value added in terms of investments is 0.58 %;

— in construction, the growth of investments by 1 % causes the increase of value added by 0.51 %.

In other economic activities, the value added has no elasticity in terms of investments in fixed capital. For these activities, the decisive factors of economic growth may be, for example, human capital, financial resources, infrastructure, institutional transformation, etc. By the way, the function (4) has demonstrated almost the same result, which reflects the significant relationship between the *GRP* of the Republic of Tatarstan and investments in the three areas indicated above.

Judging by the value of elasticity, the maximum returns are provided by investments in the distribution of electricity, gas, and water, followed by the investments in construction. Moreover, the impact of factors that are not taken into account in models (7)–(8) on the growth of production in the sector is minimal. It should be noted that the investments in fixed capital in the production and distribution of electricity, gas, and water make a substantial impact on the value added of this sector, but remain virtually insignificant for changing *GRP* as a whole.

Assessing Sectoral Investment Multipliers

To obtain the values of potential absolute growth of value added in each sector following the changes of investments in the fixed capital, we determined the sectoral multipliers. First, we calculated the initial increment in the value of investments (ΔI_i) and value added (ΔY_i) for each activity *i*. Next, we used the obtained increments to build the functions presented in Table 4.

In each of the formulas (9)–(12), there is no intercept, because, in the original models, it proved to be insignificant and was subsequently excluded, i. e. the functions that we built really reflect the value of the Keynes multiplier in its traditional form. As before, the significant models have been obtained only for some sectors. Moreover, we should note that functions (10) and (12) have low explanatory power (the coefficients of determination do not exceed 50 %), but they adequately describe the initial data at a significance level of 0.05. The regression parameter is also significant at a significance level of 0.05.

Table 4

The models of relationship between the initial increments of the value added and investments in fixed capital of sectors in the Republic of Tatarstan for 2005–2015

Model number	Model	R^2	*F*-criterion
(9)	$\Delta Y_3 = 5.21 \times \Delta I_3$ (4.468)	0.69	19.97
(10)	$\Delta Y_5 = 1.46 \times \Delta I_5$ (2.570)	0.42	6.607
(11)	$\Delta Y_6 = 8.91 \times \Delta I_6$ (7.038)	0.85	49.53
(12)	$\Delta Y_7 = 6.89 \times \Delta I_7$ (2.749)	0.46	7.55

Source: prepared by the authors.

Nonetheless, we will comment on the values of all resulting multipliers:

— the increase of investments in the fixed capital of mining industry by 1 mn rubles leads to the growth of value added in that sector by an average of 5.21 mn rubles;

— the increment of investments in the distribution of electricity, gas, and water by 1 mn rubles leads to the increase of value added by 1.46 mn rubles;

— the increase of investments in construction by 1 mn rubles results in an average increment of value added in the sector by 8.91 mn rubles;

— the increase of investments in wholesale and retail trade, as well as in the repair of vehicles and household goods by 1 mn rubles causes the growth of the value added by 6.89 mn rubles.

The resulting values of multipliers once again confirm the high importance of investments as a factor of production for such sectors as mining, distribution of electricity, gas, and water, construction and, in addition, the trade and repair of vehicles and household goods. It should be noted that, as shown by models (8) and (11), in the Republic of Tatarstan, the construction is the activity, where the investments in fixed capital generate the most significant return in terms of the multiplier effect.

However, for manufacturing, the model that evaluates the multiplier effect turned out to be insignificant (unlike the model assessing the function of elasticity).

Calculating Cross-Sectoral Elasticities and Investment Multipliers

Assuming that the gross output of the sector may depend not only on investments in the fixed capital of that sector, but also on investments in fixed assets of other activities, we calculated cross-elasticity of the manufacturing industry depending on investments in mining:

$$\underset{(2.615)}{Y_4 = 47.7} \times \underset{(5.292)}{I_{30.82}}. \quad (5)$$

For model (13), the coefficient of determination suggests that the change of investments in fixed capital in mining causes 76.6 % of the variation in the value added of the manufacturing industry. The function adequately describes the initial data, and its parameters are significant at least at a significance level of 0.05 (p-values for each regressor do not exceed 0.05).

We should note that the explanatory characteristics of the model (13) are much higher than for models (5) and (6), in which the elasticity of mining and manufacturing sectors is calculated in terms of investments in each of these sectors.

At the same time, the attempt to obtain a power function describing the relationship between the value added in the manufacturing industry and investments in the fixed capital of mining and manufacturing sectors has not been successful, as the coefficient at I4 turned out to be insignificant. The same happened with the relevant function used to simultaneously determine the multipliers of value added in manufacturing industry in terms of investments in both sectors.

However, we calculated the cross-multiplier:

$$\Delta Y_4 = \underset{(5.221)}{5.98} \times \Delta I_3. \quad (6)$$

This function has a good explanatory power — $R^2 = 0.75$; F-criterion and regression parameter are significant at a significance level of 0.01.

Thus, despite the fact that the multiplier of value added in terms of investments in the manufacturing industry could not be obtained, we calculated the multiplier for investments in the mining. It suggests that the increment of investments in the fixed capital of the mining industry by 1 mn rubles causes the value added in the manufacturing sector to grow by 5.98 mn rubles. The elasticity shows that an increase in investments in mining by 1 % leads to the growth of value added in the manufacturing by 0.82 %.

The results show that, in terms of the value, the development of the manufacturing industry in the Republic of Tatarstan, in a sense, has a stronger dependence on investments in the mining industry in that region than on those in the manufacturing. Therefore, it could be argued that the "core" of the manufacturing industry of the region is formed by production facilities focused on processing of raw materials produced by the local mining industry. In this case, it follows from the calculations that, in terms of the value, the results of economic activities in the manufacturing industry of the Republic of Tatarstan are largely determined by dynamics in the development of its petrochemical cluster, which does experience a shortage of fixed assets.

Translation

Conclusion

Based on the regression modeling, we assessed the sectoral and cross-sectoral investment multipliers in today's economy of the Republic of Tatarstan, as well as the elasticity of the gross output in the region and its individual sectors in terms of investments in various sectors of the economy.

The calculations allowed to identify the growth areas in the economy of the Republic of Tatarstan, which include the mining industry, manufacturing industry, and construction. In this case, the manufacturing industry is largely focused on processing of raw materials produced in the Republic. Despite extensive computerization of production processes in the region, the tertiary sector has not been making a significant contribution to *GRP* and aggregate value added. Moreover, the impact of investments in most sub-sectors of the service sector on output volumes in other sectors has not been particularly significant.

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