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The Role of Infrastructure Investment in Economic Growth and Balanced Regional Development

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ABSTRACT

The authors of the paper estimated infrastructure' impact to economic growth, which affects the regional balanced development. The **relevance** of the research is substantiated by the growing dynamics of investment of public funds in infrastructure development of regions. The **purpose** of the research is to determine the impact of infrastructure investments on economic growth and balanced regional development. The **objectives** of the research are: assessment of the impact of investment in infrastructure, assessment of GRP, price index in the regions, assessment of the ratio of population by regions of Russia with average per capita incomes, wages, investment in infrastructure, renewal of fixed assets and assessment of parameters for the balanced development of regions. The authors used statistical research **methods** (panel data, regression analysis) to identify cause-effect relationships in the process of growth and balance of the regional economy. The **scientific novelty** of this paper is the identification of disproportions in development of regions in comparison with the contribution of infrastructure to the regional economy. The **results** suggest that the volatility of infrastructure investment across regions remains high, with the contribution of infrastructure to economic growth and balanced development (p-values from 0.6363 to 0.9552). The authors **concluded** that the importance of infrastructure investments is one of the most important factors in achieving socio-economic development of the region. Infrastructure investment needs to be supported to reduce regional imbalances.

Keywords: balanced development; economic growth; infrastructure; infrastructure investment; regional development

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INTRODUCTION

Economic growth and balanced regional development are closely connected. In recent centuries, the world has been involved in a massive industrialization process with sustained quantitative economic growth of about 2% per year of real per capita income [1–4]. Russian economy was no exception in this process [5]. For many economists, such long-term economic growth has become illogical, for example, according to D. Ricardo [6] and J. Keynes [7] suggested that economic growth has to stop immediately. Most of these gloomy forecasts are based on assumptions about reducing returns to scale or increasing resource scarcity. In this regard, the study of regional development in Russia and its balance is relevant, as our country occupies a large geographical area, rich in resources and there are about 146 mln people.

Economic crises, especially caused by the recent COVID-19, media recession and popular political literature is associated with economic instability [8, 9]. Some economists, sociologists and political scientists argue that economic crises create unbridled capitalism, and markets need to be regulated and controlled economically [10].

Quantification — is the first stage in identifying causal relationships in the balanced economic development of regions. Any quantification requires measurement and identification of the most relevant influencing factors this or that indicator. Assessment the balance between regional development and the role of infrastructure in changing the domestic regional product (GRP) is important. The fact is that the infrastructure relates to the fixed assets that are needed for the daily functioning of the economy: it is equipment and facilities, including transport, roads, bridges, sewerage systems, water supply, power supply and communications, including facilities, needed to operate the Internet [11]. That is, infrastructure affects most of the socio-economic development of the region to some extent.

ECONOMIC GROWTH AND INFRASTRUCTURE IN BALANCED ECONOMIC DEVELOPMENT

In terms of balancing regional development, infrastructure spending is crucial to respond to its impact on the region's economy. The fact is that the money for infrastructure development is either for repair or construction, and the rate of return cost — is different. All this as a result affects the regional balance [12]. Different construction and repair times lead to different results [13]. Repairs give people jobs and speeds up regional growth in the short term [14]. Constructed buildings — are long-term economic objects. Both are important for the process of value addition, productivity and growth potential of the regions in both the short and long term [15, 16].

Another factor determining the rate of return on infrastructure costs is the intensity of future infrastructure use [17, 18]. Thus, the quantitative growth of regional economies is always the focus of economic analysis [19]. The primary problem focuses on the growth rate in equilibrium when modelling the economic growth of the region.

In economics, general equilibrium theory explains the behavior of demand [20, 21], supply and prices in general with several or many interacting markets and proves that the interaction of supply and demand will result to a general equilibrium [22–24].

It should also be taken into account that the theory of general equilibrium differs from the theory of partial equilibrium, which analyses only a certain part of the economy in order to study the balance of regional development. In a general equilibrium, permanent impacts are considered non-economic, so they go beyond economic analysis. Therefore, non-economic impacts may be volatile when economic variables change, and the accuracy of the forecast may

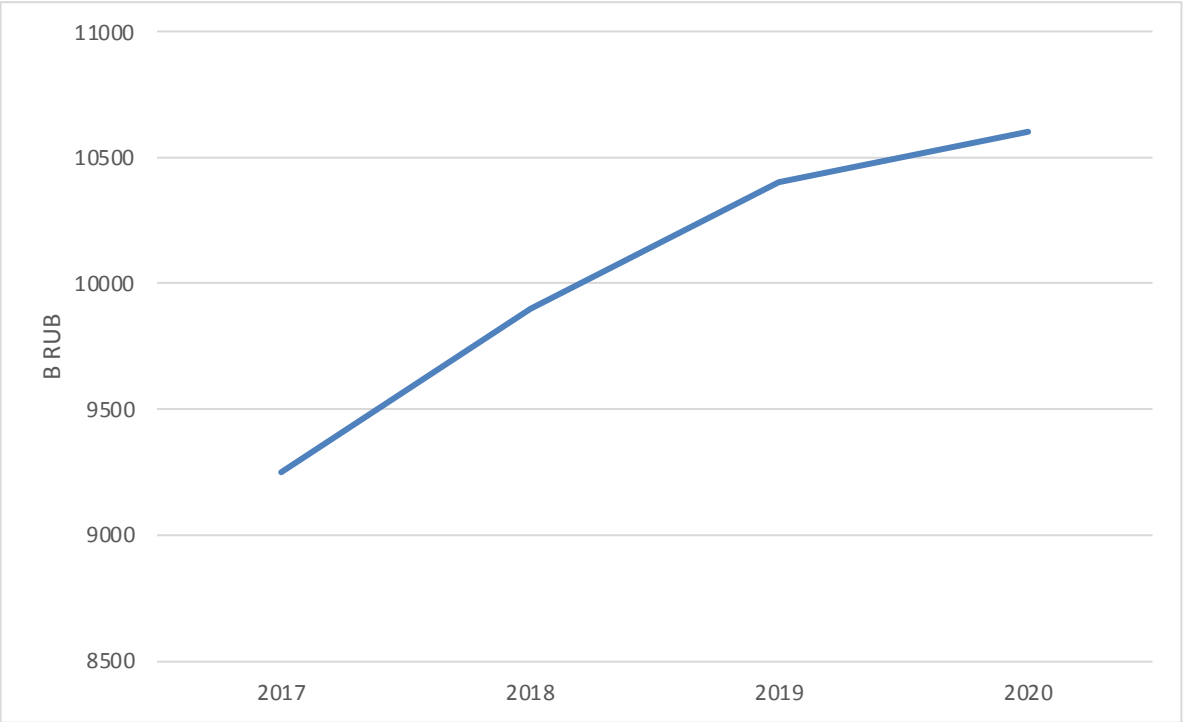

Fig. 1. **Investments in Infrastructure in 2017–2020**

Source: Compiled by the authors.

depend on the independence of economic factors.

In addition, in assessing the balanced development of the Russian regions, it is reasonable to apply the modern concept of general equilibrium, which is presented by the model developed jointly by K. Arrow, G. Debreu and W. Lionel, so-called Arrow-Debreu theory [25, 26]. The fundamentals of the theory, which must be considered in the regional vision of balanced regional economy, relate to three things.

First, it is assumed that goods differ in the place of production and delivery.

Second, it is assumed that the goods differ in their delivery times. This means that all markets are balanced at some initial point in time.

Third, delivery terms, i.e. equilibrium contracts, affect whether and how the goods are delivered.

That is, following the logic of Arrow-Debreu theory, economic theory focuses its equilibrium formulation on the combination of real interest rates (which affect contracts and supply terms) and prices that ensure the sustainable movement of goods, to which infrastructure contributes.

Also note that in recent decades the role of endogenous technological changes through research and development is becoming increasingly important [27]. These include investment in infrastructure, which uses new materials and technological developments of construction. If we take a look at this dynamic, investment in infrastructure has been steadily increasing in Russia for recent years (*Fig. 1*).

The fact is that long-term growth rates tend to increase over time as new waves of the economy come into industrialization and modernization. There have been various explanations for this tendency to increase the quantitative rate associated with infrastructure modernization.

First, there is a clear advantage of organizational and technological improvement, which increases over time as a consequence of the ongoing process in an increasing number of infrastructure enterprises.

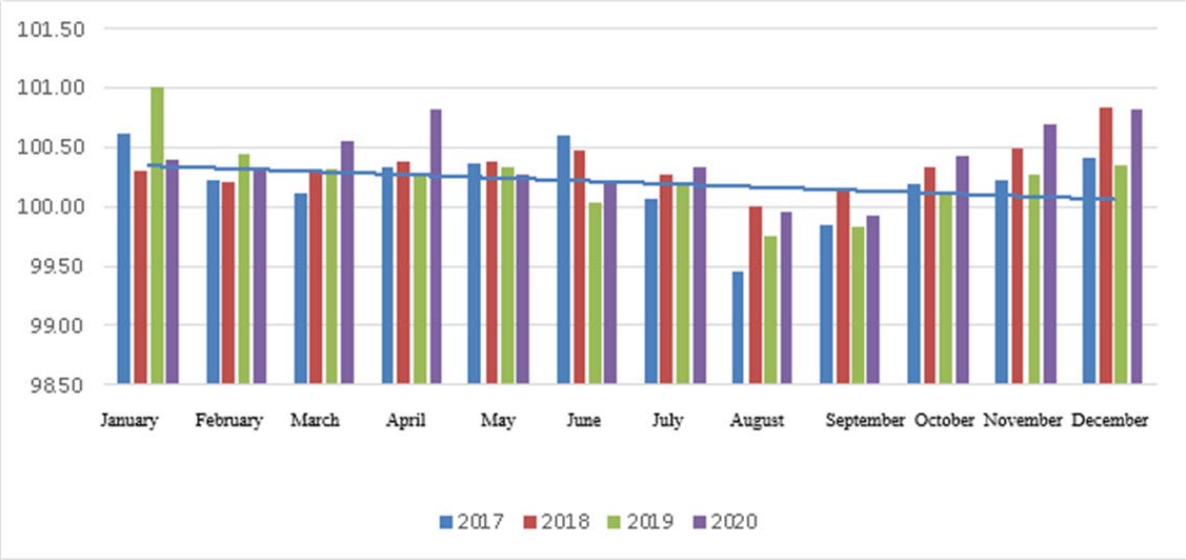

Fig. 2. **Change in the Price Index in the Regions for 2017–2020**

Source: Compiled by the authors.

Second, with expansion of industrialized regions, social capital in the form of hard and soft infrastructure is expanding and can be used at minimal cost in new regions.

However, economic growth through infrastructure modernization provides not only additional development benefits. One of the most significant impacts is the growing demand for free time following an increase in real per capita income. The steady increase in the number of workers in various industries is fully offset by a corresponding decline in the supply of labour per capita. It follows that the quantitative increase in infrastructure resources is primarily in terms of real capital growth. Thus, growth by the development of infrastructures in all directions is interesting to identify the balance of development of the regions.

METHODS OF RESEARCH

To evaluate the balance of regional economies and the role of infrastructure in this process, the authors selected the period 2017–2020. As the lower border we stopped for 2017, as it is new method of calculations, modified by the Federal Service of State Statistics, started working from this year. The study considered 85 regions of the Russian Federation, which ensures that the sample is representative.

Selection of parameters and assessment models

In order to evaluate the growth of Russian regional economies, according to the Arrow-Debreu theory, the focus should be on a combination of real interest rates and prices that ensure the sustainable movement of goods. But in the theory of Arrow-Debreu there is another important factor — the terms of delivery. It is infrastructure that provides the conditions of production and delivery, in connection with which prices are formed [28].

Since the interest rate of the Central Bank for the studied period in the regions is the same, let's consider the equilibrium of the price index change for 2017–2020 (*Fig. 2*).

As we can see, according to the graphics presented in the *Fig. 2*, the price deviations refer to seasonal changes (summer recession) and annual price changes are at 0.3%. Thus, when selecting the parameters of assessment, we can safely lower the terms of delivery and price in the assessment of balanced development of regions.

There is the following clarification. Economic growth creates capital investment

and a productive sector that turns these capital investments into goods. The production sector — is the real economic units that produce goods. Interaction of subjects of reproductive process, rhythm of work and supply of enterprises provides resources of enterprises: labor, material. Each region has a certain amount of labour and material resources, so each region is able to produce only a certain number of goods, the cost of which will be included in the cost of production.

In addition to investment and production in the regional economy, indicators of supply and demand will still play a role, which relate to both production and wages, average per capita incomes, i.e. the possibility of purchase of goods produced.

We will choose the following evaluation parameters for economic growth and balance of economic development:

Y (GRP) — dependent variable;

regressors:

X_1 — population by regions of Russia;

X_2 — average per capita income;

X_3 — wage;

X_4 — investment in infrastructure;

X_5 — renewal of fixed assets reflecting the industrialization of the region's economy.

Then the general formula of the model Y (GRP) from the factors Xi will have the following form:

$$Y = \beta_0 + \beta_1 \cdot X + \varepsilon, \quad (1)$$

where Y — value of the dependent variable; X — value of the predictor variable (regressors); β_0 — constant; β_1 — regression coefficient; ε — random model error.

Suppose that the set of parameters contains some heterogeneity due to factors that are not considered in the model (1), and unobserved factors may correlate with model regressors. Panel data for 2017–2020 and a sample of 85 regions allow this heterogeneity to be taken into account by considering individual effects (fixed) for panel objects that reflect the impact of all variables — both observed and unobserved, taking different values for sampling objects but not changing over time.

We assume that errors are distributed normally, then the coefficient vector will also be distributed normally around the real value, and its variance can be estimated. This might be testing the hypothesis on zero coefficient equality, and therefore check the importance of predictors, i.e. whether the value of Xi strongly affects the quality of the built Y model.

Gauss-Markov conditions are checked and fulfilled in model [29, 30]:

- there are not heteroskedasticity of random model errors;
- there are not autocorrelation of random errors.

The study was conducted in two stages:

Stage I — compared the dynamics of indicators.

Stage II — estimation of correlation and identification of the most significant regressors for Y (GRP).

RESULTS

Stage I

At the beginning, we will assess the development of all indicators. Data: GRP (Y), population by regions of Russia (X_1), average per capita income (X_2), wage (X_3), investment in infrastructure (X_4), rate of change in fixed assets (X_5) for 2017–2020 (*Fig. 3–8*).

As see (*Fig. 3*), the largest deviations in the GRP level by region were observed in 2018 (R^2 = 0.0362). The other years did not show such dynamics.

Changes in the population level for 2017–2020 can be observed in the Astrakhan, Chuvash, Kirov, Mordovian, Penza regions, the Altai region (*Fig. 4*).

With regard to the linear estimation of the correlation in the years under review, 2019 was noted. Whether this was due to the fall of GRP in 2018, according to the above graphics, but as a possible reason for the

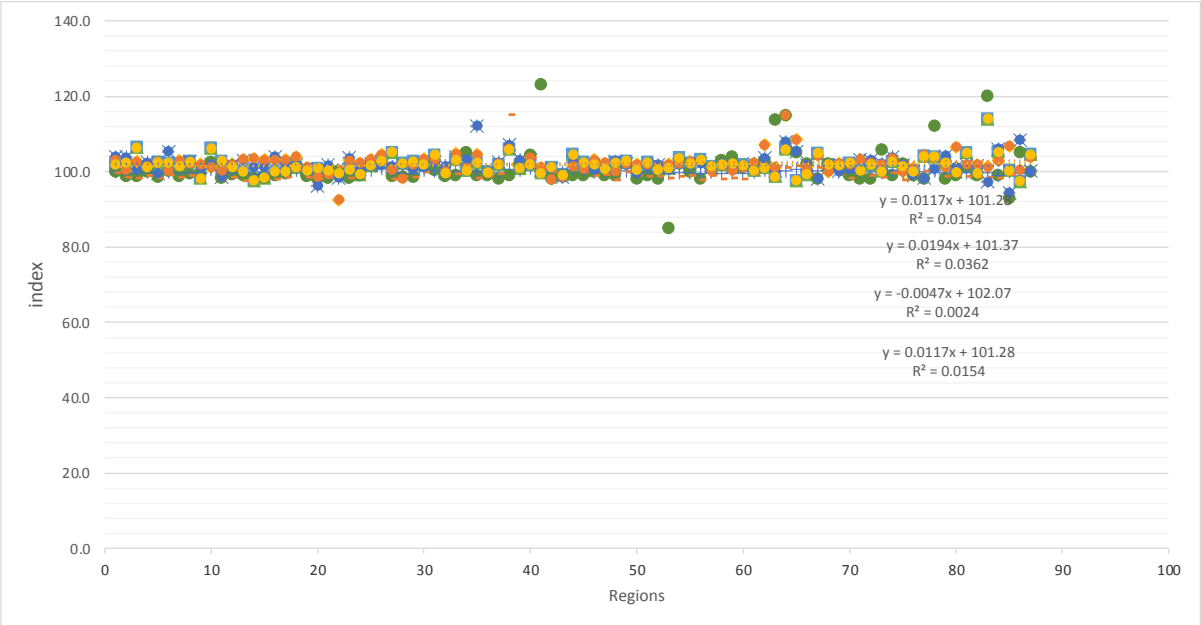

Fig. 3. **GRP of Russian regions (85 regions) for 2017–2020**

Source: Compiled by the authors.

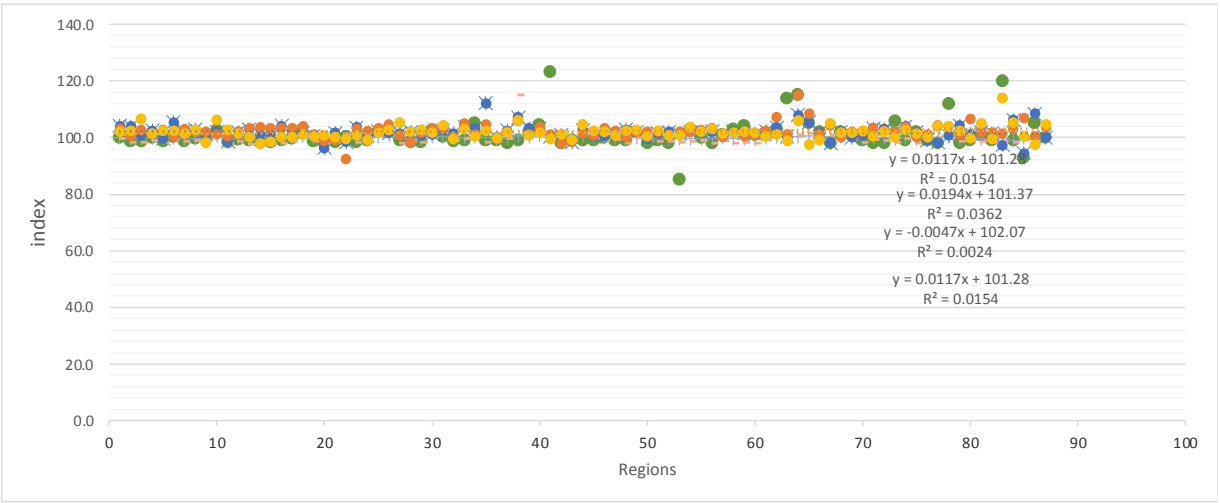

Fig. 4. **The population of Russia (85 regions) for 2017–2020**

Source: Compiled by the authors.

non-permanent migration of the population (work in other regions) can be noted.

Average per capita income (*Fig. 5*) varies significantly in 2017 R^2 = 0.064. The fall in average per capita income was observed in Kursk, Irkutsk, Buryat, Omsk regions, as well as in the Trans-Baikal region.

As for the average wage, as shown in *Fig. 6*, it varies considerably between regions. And in some regions, we see both a significant rise, especially in 2018 (Bryansk, Kostroma, Lipetsk, Arkhangelsk, Pskov, Ulyanovsk, Sverdlovsk regions), and a decrease in this indicator (Arkhangelsk, Bashkortostan, Khakassia, Kamchatka region, Chukotka). The principal changes occurred in 2020, R^2 = 0.0354.

The amount of investment in infrastructure (*Fig. 7*) varies greatly by region. Even excluding the Republic of Crimea (which

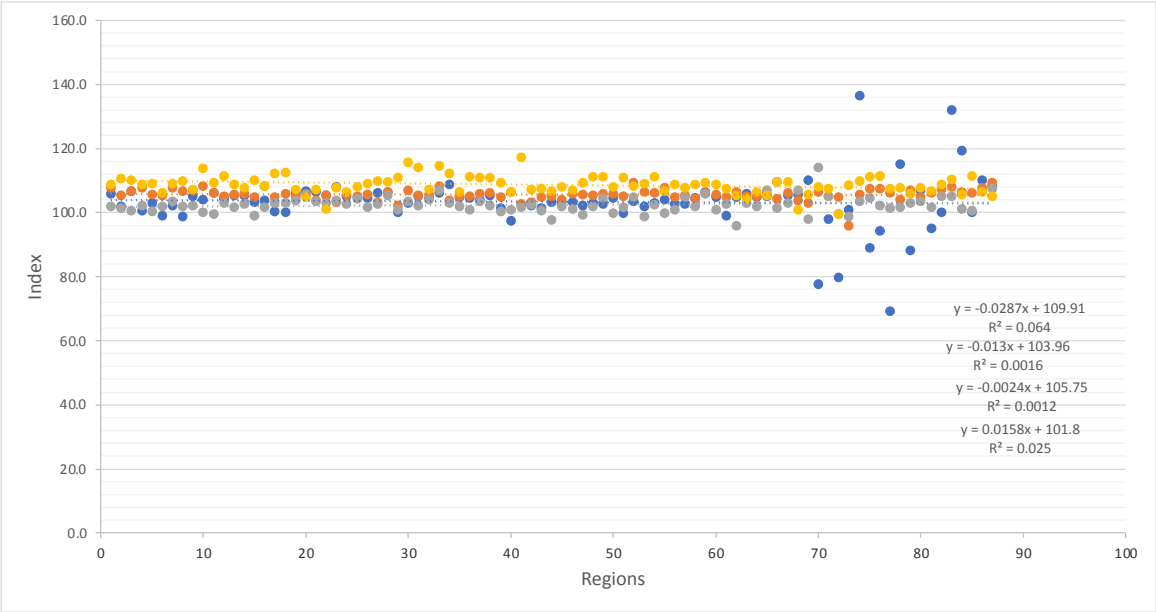

Fig. 5. **Average Per Capita Income of the Population of Russia (85 Regions) for 2017–2020**

Source: Compiled by the authors.

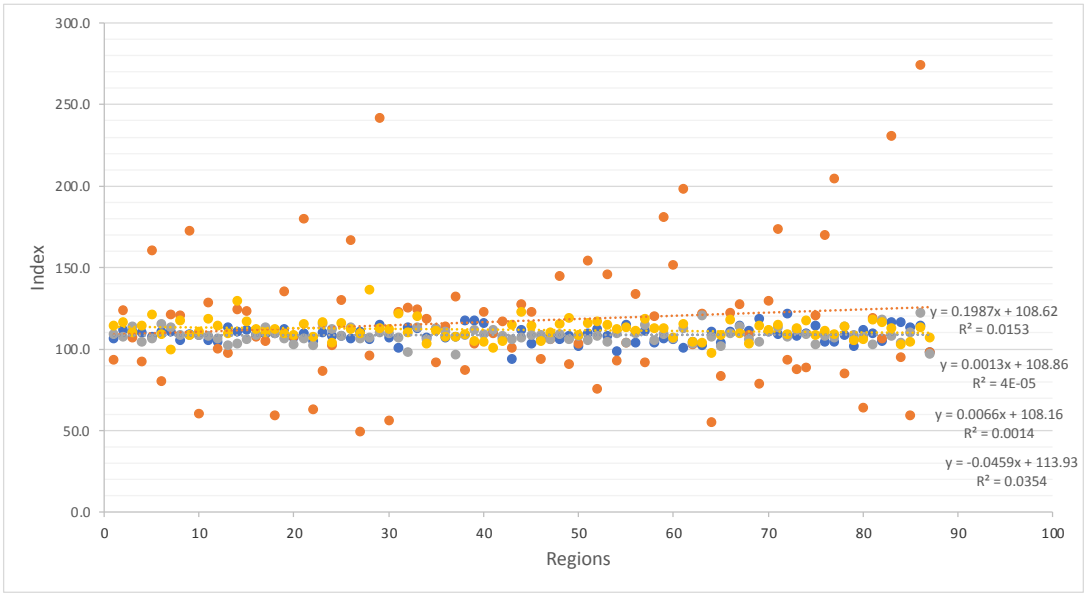

Fig. 6. **Average Salary in Russian Regions (85 Regions) for 2017–2020**

Source: Compiled by the authors.

in 2018 was invested by 400% more than in 2017), it is clear that the level of investment in infrastructure differs significantly by region.

The rate of renewal of fixed assets in the years under consideration ranges from 3% (Ivanovo region, Primorsky region) to 23% (Trans-Baikal region) (*Fig. 8*). Remember that quantitative growth through industrialization, which includes fixed assets, provides not only additional benefits of growth, but also long-term economic growth, which, following an increase in real per capita income, is a precursor to the growing demand for free time.

Thus, in Stage I we identified linear causal relationships for each parameter to assess the correlation (1).

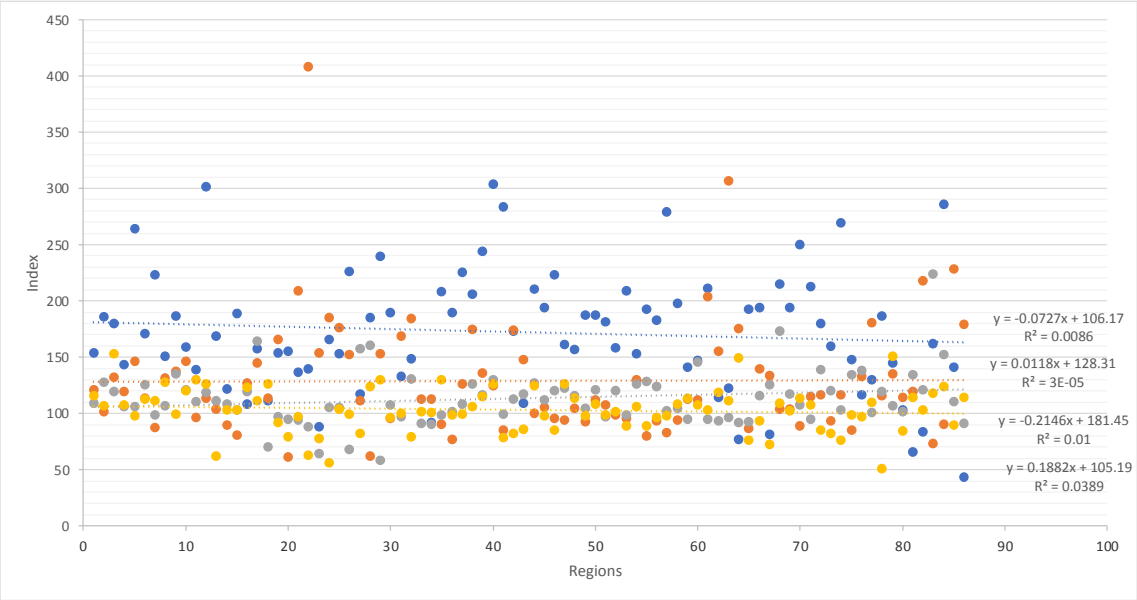

Fig. 7. **Investments in Infrastructure by Russian Regions (85 Regions) for 2017–2020**

Source: Compiled by the authors.

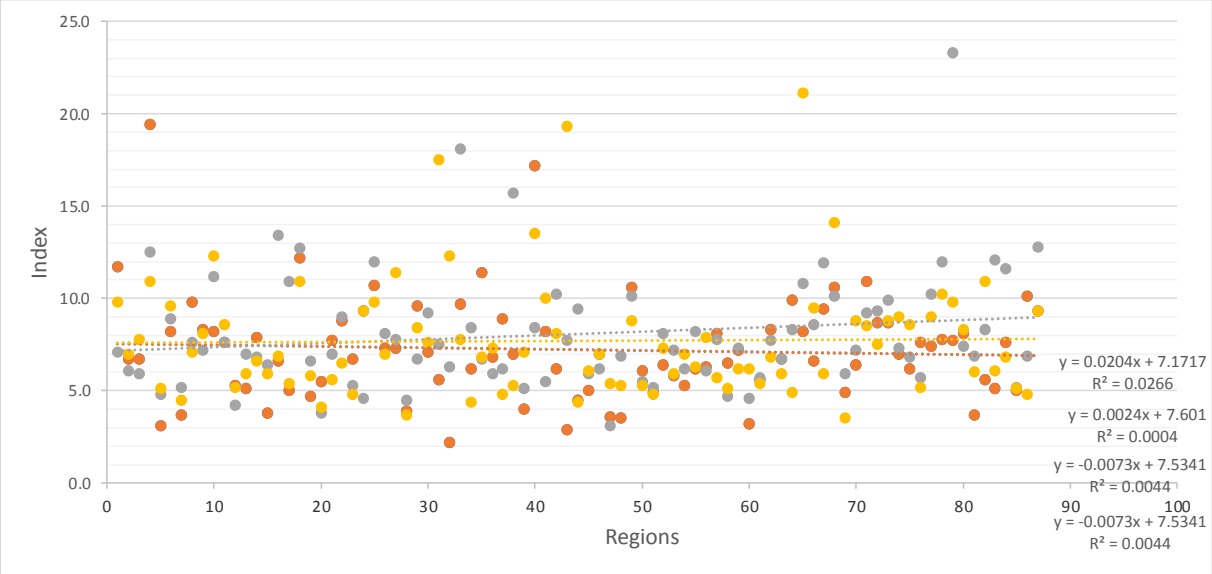

Fig. 8. **Coefficient of Renewal of Fixed Assets, by Russian Regions (85 Regions) for 2017–2020**

Source: Compiled by the authors.

Stage II

In the second stage of the study, we performed regression analysis based on the MLS for panel data 2017–2020 across 85 regions. The obtained results are presented in *Table 1*.

In 2017, the largest *p*- value of 0.9542 was obtained for X_4 — infrastructure investment. That is, the more investment — the more GRP.

So, as we can observe (*Table 2*), in 2018 the largest *p*-value of 0.9552 was also obtained for variable X_4 — infrastructure.

In 2019 (*Table 3*) the largest *p*-value of 0.8344 was obtained for variable X_2 — average per capita income of the population.

In 2020, the largest *p*-value of 0.6363 was obtained for variableX_4 — infrastructure investment.

Table 1

Regression Analysis of the Dependence of GRP on Indices of Changes in Indicators: Population, Average Per Capita Income, Wages, Investments in Infrastructure, Renewal of Fixed Assets in 2017

Regressors	Coefficient	Statistical error	*t*-statistic	*P*-value
X_1	–0.0158310	0.0173060	–0.9148	0.3630
X_2	0.217461***	0.0530676***	4.098***	< 0.0001***
X_3	0.721287***	0.0564953***	12.77***	< 0.0001***
X_4	0.000516632	0.00897457	0.05757	0.9542
X_5	0.268601	0.171884	1.563	0.1220

Source: Compiled by the authors.

Note: All tests confirmed the homoscedasticity of the residue (p > 0.05). The residue has a normal distribution (p > 0.05). *, ** and *** denote statistical significance at levels of 10, 5 and 1% respectively (Dickey and Fuller [30, p. 1057]).

Table 2

Regression Analysis of the Dependence of GRP on Indices of Changes in Indicators: Population, Average Per Capita Income, Wages, Investments in Infrastructure, Renewal of Fixed Assets in 2018

Regressors	Coefficient	Statistical error	*t*-statistic	*P*-value
X_1	0.0137956	0.0152299	0.9058	0.3677
X_2	0.954956***	0.0197554***	48.34***	<0.0001***
X_3	–0.00969721	0.00784437	–1.236	0.2199
X_4	–3.77876e-05	0.000670042	–0.05640	0.9552
X_5	0.150269	0.114950	1.307	0.1948

Source: Compiled by the authors.

Note: All tests confirmed the homoscedasticityof the residue (p > 0.05). The residue has a normal distribution (p > 0.05). *, ** and *** denote statistical significance at levels of 10, 5 and 1% respectively (Dickey and Fuller [30, p. 1057]).

We shall reduce the received data (*Table 5*).

Infrastructure investments show strong correlation with GRP. In this case, GRP is a significant parameter in assessing the balanced development of regions, as we quickly get the result on the produced infrastructure. If road construction efficiency has a long lag in GRP evaluation, then residential, office, storage construction, we can track already in the results of GRP change in a year.

Table 3

Regression Analysis of the Dependence of GRP on Indices of Changes in Indicators: Population, Average Per Capita Income, Wages, Investments in Infrastructure, Renewal of Fixed Assets in 2019

Regressors	Coefficient	Statistical error	*t*-statistic	*P*-value
X_1	1.05775***	0.112863***	9.372***	<0.0001***
X_2	−0.0205850	0.0981689	−0.2097	0.8344
X_3	−0.0447308	0.0561826	−0.7962	0.4282
X_4	0.0150266	0.0104515	1.438	0.1543
X_5	0.176674**	0.0793981**	2.225**	0.0288**

Source: Compiled by the authors.

Note: All tests confirmed the homoscedasticityof the residue (p > 0.05). The residue has a normal distribution (p > 0.05). *, ** and *** denote statistical significance at levels of 10, 5 and 1% respectively (Dickey and Fuller [30, p. 1057]).

Table 4

Regression Analysis of the Dependence of GRP on Indices of Changes in Indicators: Population, Average Per Capita Income, Wages, Investments in Infrastructure, Renewal of Fixed Assets in 2020

Regressors	Coefficient	Statistical error	*t*-statistic	*P*-value
X_1	0.192121*	0.112093*	1.714*	0.0903*
X_2	0.583255***	0.114930***	5.075***	< 0.0001***
X_3	0.145133**	0.0589802**	2.461**	0.0160**
X_4	−0.00923272	0.0194538	−0.4746	0.6363
X_5	0.0973739	0.117952	0.8255	0.4115

Source: Compiled by the authors.

Note: All tests confirmed the homoscedasticityof the residue (p > 0.05). The residue has a normal distribution (p > 0.05). *, ** and *** denote statistical significance at levels of 10, 5 and 1% respectively (Dickey and Fuller [30, p. 1057]).

CONCLUSION

The authors determined the degree of influence of infrastructure on the balance of economic development through economic growth and GRP.

The theory study showed that endogenous factors, which include investment in infrastructure, play a significant role in the economic growth of each region.

Selected quantitative characteristics of the balance of regional development for 2017–2020 showed very ambiguous dynamics of GRP, average per capita incomes, wages,

Table 5

Final Data on Testing Based on the Regression Model for 2017–2020

Years	*p*-value	Evaluation parameters
2017	0.9542	Infrastructure investment
2018	0.9552	Infrastructure investment
2019	0.8344	Per capita income of the population
2020	0.6363	Infrastructure investment

Source: Compiled by the authors.

investments in infrastructure, as well as the rate of renewal of fixed assets. There was a high regional volatility in infrastructure investments and the rate of renewal of fixed assets.

From this it follows that investment in infrastructure and the rate of asset renewal — are factors that significantly affect the economic growth of the region and GRP. These factors are the main source of regional imbalances.

The correlation between the GRP index and the indices was studied according to the presented regression model: X_1 — population by regions of Russia; X_2 — average per capita income; X_3 — wage; X_4 — infrastructure investment; X_5 — fixed assets renewal. The evaluation found that the correlation between GRP and infrastructure had *p*-values from 0.6363 to 0.9552. And only in one study year, which was used in the panel data for the estimate, 2019, there was a large dependence of GRP on average per capita income, *p*-value — 0.8344

Thus, infrastructure investment has the leading role in changing the region's economic growth and balanced development.

Indeed, in order to meet the growth and development needs of any region, special attention must be paid to its viability. Standard development arguments for a particular region simply do not apply or are not used in time. This is shown by the statistics given in the article.

The potential to address these imbalances is provided by infrastructure development that increases productivity and creates new resources for the entire region. And in an underdeveloped region, both the supply side and the demand side are rebalancing, affecting the productivity of enterprises. Economic growth in one region is not always balanced development of a country. This fact should be taken into account in the development strategy of Russia. The authors will also continue to work in this direction, assessing the development of regions, the disproportion of their development, and identifying the necessary balance of economic growth of regions.

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