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Assessment of the Influence of Growth Factors on the Gross Regional Product on the Example of Arkhangelsk Oblast [*]

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Abstract. The problem of differentiating indicators of economic development is relevant not only for the regions of Russia. One of the main indicators is the gross regional product. The work carried out a comparative analysis of its values for the constituent entities of the Russian Federation, the United States and China, which revealed differences by tens, and sometimes hundreds of times. In most cases, this is due to the specifics of a particular region. The aim of the work is to assess the influence of regional factors on the gross regional product. The article presents an analysis of existing methods for solving this problem by modern domestic and foreign researchers. A brief overview of the key factors used in the proposed models is given. However, the trends in the development of the world and domestic economies, political events, restrictions imposed by the pandemic, regional peculiarities leave this issue relevant. The paper proposes a model for assessing the impact of objective and subjective factors on the gross regional product. The testing subject was the Arkhangelsk Oblast, located in the north of the European part of the Russian Federation. Seven indicators were selected as objective factors, which have a close correlation with the resulting indicator. A multiple regression equation was developed and the quality of the model was assessed. A forecast of the values of the gross regional product for the planning period was made. The influence of subjective factors was studied using the method of expert assessments through the analysis of ratings of influential agencies. A correction factor has been introduced into the model, with the help of which the values of the volume of the gross regional product have been corrected. The results of the study can be useful for state authorities and local self-government bodies that manage the regional development of territories, and can be used to develop a strategy for the development of the constituent entities of the Russian Federation.
Keywords: *gross regional product, subjective factor, objective factor, multiple regression model, correlation, ranking, differentiation of indicators, forecasting*

Introduction

One of the main indicators of the level of development of the regional economy is the gross regional product (GRP). GRP is the main tool in economic and analytical studies conducted at the regional level, especially in comparative analysis, since its value varies significantly within one country.

Russia is the largest country in the world in terms of area — over 17.13 million km^2 [1]. The territories of such large countries as Canada, China, the USA are almost twice less. But, despite

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[1] List of states and dependent territories by area. URL: https://ru.wikipedia.org/wiki / (accessed 06 September 2021).

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this, GRP differentiation is observed not only in the regions of the Russian Federation, but also in the regions of foreign countries [1–5].

On the territory of Russia, GRP per capita varies between regions by ten times (Fig. 1). In 2018, for example, the GRP per capita of the Yamalo-Nenets Autonomous Okrug was 10 times higher than the national average and 50 times higher than the value of the Republic of Ingushetia.
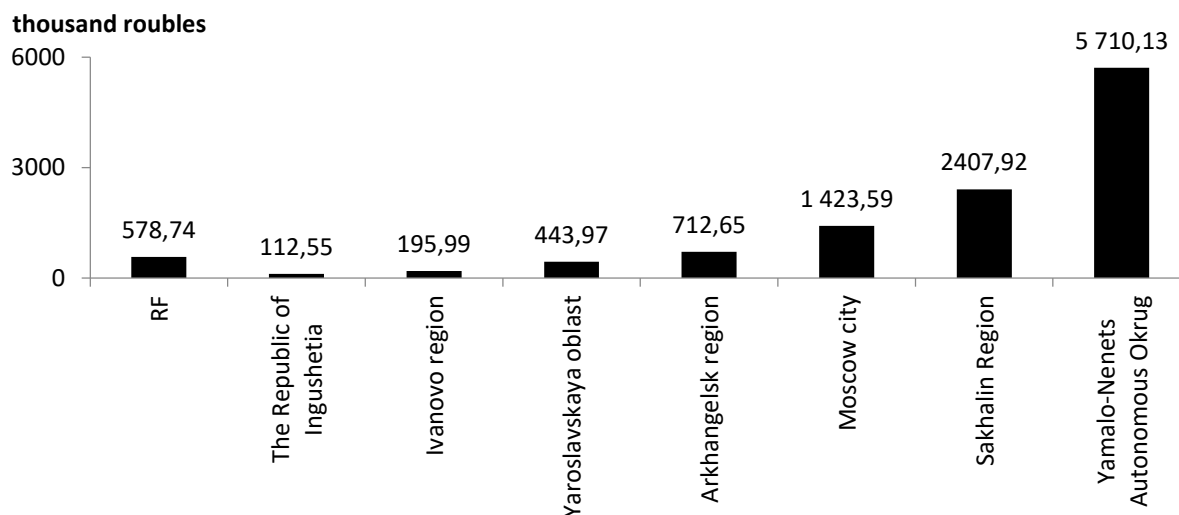
thousand roubles

RF	578,74
The Republic of Ingushetia	112,55
Ivanovo region	195,99
Yaroslavskaya oblast	443,97
Arkhangelsk region	712,65
Moscow city	1 423,59
Sakhalin Region	2407,92
Yamalo-Nenets Autonomous Okrug	5 710,13

Fig. 1. Share of GRP per capita by regions of the Russian Federation (2018) [2].

In the United States (Fig. 2), this figure in 2019 in the Colombian region was 3 times higher than the national average, but 6.6 times higher than the value of Puerto Rico.
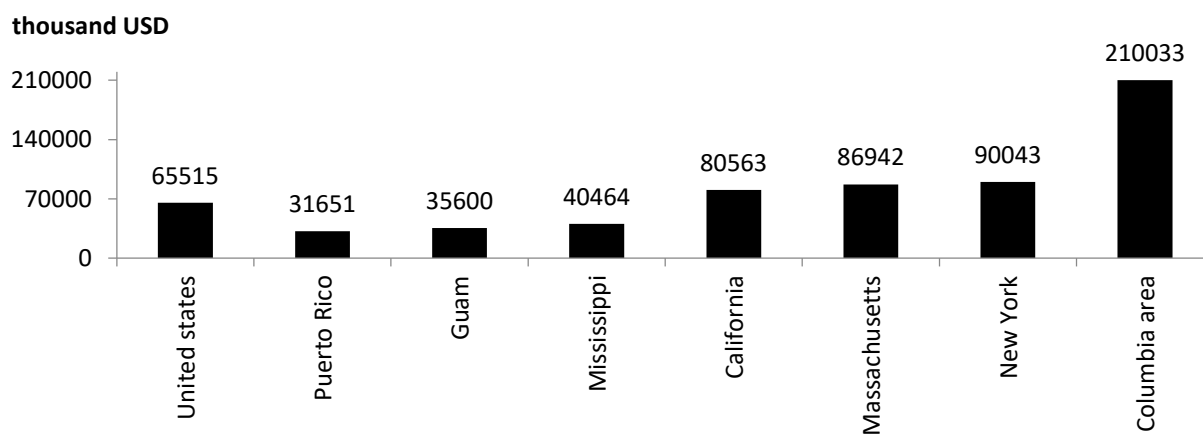
thousand USD

United states	65515
Puerto Rico	31651
Guam	35600
Mississippi	40464
California	80563
Massachusetts	86942
New York	90043
Columbia area	210033

Fig. 2. Share of GRP per capita by US regions (2019) [3].

In China (Fig. 3), in 2019, the GRP of Macau was 8.2 times higher than the national average and 18.6 times higher than the value of Gansu.

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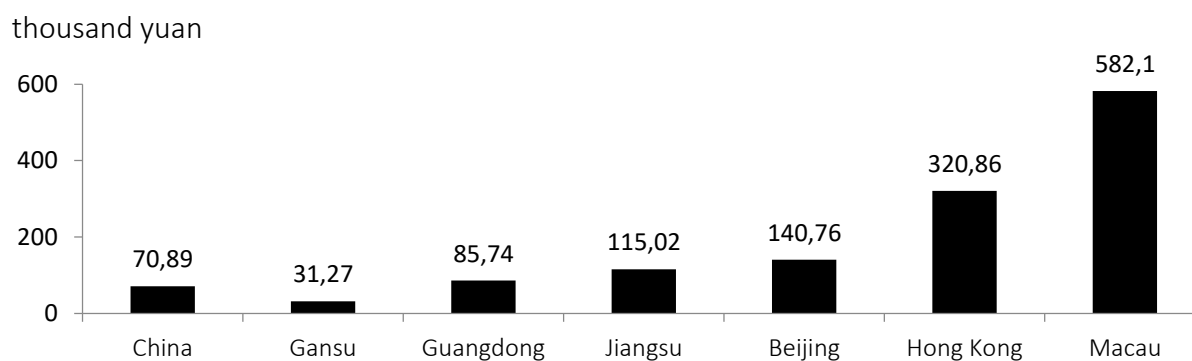
46

thousand yuan

Fig. 3. Share of GRP per capita by regions of China (2019) [4].

Consequently, the problem of differentiation of regional socio-economic development indicators is relevant for the world community and is widely discussed in academic circles.

Approaches to assessing the impact of indicators on the gross regional product

The volume of GRP is influenced by many factors. Many studies have been devoted to their study [6–21, 25].

One approach is to use the classical production function. Baranov S.V. and Skufina T.P. [6, Baranov S.V., Skufina T.P., pp. 57–62] propose to calculate GRP by selecting the value of fixed assets of the regional economy and the average annual number of employed in the economy as influencing factors.

Employees of the Institute of Socio-Economic Research of the USC RAS [7, Gafarova E.A., p. 10] developed a complex simulation model of GRP volume forecasting, where the main indicators include investment in fixed capital, labour costs of employees and costs of research and development. The same factors are chosen by the scientists R.M. Nizhegorodtsev and N.A. Petukhov of the Institute of Management Problems of the RAS [5]. To assess their impact on GRP, scientists propose to use the three-factor Cobb-Douglas model [22, 23].

One of the classic approaches to predicting the GRP volume and assessing the influencing factors is the Box-Jenkins method (ARIMA — Autoregressive Integrated Moving Average), which is a linear statistical model. This approach forms the basis of V.S. Mkhitaryan and O.A. Khokhlova's research [8, p. 53], who used the growth coefficients of the region's development indicators in the model.

Another method that has become widespread is the method of regression equations. On its basis, M.D. Mamedsupiev [9, p. 53] created an economic-mathematical model of the GRP, where he singled out cash income, investments in fixed capital, the number of employed popula-

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[4] Compiled by the authors. Source: PRC regions, population and GRP. URL: http://www.russchinatrade.ru/ru/about-china_-new/administrative-territorial-division/ (accessed 06 September 2021).

[5] Nizhegorodtsev R.M., Petukhov N.A. Regressionnyy analiz vliyaniya osnovnykh faktorov na valovoy regional'nyy produkt (na primere Severo-Zapadnogo federal'nogo okruga Rossii) [Regression analysis of the influence of the main factors on the gross regional product (on the example of the Northwestern Federal District of Russia)]. *Elektronnye biblioteki*, 2011. URL: https://www.problecon.com/export_pdf/problems-of-economy-2011-1_0-pages-17_21.pdf (accessed 05 September 2021).

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tion and the volume of industrial production as the determinants. A.N. Petrov [10, Petrov A.N., p. 93] also adheres to this method in his research, taking into account the indexes of regional economic indicators (industrial production, investment in fixed capital, the average annual number of employed people, etc.) when calculating GRP.

The model based on the balanced scorecard (BSC) is also well-known. The possibility of its application to a specific subject of the Russian Federation depends on the information capabilities of statistical data. This model is the subject of studies by E.V. Zarova and R.A. Prozhivin [11, p. 59], who developed an algorithm for assessing the impact of 130 statistical indicators on GRP.

Intuitive methods are also of great importance for the analysis of the influence of factors on GRP, for example, a two-sector simulation model of the Energy Research Institute of the Russian Academy of Sciences for assessing an array of variable factors [12, Shapot D.V., Osipov A.V., p. 74].

Another common model is the input-output method. The works of researchers from the Institute of Economic Forecasting of the Russian Academy of Sciences (IEF RAS) and The Institute of Economics and Industrial Engineering of the RAS are devoted to it. They include the RIM model (Russian Interindustry Model) — a macroeconomic intersectoral model. This model was used in the studies of M.N. Uzyakov and G.R. Serebryakova [13, 14] when evaluating the structure of the regional economy using the least squares method, and in the works of M.V. Chistov [15, 24] when predicting trends in the sectoral structure of the region's economy.

In these methodologies, researchers propose different models for assessing the influence of factors on GRP. However, it should be noted that the trends of modern economic and political events are making their own adjustments, and the issue of taking regional specifics into account remains open.

GRP forecasting model

In this study, the authors developed a methodology for assessing the impact of indicators on the gross regional product. All calculations were made on the example of the Arkhangelsk Oblast.

The Arkhangelsk Oblast is a subject of the Russian Federation, which is located in the European North and is part of the Northwestern Federal District. In terms of area, it is the eighth largest constituent entity [6].

The degree of influence of factors on GRP is proposed to be assessed by means of correlation coefficient. The data for the last 11 years from 2009 to 2019 are taken to build a multiple regression equation (Table 1). The following objective indicators were chosen as factors:

- costs of production and sale of products (goods, works and services) of organizations (legal entities) (X_1);

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[6] Official website of the Federal State Statistics Service. URL: https://rosstat.gov.ru/ (accessed 06 September 2021).

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Factors for constructing multiple regression, million rubles [7]

Factor	2009	2010	2011	2012	2013	2014
Y	323606.8	372804.8	439116.8	472470.9	500095.1	542695.3
X_1	212035.6	238969.5	277048.8	294286.6	320081.9	326221.9
X_2	96480.9	98622.3	116293.5	125233.3	148613.1	156717.6
X_3	61504.8	71455.2	87903.1	80406.0	96062.9	94218.0
X_4	204233.4	254095.8	276038.7	297986.1	449366.0	350382.4
X_5	63282.8	73836	122139.6	149210.9	143411.9	138458.2
X_6	38691.3	42421.6	45593.2	45229.6	49687.4	55316.9
X_7	1258.4	787.6	981.2	1168.3	1389.1	1572.6
Factor	2015	2016	2017	2018	2019	
Y	627698.0	680482.0	726004.8	819247.0	897103.4	
X_1	343633.0	364032.0	388306.2	423051.2	454917.1	
X_2	159024.0	161807.0	163041.4	177645.1	174346.8	
X_3	95374.5	101268.0	120777.5	123658.8	131495.7	
X_4	408996.0	425810.0	605666.8	632968.6	393056.9	
X_5	155961.0	154384.0	194847.4	173797.2	169615.9	
X_6	61278.1	68123.5	72179.8	74793.5	83855.3	
X_7	1579.6	1808.8	4989.3	1672.7	1579.6	

- amount of IE proceeds from the sale of goods, products, works, services for all types of economic activity (X_2);
- turnover of small business organizations (X_3);
- volume of shipped goods of own production, works and services performed on their own in the sections "Mining" and "Manufacturing" (X_4);
- investments in fixed assets (X_5);
- labor costs of personnel of organizations (legal entities) (X_6);
- research and development costs (X_7).

The resulting indicator (Y) is the gross regional product.

The estimation of the parameters of the multiple regression equation is carried out by means of the least squares method and takes the form of (1):

$$Y = -0.382 * X_1 - 1.179 * X_2 - 1.173 * X_3 + 0.401 * X_4 + 1.472 * X_5 + 12.647 * X_6 - 33.607 * X_7, \text{ (1)}$$

Let us analyze the impact of the regression coefficients in equation (1) on the resulting indicator. A direct comparison of the regression coefficients in equation (1) is justified, since the factors are expressed in identical units — million rubles — and have the same variability, which is estimated by means of the coefficient of variation of factor characteristics (Table 2). It should be noted that only factor X7 has a coefficient of variation different from the others and corresponds to 0.199; for other factors, the variance ranges from 0.061 to 0.119.

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[7] Compiled by the authors. URL: https://rosstat.gov.ru/ (accessed 03 September 2021).

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Table 2

Coefficients of variation of factors [8]

Factor	Coefficient of variation
X_1	0.067
X_2	0.061
X_3	0.068
X_4	0.119
X_5	0.086
X_6	0.078
X_7	0.199

The coefficients of the multiple regression equation (1) show the size of the influence of factors X_1, X_2, X_3, X_4, X_5, X_6, X_7 on the level of the resulting indicator in absolute terms. The greatest influence is exerted on GRP when factors are fixed: X_3, X_6, X_7 (Table 3).

For comparative assessments of the role of factors in the GRP formation, absolute values should be supplemented with relative, in particular, normalized regression coefficients. This will make it possible to identify the factors that contain the largest reserves for changing the performance indicator (GRP) (Table 3). The analysis of the values of the normalized regression coefficients shows that, taking into account the degree of variation of factors, the largest reserves in the GRP change lie in the increase of factors X_4, X_6, X_5, X_1.

Table 3 shows that the ranks of factors in terms of the regression coefficient (absolute values) and in terms of the normalized regression coefficient (relative values) coincide or are close in terms of factors X_2, X_5, X_6. The discrepancy in the assessment is observed for factors X_1, X_3, X_4, X_7.

Table 3

Analysis of regression coefficients [9]

Factor	Regression Coefficient	Rank of factors by the regression coefficient	Normalized regression coefficients	Rank of factors by the normalized regression coefficient
X_1	-0.382	7	-0.00052	4
X_2	-1.179	5	-0.00024	5
X_3	-1.723	3	-0.00020	6
X_4	0.401	6	0.00219	1
X_5	1.472	4	0.00058	3
X_6	12.647	2	0.00070	2
X_7	-33.607	1	-0.00001	7

Let us turn to the assessment of the quality of the regression equation (1). The multiple correlation coefficient is 0.999. According to the Chaddock table, the qualitative assessment of the relationship between the effective attribute (GRP) and factor attributes is very high. The parameters of the regression model reflect the effectiveness of the included indicators. The coefficient of multiple determination corresponds to 0.998. The adjusted multiple regression coefficient, which determines the tightness of the connection, taking into account the degrees of freedom of the total variance and residual variance, is 0.999. It allows evaluating the closeness of the relationship,

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[8] Authors' calculations.
[9] Authors' calculations.

which does not depend on the number of indicators. Both coefficients indicate a high level of correlation (over 98%).

In the paper, the reliability of the indicator of closeness of correlation was assessed according to F — Fisher's criterion. The actual value of the criterion was 1812.4 and does not exceed the permissible significance level of 5% (Fcrit = 6.09).

So, the obtained value is not accidental, it was formed under the influence of significant indicators. The statistical significance of both the regression equation and the closeness of the correlation is confirmed. The standard error of the regression equation is 17.9 billion rubles.

Table 4 shows the matrix of paired coefficients of the multiple regression model.

Table 4

Matrix of paired coefficients of multiple regression model [10]

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	y
X_1	1							
X_2	0.964	1						
X_3	0.971	0.911	1					
X_4	0.942	0.877	0.964	1				
X_5	0.924	0.891	0.906	0.85	1			
X_6	0.959	0.913	0.934	0.915	0.839	1		
X_7	0.554	0.489	0.638	0.665	0.638	0.635	1	
Y	0.986	0.935	0.951	0.930	0.881	0.987	0.569	1

As seen from Table 4, there is a direct correlation with all factors in GRP, indicating that the growth of each of them causes an increase in GRP. The strongest influence is exerted by the following factors: the costs of production and sale of products (goods, works and services) of organizations (legal entities) (X_1), the correlation coefficient is 0.986, the costs of remuneration of personnel of organizations (legal entities) (X_6). The least influence of the factors under consideration is the costs of research and development (X_7) — 0.569.

According to Table 4, there is a high dependence between the factors. This suggests that one of the factors should be excluded from consideration, but the task of the study is to predict GRP. The coefficient of multiple determination is greater than 0.9, so the presence of multicollinearity does not affect the quality of the developed model. To reduce multicollinearity, it is sufficient to increase the sample size.

Thus, the model is reliable and can be used for further forecasting.

On the basis of the average annual growth rates, the values of the factors for the forecast period were calculated (Table 5). Using the model (1), the values of GRP (Y) for 3 planning years are determined.

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[10] Authors' calculations.

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Table 5

Forecasting the values of objective factors and GRP [11]

Factor	Average annual growth rate	Value for the forecast period, million rubles		
		1 year	2 year	3 year
x1	1.079	491003.5	529952.5	571991.1
x2	1.061	184974.2	196249.5	208212.0
x3	1.079	141876.9	153077.7	165162.8
x4	1.111	653317.8	726161.9	807128.0
x5	1.104	187190.9	206586.9	227992.6
x6	1.080	90598.8	97884.6	105756.2
x7	1.023	1747.2	1787.4	1828.5
y	-	974477.6	1075555.8	1186713.3

In addition to objective factors affecting GRP, it is advisable to consider the impact of subjective factors (political, climatic, environmental) [26]. The choice of these indicators is justified by the fact that the political situation is of great importance for the development of the region's economy, especially in recent times. Consideration of climatic and environmental conditions in the Arkhangelsk Oblast is associated with the geographical location of the RF subject. It is proposed to evaluate these factors using the method of expert assessments. Let us consider the ratings of influential agencies.

In July 2020, the Petersburg Politics Foundation presented a rating of socio-political sustainability of Russian regions. According to the data, the Arkhangelsk Oblast was among the regions with low socio-political stability [12].

According to the experts of the CROS analytical department on the National Anxiety Index, calculated as a weighted average coefficient, the Arkhangelsk Oblast was in the top 10 "anxious regions" in 2019. The main reasons are the following: political changes in the country (change of the Government, amendments to the Constitution), environmental situation, coronavirus infection [13]. The work of the head of the region has a significant impact on the level of anxiety.

In 2020, the Centre for Information Communications "Rating" within the framework of the "National Rating" project, has conducted a research, based on an absentee survey of experts, aimed to evaluate the performance of heads of subjects of the Russian Federation, according to which the Arkhangelsk Oblast ranked 70th place among other regions [14].

According to the results of the study "Rating of influence of the heads of subjects of the Russian Federation" by the Agency for Political and Economic Communications, the head of the Arkhangelsk Oblast moved down from 48th to 52nd place, leaving the group of strong influence. The assessment took into account the results of the implementation of major projects in the field

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[11] Authors' calculations.
[12] Rating of the Petersburg Politics Foundation for June 2020. URL: https://fpp.spb.ru/fpp-rating-2020-06 (accessed 03 September 2021).
[13] KROS predstavil reyting trevozhnykh regionov Rossii [CROS presented a rating of disturbing regions of Russia]. URL: https://www.cros.ru/ru/exploration/research/1602/ (accessed 20 August 2021).
[14] National Rating of Governors (Results of 2020). URL: http://russia-rating.ru/info/18784.html (accessed 20 August 2021).

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of transport and social infrastructure, anti-corruption investigations, as well as the consequences of negative events with public resonance [15].

The indicator of the quality of life is of great importance among the factors influencing GRP. According to the RIA Agency, the Arkhangelsk Oblast ranked 74th by this indicator in 2019, and 75th — in 2020, entering the top ten outsiders [16]. The rating was calculated according to 70 indicators combined into 11 groups, among which attention is paid to environmental and climatic conditions.

The Arkhangelsk Oblast is located in the northern part of European Russia, has unfavorable climatic conditions for living and development of many sectors of the national economy (agriculture, housing and communal services). This leads to negative trends in demographic and environmental indicators.

According to the All-Russian public organization "Green Patrol", the Arkhangelsk Oblast took 51st place in the sphere of environmental security and protection ("National ecological rating of regions") [17].

The study of the Analytical Credit Rating Agency (ACRA) is based on the relative indicators of the negative impact obtained as the ratio of the absolute value of the factor in the analyzed entity to the size of its GRP (for example, the volume of emissions or wastewater discharge) [18]. As of February 2021, the Arkhangelsk Oblast ranked 53rd among the regions of the Russian Federation.

Thus, the analysis of the ratings of the leading agencies showed that the Arkhangelsk Oblast is in 51–75 places among 85 regions of the Russian Federation according to the selected factors, which indicates an unstable situation. As a result the GRP volume projected with the help of the presented model (1) should be adjusted for the future period, taking into account the impact of adverse subjective factors.

To do this, we introduce the correction factor presented in Table 6 into our model (1).

Table 6

GRP volume correction factor [19]

Place of the region in the ratings of leading agencies	Value of the correction factor
1–25	1.05
26–50	1.0
51–75	0.95
76–100	0.9

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[15] Rating of the influence of the heads of subjects of the Russian Federation. Russian regions and regional policy in June 2020.

[16] Quality of life in Russian regions Rating 2020. URL: https://riarating.ru/infografika/20210216/630194637.html (accessed 20 August 2021).

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[18] Ecological ranking of subjects of the Russian Federation. URL: https://www.acra-ratings.ru/research/2328 (accessed 03 September 2021).

[19] Authors' calculations.

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The regions ranked from 1st to 25th place are among the leaders that have favorable subjective factors that contribute to the development of the region's economy and the growth of GRP. Therefore, the value of the correction factor is greater than 1.

The subjects that fell into the third and fourth groups are the outsiders; therefore, the impact of subjective factors in these regions slows down the growth of GRP. The stronger the negative impact, the lower the value of the correction factor.

The Arkhangelsk Oblast, according to our methodology, falls into the third group, for which a coefficient of 0.95 is applied. Let us correct the value of the predicted GRP (Y) (Table 7).

Table 7

GRP forecast with correction factor [20]

Indicator	Value for the forecast period, million rubles		
	1 year	2 year	3 year
Y	974 477.6	1 075 555.8	1 186 713.3
$Y_{updated}$	925 753.7	1 021 778.0	1 127 377.7

As can be seen, the values of the gross regional product will decrease by 5%. Thus, the influence of the most significant subjective factors for the given region is taken into account.

Conclusion

It should be noted that this paper represents the authors' approach to assessing the impact of regional indicators on the gross regional product and only partially illuminates the complex and multifaceted problem of differentiation of the socio-economic development of the constituent entities of the Russian Federation.

The study substantiates the necessity to take into account the influence of factors on GRP, based on the characteristics of each region. This is caused by the territorial differentiation of many indicators, typical both for the economy of the Russian Federation and for foreign countries.

These factors in the paper are divided into objective and subjective. All the calculations were carried out on the indicators of the Arkhangelsk Oblast.

The evaluation of the first group was made using a multifactorial model, which is a multiple regression equation. Seven factors were selected that have a close correlation with the gross regional product. The sample of initial data was carried out for 11 years. The reliability of the model was confirmed statistically. The result is the calculation of GRP for the forecast period.

The influence of factors of the second group was taken into account on the basis of the method of expert assessments of leading agencies. Significant subjective factors for the northern region were taken for the research. Based on the study of the ratings, a scale of the GRP adjustment coefficient was developed and its significance for the Arkhangelsk Oblast was taken into account.

Thus, the advantage of this methodology is an integrated approach based on the use of statistical methods and the method of expert assessments of objective and subjective factors. The

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[20] Authors' calculations.

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developed model can be used in medium-term forecasting of regional development. It should be noted that the result of its application to data from other subjects of the Russian Federation will depend on the representativeness of the sample of initial indicators of objective factors and the list of subjective ones.

A promising direction for further research on this issue is to increase the list of assessed factors and test this methodology on statistical indicators of other regions.

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