

Multifactor Forecasting of Socioeconomic Development of Regions



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Abstract: The goal of the article is to develop an economic and mathematical model allowing to predict the nature of the socioeconomic development of the Russian regions, with due consideration for the most significant factors that determine its dynamics. An algorithm has been proposed for predicting the growth rate of the gross regional product, including justification of the factors that have both positive and negative impacts on this indicator, as well as the procedure for generating forecast estimates using the Wolfram Mathematica 11 kit. A forecast model of the socioeconomic development of the Lipetsk region, one of the backbone regions in Russia, has been formed. The statistical indicators of the region under study for 2004 – 2017 have been analyzed. The forecast data have been interpreted. The negative factors hindering the further development of the Lipetsk region have been highlighted. The results of the study can be used to develop a strategy, as well as state and regional programs aimed at ensuring and enhancing the sustainability of the socioeconomic development of the Lipetsk region.

Keywords: region, economic and mathematical model, forecasting, sustainable socioeconomic development.

I. INTRODUCTION

The introduction of the principles of strategic planning [1] in the Russian Federation necessitated the forecasts of various levels for government bodies, which formed a reasonable vision of the development prospects of the most important subjects of the national economy: regions and municipalities.

The forecasting method using economic and mathematical models has shown its rather high reliability under conditions of instability [2]. The predictive models used by the scientists and practitioners differ in their goals and construction principles, functioning methods, degree of aggregation of indicators, and some other parameters [3]. The econometric

models with a deep theoretical justification and clearly formed methodological basis are most demanded today, as they allow to obtain high-quality forecast estimates that can form the basis for managerial decisions in the system of the state and municipal administration.

The multifactor models used in Russia and abroad in making forecasts of the dynamics of complex socioeconomic systems hold a specific place among the econometric models [4], [5]. It must be noted that multifactor models based on the statistical dependence method are highly demanded by domestic researchers, as they consider for the fundamental relationships between individual equations and internal variables of the model [6]. This variety of multifactor models allows to study the interdependence of attributes, their subordination, evaluate the strength of the correlation interaction, and thus form a reasonable prediction of the dynamics for the forecasting object in the future.

The use of multifactor econometric models in order to predict the socioeconomic development of regions allows to assess the nature of their current and future socioeconomic dynamics and to make justified conclusions regarding the efficiency of the regional system and the actions of regional government bodies.

II. METHODS

The authors' technique was applied to predict the dynamics of the economic development of the region, which included the following steps:

1. Justification of the forecast indicator describing the sustainability of the socioeconomic development of the region.

The GRP growth rate indicator was chosen as the output variable vector, since this indicator was relative and allowed to avoid the inflation effect.

2. Selection of the prediction function.

It was proposed to use one of the most common dependence recovery algorithms, the linear regression method, to find the functional dependence. The dependence was established between several input variables and one output variable. The multiple (multidimensional) regression was used for its search, the task of which was to find the coefficients of the following equation:

$$Y = b_0 + b_1 X_1 + b_2 X_2 + \dots + b_n X_n, \quad (1)$$

where Y was the output variable vector, X_1, X_2, \dots, X_n were the input variable vector, and n was the number of input variables.

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Table 1: Input variables

Notation	Input variables (socioeconomic indicators)	Impact of indicators on the predicted value
x1	Share of innovative products, %	+
x2	Index of physical volume of investments in fixed assets, %	+
x3	Unemployment rate, %	-
x4	Depreciation of fixed assets, %	-
x5	Average annual number of people employed in the economy	+
x6	Industrial producer price indices, %	+
x7	Share of unprofitable enterprises, %	-

3. Selection of the object of forecasting.
4. Collection of the actual source data over time.
5. Normalization of the source data.

The Pattern formula was used to bring the initial statistical data into a comparable form:

$$Q_i^{norm..} = \frac{Q_i}{Q_{max}} \tag{2}$$

where $Q_i^{norm..}$ was the normalized private socioeconomic indicator; Q_i was the current value of the partial indicator; and Q_{max} was the maximum value of the partial indicator selected among similar indicators of a particular region for 2004 – 2017. The value of $Q_i^{norm..}$ is positive if this indicator increases the sustainability of the socioeconomic development of the region, otherwise its value is negative.

6. Forecasting the value for future periods based on polynomial extrapolation

$$X_i(j) \approx \sum_{k=0}^p \beta_i^{(k)} j^k \tag{3}$$

where p was the selected degree of approximating polynomial. The extrapolation coefficients were also found using the least squares method. In particular, the problem of finding the minimum of the following residual was solved:

$$\beta_i = \underset{\beta_i}{\operatorname{argmin}} \sum_{j=2004}^{2017} \left(\sum_{k=0}^p \beta_i^{(k)} j^k - X_i(j) \right)^2 \text{ for } i = \overline{1..7}. \tag{4}$$

7. Calculation of the predicted values of the input variables

$$\tilde{X}_i(j) = \sum_{k=0}^p \beta_i^{(k)} j^k \text{ for } i = \overline{1..7}, j = \overline{2018..2022}, \tag{5}$$

where \tilde{X}_i was the predicted values of the relevant indicators.

8. Construction of the economic and mathematical model to assess the predicted values \tilde{Y} of the target indicator for the region under study:

$$\tilde{Y}(j) = \sum_{i=1}^7 \alpha_i \tilde{X}_i(j) \text{ for } j = \overline{2018..2022}, \tag{6}$$

where a vector of coefficients was taken from the solution of the problem using the ordinary least squares (OLS) method.

9. Obtaining the results of the forecast of the GRP growth rate for 2018 – 2022 in the regions under study and their interpretation.

III. RESULTS

The Lipetsk region, which belongs to the group of the backbone regions of Russia, was chosen as the object of study. The factors forming the competitive advantages of backbone regions include the presence of industrial production and high innovative, scientific, and intellectual potential.

The statistical data describing the Lipetsk region as a reference region are presented in Table 2.

Table 2: Statistical average Russian indicators and indicators of the Lipetsk region [7]

Indicators	2006	2010	2013	2014	2015	2016	2017
Share of innovative products, %							
Russia	4.7	4.8	9.2	8.7	8.4	8.5	7.2
Lipetsk region	2.7	9.8	13.3	13.6	12.3	10.5	9.3
Industrial production index, %							
Russia	106.3	107.3	100.4	101.7	96.6	101.1	102.1
Lipetsk region	110.4	110.7	100.3	102.9	100.8	103.4	103.0

The statistical data presented in Table 2 confirm that the Lipetsk region is a backbone region of Russia, since such indicators as the share of innovative goods and the industrial production index are higher than the national average.

The analysis of the data (Table 2) allowed to reveal the following trends. A significant increase (3.63 times) in the share of innovative goods must be noted during 2006 – 2010 as a result of modernization and innovation-driven growth, which is the strategic course of the Lipetsk region. The regulatory framework formed during these years contributed

to the increase in innovative activity and the entry of the region into the Association of Innovative Regions of Russia [8]. However, a decrease in innovative activity was observed in subsequent years (2014 – 2017), despite the fact that the state program "Modernization and Innovation-driven Growth of the Economy of the Lipetsk Region" [9] had been adopted in 2013, and is being implemented at the present time.

It must be noted that the decline in innovative activity since 2013 is characteristic of the Russian economy in general. One of the factors ensuring positive dynamics of indicators (2006 – 2014) is a holistic innovation infrastructure integrated with higher education and science, which creates the necessary conditions for innovation-driven growth: from fundamental scientific research to the introduction of technologies and the implementation of finished high-tech products [10].

The industrial production index (Table 2) of the Lipetsk region amounted to 110.4 % and 0.1 % more in processing industries in 2006. These indicators are determined by the growth in production in such sectors of the economy as chemical production (19.5 %), production of machinery and equipment (10.5 %), iron and steel and manufacture of finished metal products (8.2 %), and electrical equipment (7.8 %) [11].

Major innovation processes take place in the processing industries: iron and steel (share in the structure is 60 %), food products (20 %), and production of machinery (7.6 %) [12].

Over the past 18 years (2000 – 2017), 126 new industrial enterprises were created in the region, including 32 enterprises in special federal and regional economic zones

[13].

The industrial production index amounted to 102.6 % at the end of 2017 and to 103.1 % in the processing industries. High growth rates were observed in the production of chemicals and chemical products (115.9 %), manufacture of electrical equipment (109.5 %), manufacture of finished metal products, except machinery and equipment (108.6 %), production of rubber and plastic products (103.3 %), and iron and steel production (102.8 %). The volume of shipped industrial products amounted to 661 bln rubles, which was a 107.8 % increase to 2016. The results were achieved due to the development of the institute of special economic zones, industrial parks, and technology parks [14].

The development of industrial production in the region is facilitated by the activities of the Industrial Development Fund of the Lipetsk region, the purpose of which is to assist in the implementation of the industrial policy of the Russian Federation in the territory of the Lipetsk region and to implement the support measures provided to industry actors [15].

The socioeconomic indicators of the Lipetsk region for 2004 – 2017 are presented in Table 3.

Table 3: Socioeconomic indicators of the Lipetsk region [7].

Indicators	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
GRP growth rate (Y)	106.2	101.7	108.2	108.0	103.6	93.5	104.0	104.8	101.8	103.4	105.1	101.0	101.6	101.1
1. Share of innovative products (X1)	4.6	3.9	2.7	3.6	4.7	12.5	9.8	9.9	10.9	13.3	13.6	12.3	10.5	9.3
2. Index of physical volume of investments in fixed assets (X2)	137.5	100.6	134.6	129.8	118.4	91.9	116.5	102.8	78	103.5	100.7	100.4	103.6	107.8
3. Unemployment rate (X3)	4.2	8.2	4.9	2.8	4.9	5.6	4.5	4.9	3.6	3.7	3.7	4.1	4	3.9
4. Depreciation of fixed assets (X4)	42.2	43	44.1	44.2	43.2	46	48.6	50.3	51.2	49.2	50.6	52.6	55.7	55.8
5. Average annual number of people employed in the economy (X5)	551.1	548.7	547.2	547.2	546.1	545.7	544.9	544.5	543.8	543.4	542.3	565.2	565.5	565.8
6. Industrial producer price indices (X6)	137.5	100.4	108.6	102.4	123.1	98.6	108.9	108.3	95.2	101.8	114.8	109.2	115.5	98.4
7. Share of unprofitable enterprises (X7)	36.1	38	34	22.5	24	29.4	31.4	25.5	26.1	25.7	28.2	25.5	25.6	30.5

Attracting investments remains the main condition for ensuring the proper rates of economic growth, the formation of the revenue part of budget, and solving the social problems the regions face. A favorable investment climate has been created in the region. The Investment Strategy of the Lipetsk Region for the period through to 2020 has been implemented in the region since 2009.

The regional support for business entities was carried out in the following areas, in order to enhance investment processes and reduce emerging risks, in the framework of regional laws and programs:

- provision of tax benefits;
- provision of subsidies to compensate for some costs;
- provision of state guarantees; and
- provision of collateral fund facilities.

Industrial parks are one of the tools to improve the investment climate of the region.

The Investment Memorandum of the Lipetsk region was adopted as part of the implementation of the requirements of the Standard for the executive authorities of the region of the Russian Federation to ensure a favorable investment climate, which publicly declares the general key principles for the

interaction between regional authorities and investors [16].

The volume of investments in fixed assets amounted to 139.9 bln rubles in the Lipetsk region in 2017. The increase was 7.8 % compared to 2016. The equity raised as investment accounted for 56.2 % (while average across Russia was 52.1 %), and the borrowed funds accounted for 43.8 %. The state funds (federal, regional and local budgets) amounted to 6.9 %, and the bank loans amounted to 11 % [17].

According to the results of 2018, the Lipetsk region ranked 14th in the rating of the National Rating Agency for Investment Attractiveness and was assigned IC3 status (high investment attractiveness – level three) [18].

The lowest officially registered unemployment rate among the regions of the Central Black Earth district was registered in the Lipetsk region in January 2018, as well as in 2017, – 0.5 % of the employable population. The region continues the dynamic development of the economy, investment projects being implemented in its key areas. This requires constant development of the labor market and human resources, and training of qualified personnel [19].

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As many as 16.6 mln highly productive jobs have been created and modernized in Russia, of which more than 133 thous. are in the Lipetsk region. Besides, the Lipetsk region is in top five among the territories of the Central Federal District (CFD) by the share of highly productive jobs in the regional economy, exceeding the national value (23.6 % in the Lipetsk region, and 22.2 % in the Russian Federation) [20].

The registered unemployment rate is half the national average – 0.5 % (1.0 % across the Russian Federation). This is one of the best indicators in the CFD (second place) and the Russian Federation (sixth place). There is no tension in the labor market: the number of vacancies (9.6 thous.) is more than three times higher than the number of unemployed people (second place in the CFD, ninth in the Russian Federation) [21].

The average annual number of people employed in the economy of the Lipetsk region in 2004 – 2017 had a positive trend. The maximum increase in the indicator was observed in 2015 (+22.9 thous. people), due to the adoption and launch of the implementation of the State program "Development of the labor market and the promotion of employment in the Lipetsk Region" [22] in 2014, which will last until 2024.

The Industrial Producer Price Index for 2004 – 2017 did

not have a clear trend; there were both decrease and increase in the indicator.

The enterprises of the region were able to earn 2 % more in 2018 than in 2017. Iron and steel enterprises, manufacturers of electrical equipment and food products were the most profitable, while manufacturers of vehicles, clothing and electronics were the most unprofitable in 2017 [23].

The Wolfram Mathematica 11 kit was used as a software product for research purposes. This is an integrated tool enabling to perform mathematical calculations in various fields of knowledge, including generating forecasts using machine learning algorithms.

The predicted values of the input variable vectors $X_1 - X_7$ are described by the following formulas (7):

$$x_1 = -0.00678228 t^2 + 0.154805 t - 0.0306642$$

$$x_2 = 0.00286763 t^2 - 0.0589106 t + 1.02671$$

$$x_3 = 0.00109723 t^2 - 0.0332367 t + 0.718507$$

$$x_4 = 0.000432028 t^2 + 0.0126263 t + 0.740212 \quad (7)$$

$$x_5 = 0.000698831 t^2 - 0.0086024 t + 0.986104$$

$$x_6 = 0.0018007 t^2 - 0.0328814 t + 0.907073$$

$$x_7 = 0.0042727 t^2 - 0.078729 t + 1.03728$$

The economic and mathematical model that describes the contribution of factors to the GRP dynamics of the Lipetsk region is represented by the following formula (8):

$$Y = -9,88843x_1 + 14,705x_2 - 4,64047x_3 - 41,2891x_4 + 178,525x_5 + 8,67014x_6 + 0,795889x_7 + 230,692.$$

It can be stated that the most important factors ensuring proper conditions for sustainable economic growth of the Lipetsk region include an increase in the number of people employed in the regional economy (+178.525), a decrease in depreciation of fixed assets (-41.2891), and an increase in the volume of investments in fixed assets (+14.705). Such set of drivers of economic dynamics is characteristic of industrial

regions with a powerful diversified economy, the structure of which is dominated by industry, agriculture, trade, construction, and other labor-intensive sectors.

A model with a degree of approximating polynomial equal to two was chosen to forecast the dynamics of the socioeconomic development of the Lipetsk region (Figure 1).

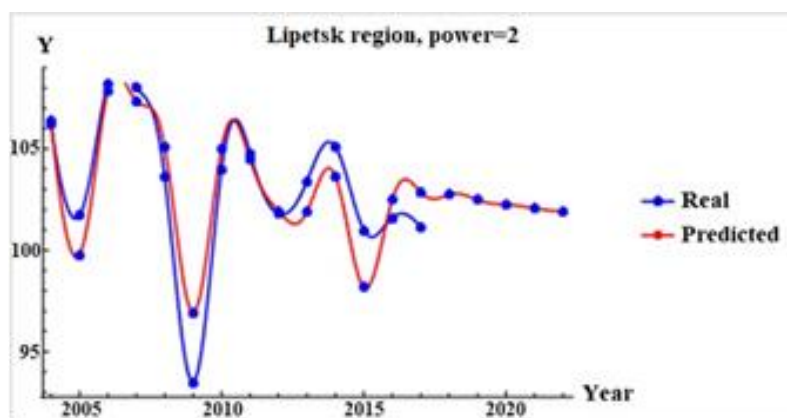


Fig. 1: Forecast of the GRP growth rate of the Lipetsk region for 2018 – 2022

The economic and mathematical model formed for the forecasting meets the basic criteria for assessing the quality of forecasts: mean absolute deviation (MAD), mean percentage error (MPE), mean absolute percentage error (MAPE), and the coefficient of determination are within the

standard values. The forecast estimates obtained with its use have an attribute of economic adequacy and, therefore, can be used as an information basis for managerial decisions in the socioeconomic development of the region (Table 4).

Table 4: Predicted values of key indicators of the socioeconomic development of the Lipetsk region

Indicators	2018	2019	2020	2021	2022
1. Share of innovative products (X1), %	10.40934	9.65527	8.71673	7.59370	6.28620
2. Index of physical volume of investments in fixed assets (X2)	108.38626	112.50934	117.42101	123.12129	129.61016
3. Unemployment rate (X3), %	3.82802	3.83439	3.85876	3.90112	3.96148
4. Depreciation of fixed assets (X4), %	57.29615	58.74802	60.24810	61.79640	63.39291
5. Average annual number of people employed in the economy (X5), thous.	573.9	581.3	589.5	598.4	608.2
6. Industrial producer price indices (X6)	112.61373	115.76802	119.4175	123.56217	128.202033
7. Share of unprofitable enterprises (X7), %	31.07252	33.11406	35.48032	38.17131	41.18703
GRP growth rate (Y), %	102.73810	102.48060	102.25558	102.06303	101.90294

Note. Calculated by the authors

The forecast estimates indicate that the downward trend in the share of innovative products, which has been observed in the Lipetsk region since 2013, will continue throughout the forecast period. As a result, the share of innovative products may decline to 6.2 % by 2022. The authors believe that urgent measures are needed to increase the level of commercialization of scientific developments and accelerate the implementation of research results in the fundamental sectors of the regional economy in order to overcome this negative trend. Promoting the creation of teams of technological entrepreneurs and the formation of sustainable financing for this type of activity – in particular, through venture tools – is a prerequisite for the development of innovations both in the Lipetsk region and in the entire country [24].

The index of physical volume of investments in fixed assets in the forecast period will demonstrate steady positive dynamics and can reach 129.6 % by 2022. Such high dynamics of investments in the regional economy will be primarily facilitated by the implementation of the state program "Ensuring the investment attractiveness of the Lipetsk region", which provides for a set of measures to improve the investment climate and create conditions for the efficient functioning of special economic zones in the regional economy [25]. The program was launched in 2014, and the average degree of achievement of its target and task indicators was 105.8 % by 2018 [26].

The unemployment rate in the Lipetsk region is most likely not to exceed 4 % throughout the forecast period (3.86 % in 2020, 3.9 % in 2021, and 3.96 % in 2022), which allows to state that the positive situation on the regional labor market, which is currently observed, will continue in the foreseeable future. The balance of the sectoral structure of the regional economy is the main factor determining the positive dynamics in labor and employment, the drivers of which include a powerful industrial complex, developed agriculture, and a rapidly developing construction complex.

The indicator of depreciation of fixed assets is most likely to demonstrate the negative dynamics in the forecast period and can reach 63.3 % by 2022. The main reason for this situation is the extremely low level of renewal of fixed assets: the average renewal rate of funds in the region was 9.3 % in 2013 – 2017, which was insufficient for the economy of the Lipetsk region and represented a threat to the sustainable socioeconomic development of the region, since it increased

the likelihood of industrial accidents and environmental damage [9].

The predicted value of the number of people employed in the regional economy in 2019, recorded in the "Key indicators of the socioeconomic development of the Lipetsk region for the medium term" [27], is 579.6 and 580.2 thous. people for the conservative and basic versions, respectively, which is comparable with the forecast data obtained (Table 2).

The increase in the industrial producer price index in the forecast period is largely due to an increase in prices in the iron and steel industry, which the Lipetsk region specializes in. The depreciation of the Russian ruble is an indirect cause of the price growth, as the competitiveness of domestic industries is increasing, and the sale of goods on the foreign market becomes more profitable than domestic trade [28].

A negative trend is the increase in the number of unprofitable enterprises in the Lipetsk region in the forecast period. It must be noted that the growth in the number of unprofitable enterprises is an all-Russian trend. For example, the share of unprofitable organizations in Russia by the end of 2018 increased by 1.1 percentage points to 2017 and reached 27.4 % [29].

The predicted values of the resulting GRP growth rate tend to slightly decrease, but an increase is observed in 2022 compared to 2017 (+0.8 percentage points).

IV. DISCUSSION

Comparison of the indicators selected for multifactor forecasting of the socioeconomic development of the Russian regions (Table 1) with the indicators used in such well-known ratings as the Socioeconomic rating of the regions of the Russian Federation [30] and the Level of development of science and technology in the regions of Russia [31] compiled by RIA RATING allows to conclude that the composition of the indicators is representative and very important in assessing the socioeconomic development of the regions. According to the forecasts of the academicians from the Financial University under the Government of the Russian Federation, the gross regional product in the Lipetsk region will increase by 1.1 % by the middle of 2019 [32].

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This forecast is more optimistic compared with the estimates obtained during the study (Table 4). The predicted slowdown in the growth rate of the gross regional product is due to the following factors hindering the dynamic socioeconomic development of the region [33]:

- the high cost of bank loans and lack of preferential rates for state-owned banks in lending to the import substituting investment projects (except for agricultural enterprises) under the conditions of economic sanctions reduce the efficiency of state support and can lead to a freeze on investment projects being implemented and proposed for implementation;

- insufficient level of innovative activity of industrial enterprises in the region;
- insufficient growth rates of labor productivity; and
- high energy intensity of the regional economy.

Besides, it must be noted that the obtained predicted values correspond to the forecast GRP growth rate of the region recorded in the Basic indicators of the socioeconomic development of the Lipetsk region for the medium term (Table 1). In particular, the predicted value for 2021 of 102.06 % (Table 4) is comparable with the predicted value of the basic forecast developed in the Lipetsk region – 102.4 % (Table 5).

Table 5: GRP growth in the Lipetsk region, % [34]

Estimate	Estimate	Forecast					
		2019		2020		2021	
2017	2018	Conservative	Basic	Conservative	Basic	Conservative	Basic
101.2	102.2	101.22	102.2	101.58	102.3	101.84	102.4

According to the experts from RIA Rating, it is unlikely that the economic situation in the Russian regions will observe significant changes in 2019 relative to 2018 [30].

V. CONCLUSION

A medium-term forecast of the dynamics of the socioeconomic development of the Lipetsk region, one of the backbone regions of Russia, has been made in the course of the study. A multivariate econometric model has been developed for forecasting purposes, which includes the factors that have the most significant impact on a key indicator of the regional economic development – GRP. The model allows to predict the nature and pace of the regional socioeconomic dynamics with a high degree of certainty and justify the efficient managerial decisions aimed at making the process focused and sustainable.

Following the analysis of the predicted values, it has been found that the following factors have the most significant impact on the dynamics of the gross domestic product of the Lipetsk region: the number of people employed in the regional economy, the level of depreciation of fixed assets, and the volume of investment in fixed assets. Consideration of these factors in the formation of the strategy and tactics of the socioeconomic development of the Lipetsk region will allow to ensure a long-term, sustainable nature of the regional socioeconomic dynamics.

The forecast of the key indicators for the economic development of the Lipetsk region in 2018 – 2022 allows to identify the following most likely trends in the regional dynamics:

- 1) positive trends:
 - an increase in the index of the physical volume of investments in fixed assets by 21.22 percentage points;
 - a decrease in unemployment by 0.13 percentage points; and
 - an increase in the average annual number of people employed in the economy by 34.3 thous. people.
- 2) negative trends:
 - a reduction of the share of innovative goods in the total volume of output by 4.12 percentage points;
 - an increase in depreciation of fixed assets by 6.1

percentage points;

- an increase in the industrial producer price index by 15.59 percentage points; and
- an increase in the share of unprofitable enterprises by 10.11 percentage points.

As such, the development of economic processes in the Lipetsk region is likely to be dominated by negative trends in the medium term.

The obtained forecast estimates indicate a slowdown in the GRP growth: for example, the GRP growth rate could reach 101.9 % by the end of 2022, i.e., the indicator under study for 2018 – 2022 may decrease by 1.1 percentage points.

The following urgent measures are required to overcome the identified negative trends in the economic development of the Lipetsk region:

- to ensure the growth of profitability of the real sector through successful investments in the regional economy;
- to improve the quality of business infrastructure – in particular, for investors; and
- to create conditions for the further development of the labor potential of the region.

The implementation of these measures will contribute to the economic development of the Lipetsk region and improvement of the living standards of the population on its basis, since the prospects for the technological and economic "breakthrough" of the region are determined by the development of social capital and the growth of prosperity of residents.

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