ORIGINAL PAPER

DOI: 10.26794/2587-5671-2021-25-6-68-84
UDC 336.14.330.43(045)
JEL C1, G17, G18

Scenario Modelling of the Impact of the Dynamics of Public Debt on the Gross Regional Product of Russian Regions

I.V. Naumov[a] ✉, **N.L. Nikulina**[b]
Institute of Economics of the Ural Branch of RAS,
Yekaterinburg, Russia
[a] https://orcid.org/0000-0002-2464-6266; [b] https://orcid.org/0000-0002-6882-3172
✉ Corresponding author

ABSTRACT

The **subject** of this research is public debt and its impact on the dynamics of the gross regional product (GRP) of Russian regions. The aim of the paper is to study and scenario forecast the dynamics of changes in the internal public debt of Russian regions and model its impact on the gross regional product. The **relevance** of the study is due to the fact that most regions in Russia are forced to increase their internal public debt to cover the budget deficit and attract additional resources to solve important problems of socio-economic development and implement strategic projects and programs. The **scientific novelty** of the research consists in the development of a methodological approach to modelling and scenario forecasting of the level of GRP of different groups of regions, taking into account the dynamics of changes in their public debt using ARIMA modelling methods and panel regression analysis. The authors apply the **methods** of panel regression analysis and ARIMA modelling. The authors theoretically substantiated that public debt has a different effect on the GRP of Russian regions, grouped the regions according to the identified trends in the dynamics of public debt (the first group — regions with the dynamics of debt reduction over the period from 2005 to 2019, the second group — with the all-Russian trend of debt reduction since 2017, and the third group — with the dynamics of increasing debt over the period under review); developed a methodological approach to modelling and scenario forecasting of the GRP level of the Russian regions, taking into account the dynamics of changes in their public debt; carried out ARIMA forecasting of the dynamics of the public debt of different groups of regions and built regression models of the influence of the dynamics of the public debt on the GRP of Russian regions within the selected groups; formed forecast scenarios for changes of the GRP level of regions, taking into account the identified dynamics of transformation of their internal public debt. **Conclusions:** public debt has a negative impact on the dynamics of the GRP of Moscow and the Moscow region and a positive effect on the dynamics of the GRP of the regions of the second and third groups. The findings of the study may be used by the federal and regional executive authorities to find ways to reduce public debt and increase the level of socio-economic development of territories.

Keywords: public debt; scenario forecasting; ARIMA modelling; panel regression analysis; gross regional product

For citation: **Naumov I.V., Nikulina N.L. Scenario modelling of the impact of the dynamics of public debt on the gross regional product of Russian regions.** ***Finance: Theory and Practice.*** **2021;25(6):68-84. DOI: 10.26794/2587-5671-2021-25-6-68-84**

INTRODUCTION

Public debt plays an ambiguous role in the economic development of regions. The overwhelming majority of Russian regions today are forced to increase their domestic public debt to cover the budget deficit and attract additional resources to solve acute problems of socio-economic development and implement strategically important projects and programs. Budgetary and bank lending to the regions of the Russian Federation, attracting investments in their debt securities constitute the financial basis for the economic development of these regions. Such researchers as I.V. Kisel' [1], N.N. Parasotskaya and N.D. Yakovlev [2], S. Li, P. Cao [3], R. Zhao, Y. Tian, A. Lei, F. Boadu, Z. Ren [4], A.C. Carlo [5], S.W. Yong, R. Suhaimi, S.Y. Chai [6] studied the positive impact of the public debt on the social-economic development of territories.

On the other hand, by increasing the internal public debt, the Russian regions increase the level of debt burden on regional budgets, which can lead the overwhelming majority of regions to adverse consequences — threats of loss of budgetary security. The negative effect of increasing public debt is considered in the works of L.B. Mokhnatkina [7], S. Soldatkin [8], A. Afonso, J. Alves [9], U. Panizza, A.F. Presbitero [10], G. Gagarina, L. Chainikova, L. Arkhipova [11]. S.G. Cecchetti, M.S. Mohanty and F. Zampolli, who note that after reaching a certain level, public debt begins to negatively affect socio-economic development [12]. For a number of central regions of Russia, which have a fairly high budgetary provision, the growth of the internal public debt, on the contrary, contributes to a decrease in the rate of economic development due to an increase in the cost of maintaining the accumulated debt. Such regions are trying to reduce the debt burden on the budget and increase the level of budgetary independence and autonomy. Thus, it can be assumed that public debt has either a positive or a negative impact on certain groups of regions that differ in terms of GRP. This paper is devoted to the substantiation of this hypothesis.

Based on the importance and relevance of this problem, the main aim of this paper is to study and scenario forecast the dynamics of changes in the internal public debt of the regions of the Russian Federation and model its impact on GRP. To do this, the following objectives were set:

- theoretical analysis of approaches to understanding the role of public debt in the economic development of territories;
- study of the methodological foundations of scenario forecasting of the dynamics of public debt and modeling of its impact on the GRP of the Russian regions;
- grouping of regions according to the identified trends in the dynamics of public debt;
- ARIMA modelling the dynamics of the public debt of various groups of regions;
- construction of regression models of the influence of the dynamics of public debt on GRP within the selected groups.

Reaching these objectives allows establishing the degree of influence of the public debt on the GRP of the regions of the Russian Federation of various groups and to formulate forecast scenarios for its change, considering the revealed dynamics of transformation of the domestic public debt.

THEORETICAL AND METHODOLOGICAL QUESTIONS OF RESEARCH

N.N. Parasotskaya and N.D. Yakovlev noted the positive influence of public debt on socio-economic development [2]. In their study, they write about the expedient and reasonable use of government borrowing, since this allows budgetary maneuvers to be carried out, helps to contain the negative impact of shocks on the country's economy, and can yield positive results for the economy as a whole.

S. Li, P. Cao investigate the impact of public debt on urbanization. Empirical studies show that the debt of local authorities contributes to an increase in the

rate of urbanization, the development of infrastructure [3].

Among the researchers who focus on the positive role of public debt in socio-economic development are I. V. Kisel' [1], R. Zhao, Y. Tian, A. Lei, F. Boadu, Z. Ren [4], A. C. Carlo [5], S. W. Yong, R. Suhaimi, S. Y. Chai [6].

The negative impact of public debt on socio-economic development is presented in the study by L. B. Mokhnatkina. The attraction of sources of financing the budget deficit leads to the accumulation and growth of public debt, while the growth of public debt leads to an increase in the cost of servicing debt obligations. In conditions of austerity of budgetary funds, the accumulated public debt becomes a significant source of threat to regional economic security [7].

Foreign scientists U. Panizza, A. F. Presbitero investigate the impact of public debt on economic growth in a sample of OECD countries. The results are consistent with studies that found a negative correlation between debt and growth [10].

The negative role of public debt is considered in the works of scientists such as S. N. Soldatkin [8], A. Afonso and J. Alves [9], G. Gagarina, L. Chainikova, L. Arkhipova [11].

The authors single out another group of studies related to assessing the role of public debt. S. G. Cecchetti, M. S. Mohanty, F. Zampolli [12], A. A. Kumykov [13], S. Chen and W. Li [14] note both the positive and negative impact of the public debt on the socio-economic development of the territories. The research results obtained by S. Chen and W. Li, show that the excessive accumulation of latent public debt in the eastern region does not contribute to economic growth, while public debt in the central and western regions makes a significant contribution to local economic growth [14]. S. G. Cecchetti, M. S. Mohanty and F. Zampolli point out that after reaching a certain level, public debt begins to negatively affect socio-economic development [12]. The ambiguity in understanding the role of public debt in the economic development of territories has generated interest in this study.

In the scientific literature, there are several methodological approaches to assessing the role of public debt in the economic development of territories. A theoretical review of the works showed that to model the influence of the public debt of the regions of the Russian Federation on the indicators of their socio-economic development, the main of which is GRP, the *methods of regression analysis* are usually used: a least-squares method for spatial data and spatial regression modelling using panel data. For example, regression analysis was used in the work of K. V. Matvienko to identify the relationship between the volume of debt obligations of various types and the region's GRP, as well as the volume of the revenue side of the consolidated budget of the region [15].

A. Afonso and J. Alves used panel data methods to analyze the impact of public debt on economic growth. One of the important advantages of using panel data estimation is that it emphasizes individual heterogeneity if there are some distinctive features in the cross-sections [9].

Spatial regression methods were applied in the works of R. Zhao, Y. Tian, A. Lei, F. Boadu, Z. Ren, who investigated the correlation between local government debt and regional economic growth in 30 provinces of China. Using a Moran's scatter plot, a Local Indicator of Spatial Association (LISA) map, and a semi-parametric spatial model (SE-SDM), the authors demonstrated the impact of spatial agglomeration effect and local government debt on regional economic growth. Their semi-parametric spatial model characterizes the nonlinear relationship between local government debt and regional economic growth and allows one to estimate the size of local government debt, above which economic growth will be suppressed by crowding out private investment and cuts in public spending [4].

The methods of simulation modelling using regression analysis were applied by A. Yu. Zhigaev to build scenario forecasts of public debt for the medium term [16], S. Chen

and W. Li to study the correlation between local government debt, economic growth and other variables [14]. A multi-parameter dynamic model of Russia's external debt was also developed by S.E. Tsvirko. This model contained a number of exogenous variables reflecting the domestic and foreign policy of the state and made it possible to describe the influence of various methods of settling external debt, known in world practice, on the size of the public debt [17].

These methods make it possible not only to establish the dependence of the economic development of territories on the dynamics of public debt but also to build various scenarios for predicting its changes in the future. However, to form more accurate regression models, it is necessary to use data reflecting the same trends in the dynamics of the public debt of the Russian regions. The use of data for grouped regions with multidirectional trends in the dynamics of public debt in regression analysis will make it possible to objectively assess its impact on the gross regional product of the Russian regions. A theoretical review of the work carried out using this toolkit showed that the constructed regression models for the entire set of regions did not allow us to identify the features of the influence of public debt on the level of their economic development. In such studies, it was found that the dynamics of the growth of the public debt of the territories had both a positive and a negative impact on the indicators of socio-economic development.

To construct predictive scenarios for changes in the dynamics of economic development of regional systems using regression modeling, an important aspect is the construction of accurate forecasts of changes in the dynamics of the public debt of the Russian regions. An overview of works in this area showed that the most popular methods for predicting the dynamics of the public debt of territories are methods of extrapolation, moving averages and exponential smoothing. They were used, for example, in the work of A. Yu. Kolodyazhnaya for forecasting the public debt of the Orenburg region [18], N. A. Tolstobrova, V. Postnikov, M.A. Kamenskikh to analyze changes in economic development indicators and study the dynamics of changes in public debt and Russia's GDP, forecasting the external and internal public debt of Russia in absolute and relative terms [19]. These methods make it possible to form short-term forecasts based on the identified trends in the dynamics of changes in the indicator. If the dynamics of the studied indicator were nonlinear, had high volatility, then the forecasts generated using these methods were not reliable enough. The most accurate forecasting method, in this case, is first or second-order autoregressive modelling, for example, ARIMA modelling.

The ARIMA modelling method was used in the work of N.V. Kovtun, O. Ya. Dolinovskaya, V. Ignatyuk to develop three types of economic and statistical models for the formation of external public debt, namely:

- autoregression models that consider seasonality and violations of a different order, which makes it possible to study in isolation the patterns of formation of the dynamics of external public debt on the principles of decomposition of a number of dynamics;
- a mixed model of autoregression with the inclusion of seasonality, random processes and factor scaling, on the basis of which it is possible to study the patterns of the formation of the debt burden, considering not only its decomposition but also taking into account the factors of accumulation, lending and consumption;
- a mixed autoregression model based on actual data on external public debt, consumption and accumulation, considering MA-, AR-processes and seasonality, which allows determining the dominant factors causing an increase in the debt burden [20].

F. Zhuravka, H. Filatova and J.O. Aiyedogbon studied theoretical and practical aspects of forecasting public debt in Ukraine. A visual analysis by the authors of the change in the size of public debt made it possible to draw a conclusion about the

deepening of the debt crisis in the country. Their methodological approach was based on an autoregressive integrated moving average (ARIMA) as the basic forecasting model [21].

This method of forecasting the dynamics of the public debt of territories, in contrast to the previous methods, is based on the results of regression modelling, considers the volatility of the dynamics of the analyzed indicator and can be used to make forecasts for the medium term. The advantage of ARIMA modelling is not only the formation of the most probable forecast, considering the established trends in the dynamics of the studied indicator, but also the corridor of its possible values, which is especially valuable for the formation of the most negative and positive scenarios.

The need to consider the specifics of the regions from the point of view of the dynamics of changes in public debt for the formation of regression models substantiating its influence on the GRP of the Russian regions, as well as the development of predictive development scenarios of Its change, considering the current trends in the dynamics of public debt, required the development of a new methodological approach. *Fig. 1* presents the algorithm for modelling and scenario forecasting of the GRP of the Russian regions, considering the dynamics of changes in their public debt.

At the initial stage of the study, using graphical methods of analysis, it is planned to assess the dynamics of changes in the total public debt of all Russian regions and their municipalities, as well as to identify regions with different dynamics of this indicator (with trends of growth and decrease in the debt burden on regional budgets). The grouping formed based on the results of the implementation of this stage of the study will make it possible in the future to assess the influence of the established trends in the change in the public debt of the Russian regions on the dynamics of the level of their GRP.

At the second stage of the study, using the methods of ARIMA modelling, it is planned to build three predictive scenarios for changes in the public debt of 85 Russian regions until 2022 within the selected groups of regional systems. The use of this method will allow us to consider the volatility of the dynamics of the indicator under study and build a more accurate scenario of the inertial forecast in comparison with the methods of extrapolation and moving averages. The advantage of using ARIMA modelling is the formation of a corridor of possible forecast values of the indicator, the extreme values of which will be used to build pessimistic and optimistic scenarios for forecasting changes in the public debt of the Russian regions.

The regression analysis carried out at the next stage using panel data for selected groups of regions with multidirectional dynamics of public debt will allow us to establish its influence on the main indicator of the socio-economic development of regions — their gross regional product. Regression modelling, in this case, acts as a tool for substantiating the hypothesis put forward about the different impact of public debt on the GRP of different groups of regions, as well as a method for constructing predictive scenarios for changes in the GRP of the Russian regions, considering the dynamics of their public debt. This study involves the use of panel least squares regression analysis with the necessary preliminary analysis of stationarity, linearity of data distribution, construction of models with fixed and random effects, panel diagnostics to select the optimal model and check statistical significance of its parameters, as well as the Gauss-Markov assumptions (autocorrelation of residuals, normality of their distribution, heteroscedasticity, etc.).

Formed regression models of the GRP dependence on the dynamics of the public debt of the Russian regions and their municipalities for the indicated groups of regions, as well as predictive scenarios for its change at the final stage of the study are the basis for constructing an inertial scenario of GRP dynamics, which assumes

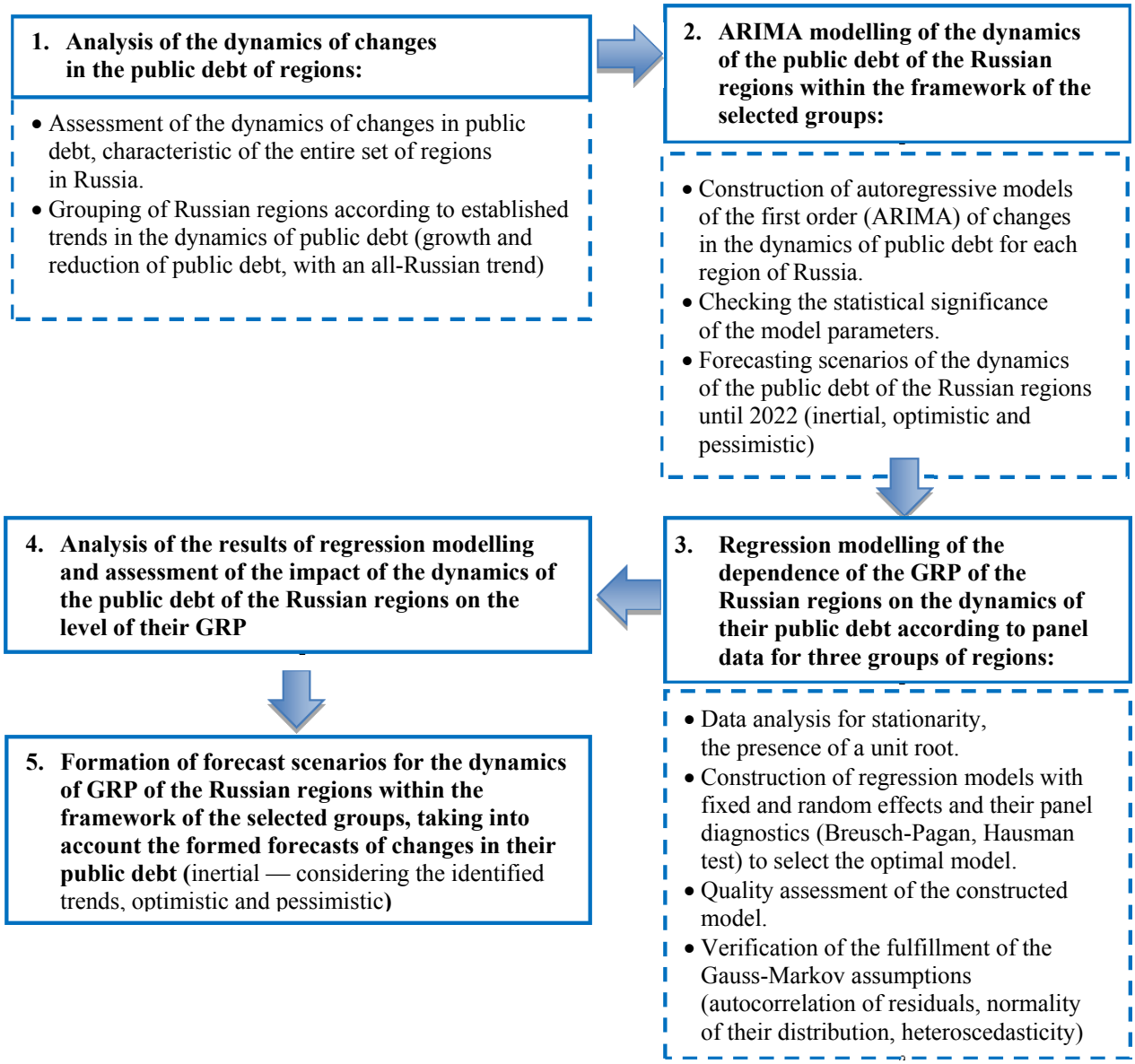

Fig. 1. **Algorithm for modelling and scenario forecasting of the GRP of Russian regions taking into account the dynamics of changes in their public debt**

Source: compiled by the authors.

the preservation of both current trends in the future and an extremely optimistic and pessimistic scenarios. The predicted scenarios of changes in the public debt of the regions of the Russian Federation and the dynamics of their GRP will help to confirm or refute the hypothesis put forward.

RESEARCH RESULTS

The data of the Ministry of Finance of Russia for the period from July 2005 to December 2020 were used to study the dynamics of the public debt of the Russian regions and their municipalities.[1] To cover the emerging budget deficit and increase budgetary provision, the regions are forced to increase the level of their public debt by issuing and selling government debt securities, obtaining budget loans, loans from credit institutions, foreign banks and international financial organizations, issuing state guarantees of a region of the Russian Federation and other debt obligations. The total public debt of all Russian

[1] The size and structure of the public debt of the Russian regions and municipalities. URL: https://minfin.gov.ru/ru/perfomance/public_debt/subdbt/ (accessed on 01.11.2021).

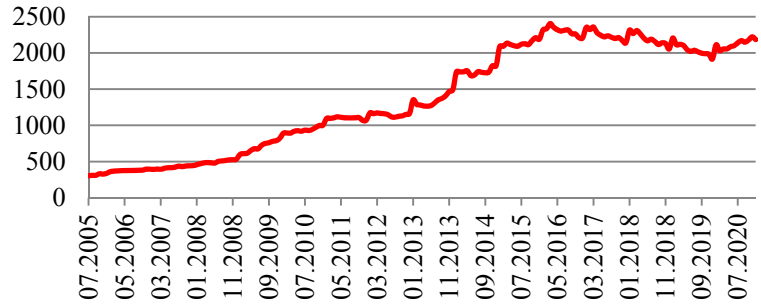

Fig. 2. **Dynamics of the total public debt of Russian regions and their municipalities from 07.2005 to 12.2020, billion rubles**

Source: compiled by the authors. URL: https://minfin.gov.ru/ru/perfomance/public_debt/subdbt/ (accessed on 01.11.2021).

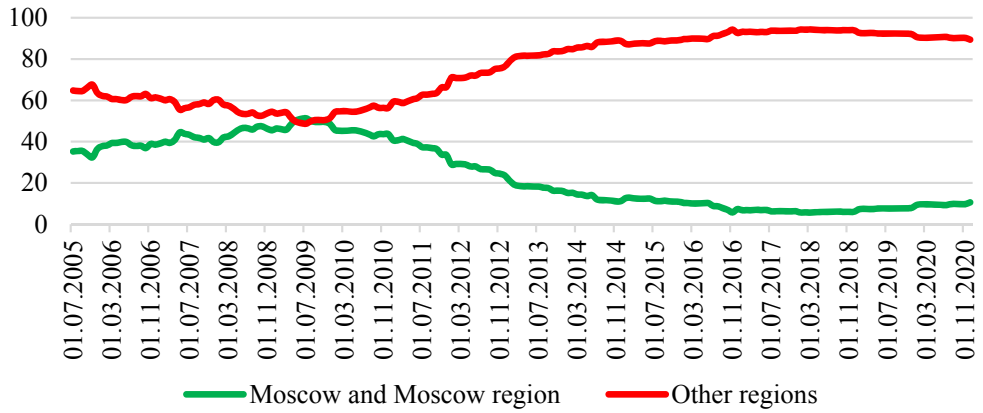

Fig. 3. **Dynamics of changes in the share of Moscow, the Moscow region and other regions in the total public debt of Russian regions, %**

Source: compiled by the authors.

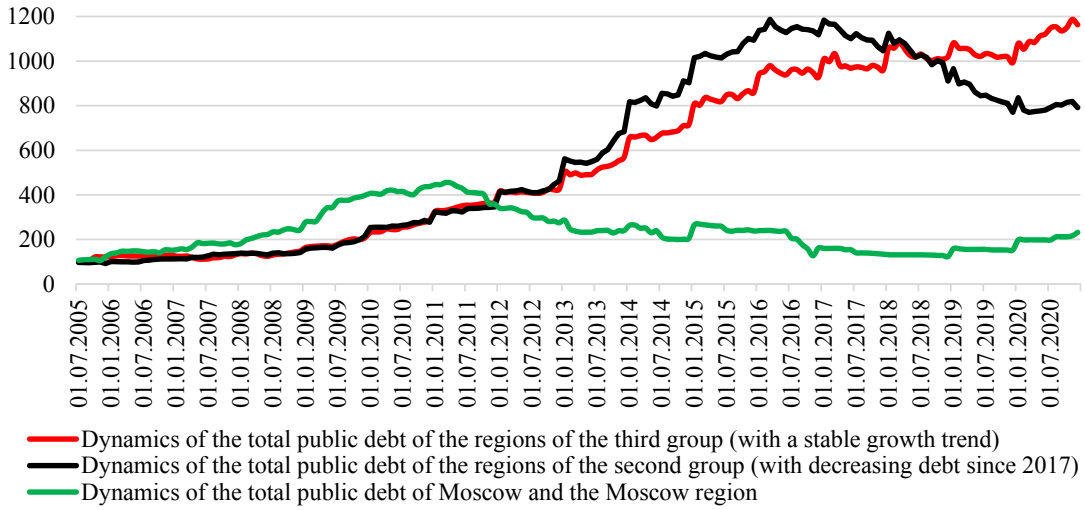

Fig. 4. **Dynamics of public debt in three groups of regions, billion rubles**

Source: compiled by the authors.

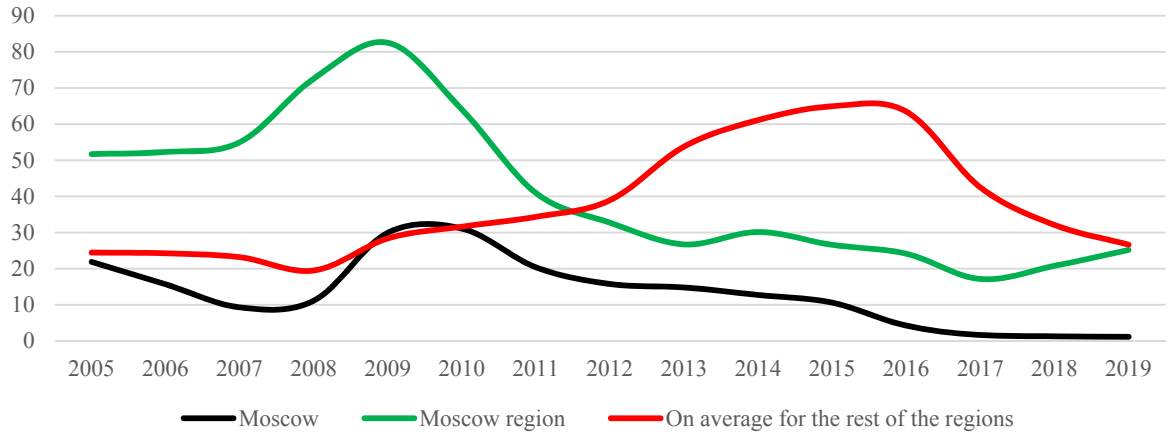

Fig. 5. **Dynamics of changes in the ratio of coverage of budgetary debt in Moscow and the Moscow region, %**
Source: compiled by the authors.

regions and their municipalities for the period under review increased by 7.2 times —from 303 billion rubles in July 2005 to 2 186 billion rubles by the end of 2020 (*Fig. 2*).

If in 2005 35.3% of the total public debt accounted for Moscow and the Moscow region, by the end of 2020 the share of these regions in the structure of public debt fell to 10.6%. The rest of the regions have been actively increasing the level of public debt over the past 15 years (*Fig. 3*). At present, these regions concentrate about 89% of the total public debt of the Russian regions. The presented figure confirms the spatial heterogeneity of the distribution of public debt of regions and their municipalities established by our previous study [22].

Over the period from 2005 to 2020, the share of public debt in the structure of total public debt for all regions of the Russian Federation increased significantly in such regions as: Krasnodar Territory (up to 4.8%), Sverdlovsk Region (up to 4.4%), Republic of Tatarstan (up to 4.4%), St. Petersburg (up to 3.9%), Krasnoyarsk Territory (up to 3.5%), Nizhny Novgorod Region (up to 2.9%), Udmurt Region (up to 2.5%), Khabarovsk Territory (up to 2.5%), Republic of Mordovia (up to 2.2%), Samara Region (up to 2.2%), Volgograd Region (up to 2.2%), Saratov Region (up to 2.1%), Tomsk region (up to 1.9%), etc.

The spatial transformation of the debt burden on regional budgets is also confirmed by the grouping of regions formed by us according to the characteristic trends in the dynamics of their public debt (*Fig. 4*).

The study identified three groups of regions with similar dynamics of changes in public debt over the period 2005–2020. In the first group of regions, to which we include Moscow and the Moscow region, there were tendencies of decreasing public debt. The most noticeable decrease in the debt burden on the budget was observed in Moscow. This trend is natural, since the region has a fairly high budgetary provision. In the Moscow region, despite the growth in public debt that began in mid-2017, the overall debt burden on the budget decreased (*Fig. 5*). The coverage ratio of the budgetary debt of the Moscow region, which characterizes the ratio of the public debt of a region of the Russian Federation to the volume of its own tax and non-tax revenues, had a similar dynamics decline as in Moscow. At the end of 2019, this indicator for the Moscow region decreased from 82.5% as of 2009 to 25.2%. To construct the three most probable scenarios for predicting changes in the dynamics of the public debt of the regions of the first group by 2022, ARIMA modelling was used, the results of which are presented in *Table* and *Fig. 6*.

The statistical significance of the model parameters is evidenced by the P-values of the coefficients that are within the permissible values, the determination coefficients taking values close to one, as well

Table

Results of ARIMA modelling of the dynamics of the total public debt of Moscow and the Moscow region

	Coefficient	Standard error	z	P-value
const	203 971	65 564.5	3.111	0.0019
phi_1	0.989241	0.00850885	116.3	0.0000
theta_1	0.0915908	0.00653365	4.402	0.0161
	Real unit	Imaginary unit	Module	Frequency
AR — Root 1	1.0109	0.0000	1.0109	0.0000
MA — Root 1	–10.9181	0.0000	10.9181	0.5000
R-squared	0.983361	Norm. R-squared	0.983270	
Akaike criterion	4017.428	Schwarz criterion	4030.309	
Hannan-Quinn criterion	4022.648			

Source: compiled by the authors.

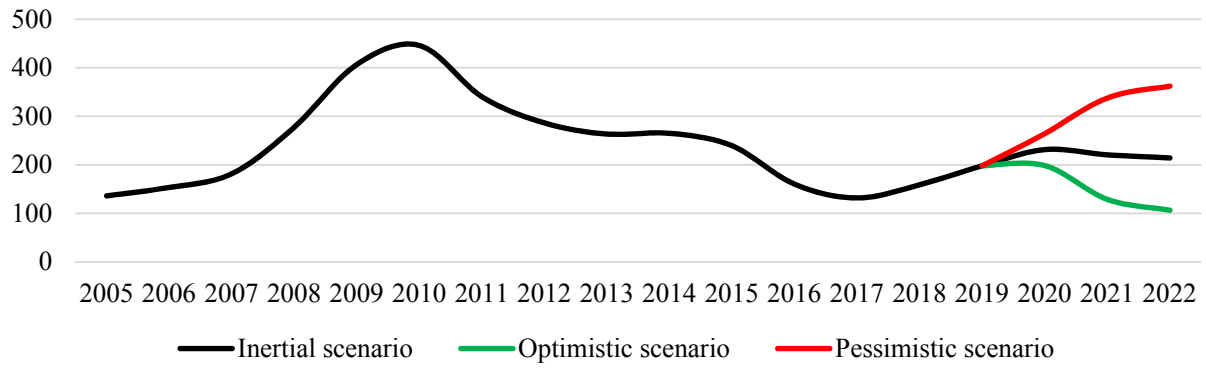

Fig. 6. **Scenarios of the dynamics of the total public debt of Moscow and the Moscow region until 2022, billion rubles**

Source: compiled by the authors.

as the information criteria Akaike, Schwarz and Hannan-Quinn. To assess the reliability of the model, tests were carried out for the presence of autocorrelation up to the 12th order (Ljung-Box Q) and the normality of the distribution of residuals. The tests carried out have confirmed the statistical significance of the parameters of this model.

According to the generated ARIMA model, the inertial scenario shown in *Fig. 6*, suggests that the noted downward trend in the public debt of Moscow and the Moscow region will continue in the short term (to 214.1 billion rubles by 2022). A more positive scenario is also possible — a decrease in the public debt of the regions to 106.3 billion rubles. Since the total public debt of the regions of the first group over the past three years has been growing, which is pronounced in the Moscow region, the scenario of a pessimistic forecast

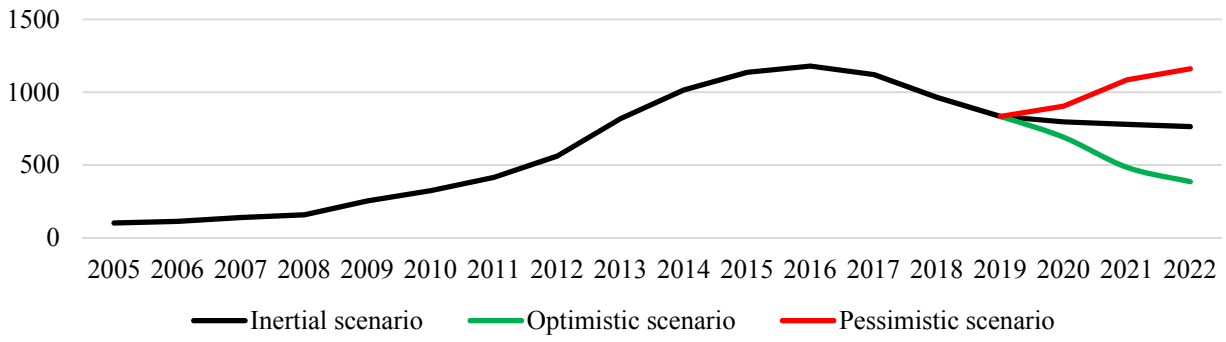

Fig. 7. **Scenarios of the dynamics of the aggregate public debt of the regions of the second group until 2022, billion rubles**

Source: compiled by the authors.

is possible — an increase in the total public debt of regions to 362.2 billion rubles. This is an extremely negative scenario of a change in the debt burden on the regional budget, formed as a result of ARIMA modelling with a 95% confidence level.

If in Moscow and the Moscow region the level of debt burden on the budget's own tax and non-tax revenues has been decreasing since 2009, in other regions of Russia it increased until 2016 (*Fig. 5*). The debt burden on the budget of these regions began to decline only in 2017. A similar trend was observed in the dynamics of changes in the public debt of all regions of the second group, to which we include the Belgorod, Bryansk, Voronezh, Ivanovo, Kostroma, Kursk, Lipetsk, Ryazan, Tver, Arkhangelsk, Volgograd, Leningrad, Murmansk, Astrakhan, Volgograd, Rostov, Samara, Orenburg, Chelyabinsk, Amur, Magadan, Kemerovo and Sakhalin regions, the Republic of Karelia, Komi, Dagestan, Bashkortostan, Chuvashia, Kabardino-Balkaria, Altai, as well as Krasnodar, Stavropol, Krasnoyarsk, Altai, Kamchatka, Primorsky Krai, Khanty-Mansi Autonomous Okrug, Yamalo-Nenets Autonomous Okrug, Nenets and Chukotka Autonomous Okrugs (*Fig. 3*). These regions are characterized by an all-Russian tendency to change the dynamics of public debt. As a result of using the ARIMA modelling tool, three forecast scenarios of changes in the total public debt of the regions of the second group until 2022 were built (*Fig. 7*).

The inertial scenario, formed with a reliability of 95%, predicts a continuation of the trend towards a decrease in the size of public debt in all regions of the second group. The total debt of the region, according to this forecast, may decrease by 2022 from 833.8 to 763.5 billion rubles. Two extremely opposite scenarios (optimistic and pessimistic), which, as the model showed, are quite realistic, allow reducing the public debt of the regions to the level of 2010 (to 385.1 billion rubles) and its growth to the level of 2016 (to 1 161 billion rubles) in the event of a deterioration in the budgetary provision of these regions.

In the regions of the third group, to which we include St. Petersburg, the Republic of Tatarstan, Sakha, Ingushetia, Karachay-Cherkessia, North Ossetia, Chechnya, Mari El, Mordovia, Udmurtia, Tuva, Khakassia, Buryatia, Adygea, Kalmykia, Crimea, Perm, Transbaikal, Khabarovsk Territories, Kurgan, Sverdlovsk, Novosibirsk, Omsk, Tomsk Regions and other regions throughout the entire period under review, there was a steady growth trend in public debt (*Fig. 4*). This group, in addition to subsidized regions with low budgetary security, also includes actively developing regions that attract budget and bank loans, investments in debt securities to solve the most important problems of socio-economic development and implement strategic projects and programs. The use of ARIMA modelling made it possible to identify three possible scenarios for further changes in the dynamics of their public debt (*Fig. 8*).

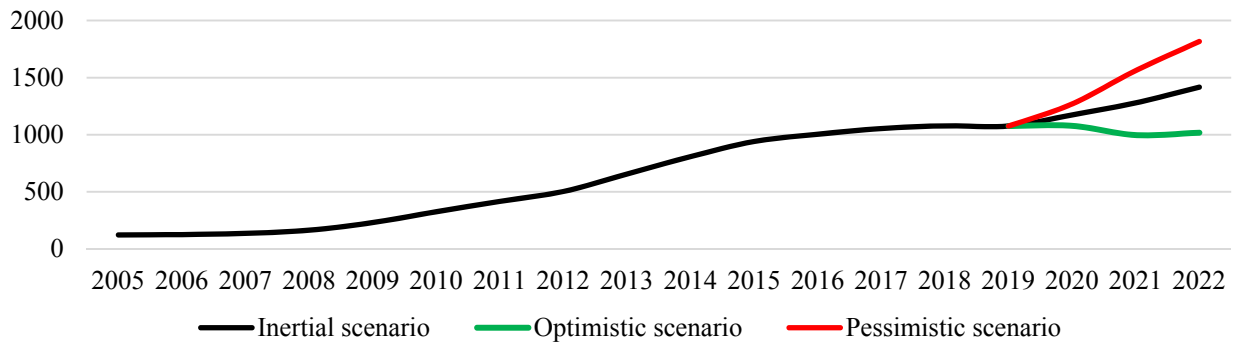

Fig. 8. **Scenarios of the dynamics of the aggregate public debt of the regions of the third group until 2022, billion rubles**

Source: compiled by the authors.

Since over the entire study period the size of the public debt of the regions of this group did not practically decrease, the most likely scenario, considering the noted rates of its change, is an increase in the total public debt of the regions of Russia of the third group for 1 416.9 billion rubles.

A more significant increase in their public debt is also possible — up to 1 816.8 billion rubles, since this group includes subsidized regions. Even an optimistic forecast, as shown by ARIMA modelling, allows maintaining the high level of public debt achieved by the regions (1 017.7 billion rubles) until 2022.

To assess the impact of the dynamics of public debt on the key indicator of socio-economic development — the GRP of the three indicated groups of regions and to further build predictive scenarios for changing its dynamics until 2022, regression modelling using panel data was used. The gross regional product was considered as a dependent variable, and the volume of public debt of the Russian regions and their municipalities was considered as the factor under study. When constructing a model for the first group of regions with a decreasing debt burden on the budget, which is formed by Moscow and the Moscow region, 30 observations were used (annual statistics of the Ministry of Finance of the Russian Federation on the size of public debt of the Russian regions for the period 2005–2019). For the second group of regions with a characteristic tendency towards a decrease in the debt burden on the budget, 585 observations have been used since 2017, for the third group of regions with a steady increase in public debt throughout the entire period under consideration — 615 observations.

Before the formation of regression models for the three types of regional systems, the data were analyzed for stationarity using the Dickey-Fuller test, for the presence of unit roots in the panel using the Chow test. The choice between models with fixed or random effects was carried out using the Hausman and Breusch-Pagan tests, the test for the statistical significance of the regression coefficients (including the Wald test), and the analysis of information criteria of Schwarz, Akaike, and Hannan-Quinn, a Durbin-Watson residual autocorrelation test, a Jarque-Bera test to evaluate the normal distribution of residuals. The Hausman and Breusch-Pagan test showed that the most accurate and adequate model for all groups of regions is the model with fixed effects.

The constructed regression models made it possible to confirm the hypothesis that public debt negatively affects the dynamics of the GRP of Moscow and the Moscow region and has a positive effect on the dynamics of the GRP of the regions of the second and third groups. The economic development of the first group of regions of the Russian Federation (Moscow and the Moscow region) is negatively affected by the processes of increasing public debt, the

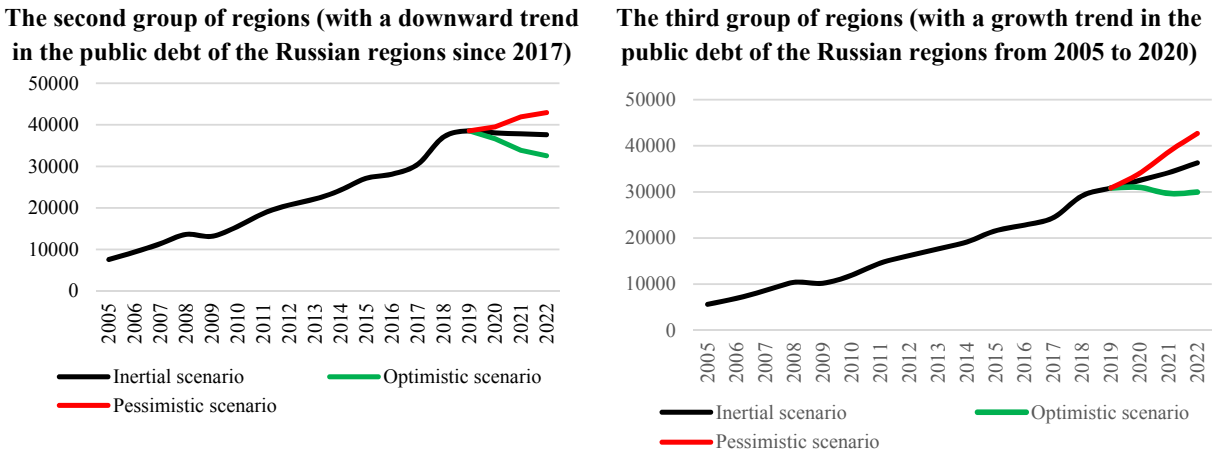

Fig. 9. **Basic forecast scenarios for the development of the dynamics of the GRP of the regions of the second and third groups until 2022, billion rubles**

Source: compiled by the authors.

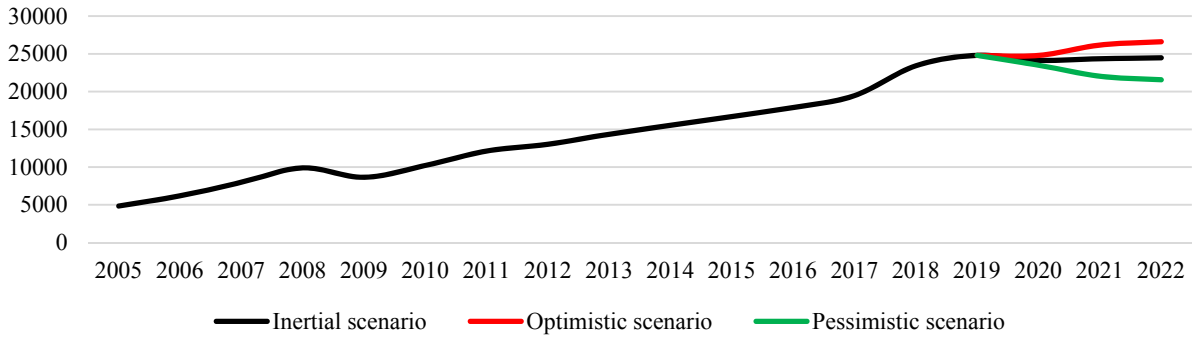

Fig. 10. **Basic forecast scenarios for the development of the dynamics of the GRP of the regions of the first group (Moscow and the Moscow region) until 2022, billion rubles**

Source: compiled by the authors.

relationship between these variables in the regression model is inverse. Thus, according to the constructed model, the growth of the national debt of these regions by 1 million rubles leads to a decrease in their GRP by 19.7 million rubles (*Appendix*).

In the second and third groups of regions, an inverse relationship is observed: an increase in the public debt of the Russian regions leads to an increase in their gross regional product. At the same time, the regions of the third group are most dependent on budget and bank loans, attracted investments in debt securities of financial institutions, with a stable trend of growth in public debt throughout the entire period under review.

An increase in the public debt of the Russian regions of this group by 1 million rubles, according to the constructed model, leads to an increase in their GRP by 15.7 million rubles, and in the regions of the second group by 13.4 million rubles. Regression modelling has shown the importance of attracting additional financial resources for the growth of the key indicator of the socio-economic development of regions (GRP) of the second and third groups. Due to insufficient budgetary provision, these regions are forced to increase public debt. Implement the optimistic scenario in the dynamics of the GRP of the regions of the second group, i.e. growth of this indicator from 38,557 to 42,929 billion rubles. (*Fig. 9*)

it is necessary to attract additional financial resources — the implementation of the pessimistic scenario (*Fig. 7*) in the dynamics of the public debt of these regions, its growth by 327.2 billion rubles.

To implement the optimistic scenario of changes in the dynamics of GRP (its growth from 30,843 to 42,682 billion rubles), it will be necessary to attract additional resources from the public debt in the amount of 741 billion rubles (implementation of the pessimistic scenario of changes in the dynamics of the public debt of the regions, shown in *Fig. 8*). A decrease in the level of public debt of the regions of Russia included in these groups will lead, according to the constructed regression model, to a decrease in the GRP of regions to the level of 2017 in the second group and to a decrease in the GRP of regions to the level of 2017, to the level of 2019 in the third (*Fig. 9*).

The inertial scenario of changes in the dynamics of the GRP of the regions of the second group (its moderate decrease) is possible in the presence of the previously noted (*Fig. 7*) trend of decreasing the public debt of the Russian regions i.e. inertial scenario of changes in its dynamics. Thus, the constructed model and scenarios confirm the positive impact of public debt on the dynamics of the GRP of the regions of the Russian Federation of the second and third groups. More prosperous regions (Moscow and the Moscow region), on the contrary, are forced to reduce the debt burden on the budget. An optimistic scenario of the dynamics of the GRP of the central regions is possible only if a similar scenario of changes in their public debt is realized. A decrease in the public debt of these regions of Russia has a positive effect on the dynamics of their GRP (*Fig. 10*). To implement the optimistic forecast for the development of the dynamics of the GRP of Moscow and the Moscow region, it is necessary to reduce the total size of their public debt by 91.7 billion rubles. Reducing the debt burden on the budgets of these regions will increase their GRP from 24,801 to 26,609 billion rubles.

Maintaining the current rate of decrease in the public debt of the regions will only slightly increase the volume of GRP. The constructed regression model and scenarios for this group of regions indicate the negative impact of the dynamics of public debt on their GRP. Thus, as a result of the study, it was confirmed that the public debt has a negative impact on the dynamics of the GRP of Moscow and the Moscow region and a positive effect on the dynamics of the GRP of the regions of the second and third groups, the importance of attracting investments in debt securities of the Russian regions, as well as additional bank and budget loans, i.e. building up public debt for the economic development of regions that do not have high budget security.

CONCLUSIONS

A theoretical analysis of works in this area has shown that public debt has a different effect on the key indicator of the socio-economic development of territories — the gross regional product. Panel regression analysis and ARIMA modelling were used to assess the impact of the public debt of the Russian regions on GRP. The developed methodological approach involves analyzing the dynamics of changes in the public debt of regions, grouping them according to the established trends in the dynamics of this indicator, building autoregressive ARIMA models and the most probable scenarios for predicting changes in the dynamics of public debt for each region of Russia until 2022 (inertial, optimistic and pessimistic), regression modeling of the dependence of the GRP of the Russian regions on the dynamics of their public debt according to panel data for three groups of regions and the design of corresponding scenarios for predicting changes in their GRP.

This approach allows us identifying the types of regions with different trends in the dynamics of changes in public debt: regions with a decrease in the debt burden on the budget, with a trend towards a decrease in the

debt burden of the Russian Federation on the budget since 2017 and regions with a steady growth in public debt throughout the period under consideration. ARIMA modelling of the dynamics of the public debt of these groups of regions, panel regression analysis of the impact of the dynamics of public debt on GRP within the selected groups, predicted scenarios of changes in the public debt of regions and the dynamics of their GRP until 2022 helped to substantiate the hypothesis that the public debt negatively affects the dynamics of the GRP of Moscow and the Moscow region and has a positive effect on the GRP of the regions of the second and third groups.

ACKNOWLEDGEMENTS

The article has been prepared in accordance with the research plan for 2021. Institute of Economics of the Ural Branch of RAS, Yekaterinburg, Russia.

REFERENCES

1. Kisel' I.V. Public debt in the system of economic relations. In: Sustainable development of the economy: State, problems, prospects. Proc. 5th Int. sci.-pract. conf. (Pinsk, Apr. 28–29, 2011). (in 2 pts.). Pt. 1. Pinsk: Polessky State University; 2011:49–51. (In Russ.).
2. Parasotskaya N.N., Yakovlev N.D. Pros and cons of public borrowing and public debt for the Russian budget system. *Uchet. Analiz. Audit = Accounting. Analysis. Auditing.* 2019;6(4):61–69. (In Russ.). DOI: 10.26794/2408–9303–2019–6–4–61–69
3. Li S., Cao P. Does local government debt promote China's new urbanization? *The Chinese Economy*. 2020;53(4):342–354. DOI: 10.1080/10971475.2020.1728482
4. Zhao R., Tian Y., Lei A., Boadu F., Ren Z. The effect of local government debt on regional economic growth in China: A nonlinear relationship approach. *Sustainability.* 2019;11(11):3065. DOI: 10.3390/su11113065
5. Carlo A.C. The impact of the balanced budget principle on regional financial autonomy in Italy. *Revista General de Derecho Constitucional*. 2018;(27):420010.
6. Yong S.W., Suhaimi R., Chai S.Y. The effect of public debt on FDI-growth nexus: Threshold regression analysis. *Advanced Science Letters.* 2017;23(8):7342–7345. DOI: 10.1166/asl.2017.9470
7. Mokhnatkina L.B. Budget balance and government debt as indicators of region's financial and budgetary security. *Nauchno-issledovatel'skii finansovyi institut. Finansovyi zhurnal = Research Financial Institute. Financial Journal.* 2018;(2):106–119. (In Russ.). DOI: 10.31107/2075–1990–2018–2–106–119
8. Soldatkin S.N. The effectiveness of regional debt policy through the prism of investment activity. *Regional'naya ekonomika: teoriya i praktika = Regional Economics: Theory and Practice.* 2015;(30):46–57. (In Russ.).
9. Afonso A., Alves J. The role of government debt in economic growth. *Hacienda Pública Española = Review of Public Economics*. 2015;(4):9–26. DOI: 10.7866/HPE-RPE.15.4.1
10. Panizza U., Presbitero A.F. Public debt and economic growth: Is there a causal effect? *Journal of Macroeconomics.* 2014;41:21–41. DOI: 10.1016/j.jmacro.2014.03.009
11. Gagarina G., Chaynikova L., Arkhipova L. The role of the analysis of sustainable development of regions of Russia in the strategic planning. *Federalizm = Federalism.* 2019;(4):5–21. (In Russ.). DOI: 10.21686/2073–1051–2019–4–5–21
12. Cecchetti S.G., Mohanty M.S., Zampolli F. The real effects of debt. BIS Working Paper. 2011;(352). URL: https://www.bis.org/publ/work352.pdf
13. Kumykov A.A. Public debt: Economic nature and place in the economic mechanism. Doct. econ. sci. diss. Synopsis. Moscow; 2003. 52 p. (In Russ.).
14. Chen S., Li W. Local government debt and regional economic growth in China. *China Political Economy.* 2019;2(2):330–353. DOI: 10.1108/CPE-10–2019–0028
15. Matvienko K.V. Economic security strategy in the system of government debt policy management in Russia. Doct. econ. sci. diss. Synopsis. Yoshkar-Ola: Volga State University of Technology; 2020. 48 p. (In Russ.).

16. Zhigaev A. Yu. A plot method for forecasting of dynamics of government debts in a medium-term outlook. *Ekonomicheskii zhurnal Vysshei shkoly ekonomiki = The HSE Economic Journal.* 1999;3(3):395–422. (In Russ.).
17. Tsvirko S. E. Modeling the dynamics of Russia's external debt. Cand. econ. sci. diss. Synopsis. Moscow: Financial Academy under the RF Government; 2004. 28 p. (In Russ.).
18. Kolodyazhnaya A. Yu. Forecasting the public debt of the Orenburg oblast through the analytical alignment method. *Finansovaya analitika: problemy i resheniya = Financial Analytics: Science and Experience.* 2016;(12):37–46. (In Russ.).
19. Tolstobrova N. A., Postnikov V. P., Kamenskikh M. A. The impact of public debt on the dynamics of economic development in the Russian Federation. *Finansy i kredit = Finance and Credit.* 2013;(20):37–42. (In Russ.).
20. Kovtun N. V., Dolinovskaya O. Ya., Ignatyuk V. V. Modeling public debt in the face of financial instability. *Vestnik Universiteta (Gosudarstvennyi universitet upravleniya).* 2013;(17):101–116. (In Russ.).
21. Zhuravka F., Filatova H., Aiyedogbon J. O. Government debt forecasting based on the Arima model. *Public and Municipal Finance.* 2019;8(1):120–127. DOI: 10.21511/pmf.08(1).2019.11
22. Naumov I. V. Role of financial resources of the economy's banking sector in Russian regions' socio-economic development. *Ekonomicheskie i sotsial'nye peremeny: fakty, tendentsii, prognoz = Economic and Social Changes: Facts, Trends, Forecast.* 2020;13(6):152–168. (In Russ.). DOI: 10.15838/esc.2020.6.72.9

ABOUT THE AUTHORS

Il'ya V. Naumov — Cand. Sci. (Econ.), Senior Researcher of the Center for Strategic Development of Territories, Institute of Economics of the Ural Branch of RAS, Yekaterinburg, Russia
ilia_naumov@list.ru

Natal'ya L. Nikulina — Cand. Sci. (Econ.), Senior Researcher of the Laboratory for Modelling Spatial Development of Territories, the Institute of Economics of the Ural Branch of RAS, Yekaterinburg, Russia
nikulinanl@mail.ru

Appendix

Results of regression modelling of the dependence of the GRP of the Russian regions on the dynamics of their public debt for three groups of regions

Model 1 — for the first group of regions — Moscow, Moscow region (with a downward trend in public debt since 2010)				
	Coefficient	*St. error*	*t- statistic*	*P-value*
const	9231710000	1307040000	7.063	1.36e-07 ***
X	**–19.72**	9.581	–2.058	0.049 **
LSDV R-squared	0.675		Within *R*-squared	0.136
LSDV F(2, 27)	28.148		*P*-value (*F*)	2.48e-07 ***
Schwarz criterion	1406.46		Akaike criterion	1402.256
rho-parameter	0.87		Hannan-Quinn criterion	1403.601
Wald test for heteroscedasticity (null hypothesis — observations have total error variance):			Test statistic: Chi-square (2) = 38.684	3.97951e-009 ***
Wooldridge test for assessing autocorrelation:			Test statistic: *F* (1, 1) = 4394.63	0.0096 ***
Null hypothesis — normal distribution:			Chi-square (2) = 3.048	0.021 ***
Model 2 — for the second group of regions (with a downward trend in public debt of the Russian regions since 2017)				
	Coefficient	St. error	t- statistic	P-value
const	334826000	15524500	21.57	4.70e-075 ***
X	**13.364**	18.84	0.709	2.46e-061 ***
LSDV R-squared	0.819		Within R-squared	0.394
LSDV F (39, 545)	63.604		P-value (F)	2.8e-176 ***
Schwarz criterion	24557.87		Akaike criterion	24383
rho-parameter	0.991		Hannan-Quinn criterion	24451.15
Breusch-Pagan test statistic:			LM = 2266.56	0.0 ***
Hausman test statistic:			H = 0.259	0.61
Wald test for heteroscedasticity (null hypothesis — observations have total error variance):			Chi-square (39) = 2.09359e + 006	0.0 ***
Wooldridge test for assessing autocorrelation:			Test statistic: *F* (1, 38) = 222.483	1.81e-017 ***
Null hypothesis — normal distribution:			Chi-square (2) = 299.67	0.0 ***

Appendix (continued)

Model 3 — for the third group of regions (with a growth trend in public debt of the Russian regions from 2005 to 2020)				
	Coefficient	*St. error*	*t- statistic*	*P-value*
const	185084000	14647900	12.64	1,85e-032 ***
X	**15.749**	0.780	20.17	8,72e-069 ***
LSDV R-squared	0.829		Within *R*-squared	0.415
LSDV F (41, 573)	68.199		P-value (*F*)	3.0e-192 ***
Schwarz criterion	25708.87		Akaike criterion	25523.16
rho-parameter	0.933		Hannan-Quinn criterion	25595.37
Breusch-Pagan test statistic:			LM = 2288.02	0.0 ***
Hausman test statistic:			H = 0.685	0.407
Wald test for heteroscedasticity (null hypothesis — observations have total error variance):			Test statistic: Chi-square (41) = 2.3304e+007	0.0 ***
Wooldridge test for assessing autocorrelation:			Test statistic: *F* (1, 40) = 2477.48	1.32859e-037 ***
Null hypothesis — normal distribution:			Chi-square (2) = 1890.4	0.0 ***

Source: compiled by the authors.

Note: ***, ** Statistical significance at the 1% and 5% level, respectively.

The article was submitted on 28.05.2021; revised on 11.06.2021 and accepted for publication on 27.09.2021.
The authors read and approved the final version of the manuscript.