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Econometric Analysis of the Effectiveness of Government Incentive Measures for the Development of the Region

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ABSTRACT

This study aims to identify the main factors that can influence the growth of the regional economy in order to assess the effectiveness of the government support measures for regions, designed to stimulate the regional domestic product growth. The subject of the study is the relationship of socio-economic indicators in the Northwestern Federal District of Russia. The authors apply the method of correlation-regression analysis. The scientific novelty lies in the development of an econometric model based on statistical data of the constituent entities of the Northwestern Federal District to forecast the levels of regional domestic product and consumer spending per capita. The main socio-economic indicators of the development of the Northwestern Federal District have been identified, which make it possible to quantitatively assess the measures taken by the government to financially support the population and the economy of the region. The Menges model was chosen as the basis for the study, which allows analyzing the relationship between such significant financial and economic indicators of an economic entity as gross regional product, investments, profit of organizations and consumption. The article developed an econometric model in the form of a system of interconnected econometric equations, the coefficients of which were estimated in the Gretl package of applied econometric programs. Based on the analysis and modification of the classical Menges model, the authors were able to determine the key indicators that have a significant impact on the dynamics of the economy of the Northwestern Federal District. These include the following factors: investments; consumer spending per capita; taxes; social payments; household deposits; personal loans; industrial production; income from business activities; profit of organizations. The authors conclude that financial support for entrepreneurs and businesses does not have a significant impact on the economic growth of the region, and measures aimed at increasing the wages of employees of organizations for the economy of the Northwestern Federal District are more effective than measures associated with an increase in social benefits. The research results will be useful to those who make regional management decisions to stabilize the post-pandemic economic situation in the Northwestern Federal District.

Keywords: financial and economic indicators; Northwestern Federal District; Menges model; econometric analysis; forecasting; the effectiveness of government support measures; investments; profit of organizations; consumption; entrepreneurial activity

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INTRODUCTION

The 2020 pandemic had a negative impact on the global economy. Suspension of production, reduction of services in the consumer's sector, falling incomes — these are the economic consequences of the quarantine, which led to a slowdown, up to a complete stop, of economic development of both the country as a whole and its regions.

In the current conditions of the global crisis and the constantly changing external environment, the Government of the Russian Federation pays special attention to supporting the population and business. The socio-economic measures being taken are aimed at stabilizing the economic situation in the country, supporting the regional economy and the social well-being of citizens. This determines the importance of studying the drivers of economic growth in the regions, the impact on which can increase the effectiveness of government support measures.

The Northwestern Federal District, formed by the Decree of the President of the Russian Federation dated May 13, 2000, was chosen as the object of study. It is located in the north and northwest of the European part of the Russian Federation. The district includes 11 subjects with a population of 13,941,959 people (9.54% of the population of Russia as of January 1, 2021) and an area of 1,686,972 km^2 (9.85% of the territory of the Russian Federation).[1] The center of the region is the federal city of St. Petersburg. The Northwestern Federal District includes: the Republic of Karelia, the Komi Republic, the Arkhangelsk, Vologda, Kaliningrad, Leningrad, Murmansk, Novgorod, Pskov regions, the city of St. Petersburg, the Nenets Autonomous Okrug.

The industrial production index in the Northwestern Federal District in January-November 2020, according to Rosstat, amounted to 97.2% compared to the corresponding period last year. This coincides with the all-Russian data (97%). According to this indicator, the Northwestern Federal District ranks fifth among eight federal districts.

From an economic perspective, 2020 has become the most challenging year for the Northwestern Federal District in the last decade. Although there were no obvious economic collapses, the recession in a number of industries was significant.

The oil-producing Nenets Autonomous Okrug (NAO) and the Komi Republic (–7%), as well as the Kaliningrad Region (–8%), suffered the largest losses (–11% in the first eleven months of 2020). The structure of industrial production in the NAO and Komi is such that the extractive industry makes a significant contribution to their regional domestic product. Russia's accession to the OPEC+ deal has led to a decline in oil production in almost the entire country. In the NAO, the decline in production amounted to 11.2% compared to January-November 2019, and in the Komi Republic — 8.7%. As for the economy of the Kaliningrad region, its decline was largely due to the automotive cluster, which reduced production by 27.2%.

The industry showed growth only in two regions of the North-West — the Vologdskaya Oblast (+1.8%) and Karelia (+22.8%). In the first case, this is primarily the result of the stable operation of the Cherepovets Metallurgical Plant, the main asset of Severstal.

According to the results of January-November 2020, the Republic of Karelia ranked second in terms of the dynamics of the industrial production index after North Ossetia. The extraction of crushed rock increased 5.3 times, the output of the food industry increased by 16.6%, and the volume of beverage production increased by 72.1%. But the industries that seem traditional for Karelia — woodworking and paper production — did not give a significant increase. This determines the relevance of studying the reasons for this situation, both as a result of the efforts of regional authorities to diversify the economy, and the effect of a

[1] Northwestern Federal District. Official site of the Plenipotentiary Representative of the President of the Russian Federation in the Northwestern Federal District. URL: http://szfo.gov.ru/ (accessed on 23.03.2021).

low base since in previous years the industry of the republic was in a rather depressed state. The rational use of economic resources can lead to significant economic development in the region and an increase in the standard of living of the population. Therefore, it is very important to understand the relationship between the main financial and economic indicators of the region and to identify the key factors influencing the economic development of the region.

PREVIOUS RESEARCH

The study of the development of the economy, both individual regions and national economies, is today a topical problem, the solution of which is devoted to a lot of scientific articles by modern domestic and foreign authors.

In 2001, Academician A. G. Granberg outlined the strategy of the territorial socio-economic development of Russia [1], the main provisions of which were developed in the scientific works of many domestic researchers and were included in the main documents that form the state policy.

The works of P. A. Minakir and A. N. Demyanenko discussed the evolution of approaches and methodology of spatial economics [2].

G. B. Kleiner and M. A. Rybachuk [3] presented the results of the analysis of the systemic balance of the constituent entities of Russia, based on the calculation of the systemic balance index. The authors showed a significant scatter of regions in terms of the degree of balance and a high proportion of structurally unbalanced regions. In the region under study, certain regions of the Northwestern Federal District, for example, the Nenets Autonomous Okrug, fell into the category of outsiders. A.N. Bereznyatskiy and B.E. Brodskiy [4] described St. Petersburg as a leading region.

S.A. Aivazian, M. Yu. Afanasiev, A.V. Kudrov [5] developed indicators that characterize the socio-economic state of the regions of the Russian economy. The differentiation is based on eight indicators that characterize the five main areas of socio-economic development of the constituent entities of Russia, including production of goods and services, material well-being, quality of the population, quality of social services, and internal security. St. Petersburg is ranked among the leaders in terms of the main parameters for ensuring stable development.

We will use the understanding of the systemic balance and stability of various areas of the Northwestern Federal District, obtained by previous researchers, to analyze the validity of government support measures for individual regions of the district.

The use of econometric methods for studying various economic problems makes it possible to obtain a quantitative assessment of the influence of various endogenous and exogenous factors on the socio-economic characteristics of regions. Problems of this type for the regions of Russia were solved using econometric modeling in the publications of many authors.

In the article by A.N. Bereznyatskiy, and B.E. Brodskiy [4], the authors were interested in the problem of modeling the macro dynamics of the Russian economic region. At the same time, the authors took into account only intra-regional factors of economic development. They built models where the gross regional product was used as a simulated indicator; world oil prices, world prices for products of the domestically oriented sector, tariffs for products of the natural monopoly sector, real investment in fixed assets, the real exchange rate of the ruble, subsidies were exogenous variables. However, for the purposes of our study, we need a set of factors that reflect the internal parameters of regional development.

The article by N.E. Egorov [6] analyzed and assessed the creative potential of the Far Eastern Federal District in the field of scientific, educational, and innovative activities for the period 2010–2014. The results of the econometric analysis are presented in the form of tables, allowing the formulation of realistic management recommendations.

In the works [7, 8], econometric methods are used to develop managerial decisions based on the analysis of the determinants of the socio-economic development of various economic entities. Panel data models for studying the economic development of regions are also found in modern literature.

The study of the influence of initial conditions on the properties of the parameters of dynamic panel data models was considered in the work of R. J. Barro et al. (2017), where, along with studies of the determinants of economic growth, the authors examined this growth using econometric models of the economies of individual countries [9].

S.A. Aivazian et al. [10] developed dynamic multiple linear regression models in which the variables were taken in logarithmic form. The endogenous variable was the natural logarithm of the regional domestic product, and the natural logarithms of the value of fixed assets, the economically active population, the number of organizations performing scientific research, the number of the time period, the product of the logarithms of the above indicators by the number of the period time. Panel data for 80 Russian regions for the period 2009–2013 became the empirical basis for modeling. As significant conclusions of their study, the authors announced a significant increase in the elasticity of the regional domestic product by the number of organizations performing scientific research. The use of the logarithm of empirical data makes it possible to deal with the effects of the so-called spurious regressions. However, this smooths out the effect of the impact of crises, which can be included in the models in the form of structural shift variables. In this paper, we will use "pure" data and substantiate the significance of the obtained simulation results using special tests. At the same time, the results of S.A. Aivazian et al. [10], with the appropriate transformation of the initial data, can be used to verify our own research results.

Among all the works studied, we are close to the approach presented by G.P. Litvintseva, I.N. Karelin [11], H.T. Hoang, L.T.D. Huynh, and G.S. Chen [12].

G. P. Litvintseva and I. N. Karelin [11] attempted to determine the impact of digital factors on the main indicator of the social well-being of the population (gross regional product per capita) for the period from 2015 to 2018 in the constituent entities of Russia. To assess the effects, panel data models were used, showing the relationship of parameters simultaneously in space and time for the period 2015–2018.

H.T. Hoang, L.T.D. Huynh, and G.S. Chen [12] estimated the structural model using data on the provinces of Vietnam for the period 2000–2012.

P.S. Bravok and L.E. Pynko [13] estimated the expected values of the region's development in terms of the regional domestic product based on an econometric analysis of the report's panel data, which proposes an analysis of the main economic indicators of the Far Eastern Federal District. The purpose of this analysis was to forecast the gross regional product of the Far Eastern Federal District for 2019–2021, using a time series model and panel data, and comparing the accuracy of time series forecasts and panel data models. The authors stated that a fixed effects model can be used for forecasting. Due to the peculiarities of data accounting, it is possible to make forecasts simultaneously for all regions of the Far Eastern Federal District. According to their hypothesis, for a more accurate and efficient forecast of the regional domestic product, the simultaneous use of many types of models is necessary. It is possible to determine the model that offers the most reliable prediction by comparing their characteristics.

In this paper, we will apply a similar approach to the Northwestern Federal District.

As for research on the development of the Northwest region itself, there are not so many studies. S.V. Kuznetsov proposed a strategy for the scientific and technological development of the Northwest as an instrument of regional policy [14]. B.M. Grinchel' and E.A. Nazarova, assessing the sustainability of the innovative development of the regions of the Northwestern Federal District according to the

data of 2013–2016, concluded that a decrease in the costs of scientific research and the introduction of technological innovations into production indicates a decrease in the pace of innovation in the region [15]. I.V. Tregub [16] studied the development of regions from the standpoint of demography and identified factors that affect the effectiveness of government support measures.

Among the works of interest, in our opinion, are the works of P.V. Stroev et al., V.K. Kashin and S.V. Makar [17, 18], who studied the socio-economic development of the regions of the Russian Federation under the conditions of increased volatility of the ongoing processes in the Russian and global economies. At the same time, V.K. Kashin and S.V. Makar substantiated [18] that the Northwestern Federal District can be considered as a model of Russia, where various types of regional dynamics are presented. This conclusion is also very important for our study since it allows us to extrapolate the obtained data to the Russian economy as a whole.

Thus, summing up the review of scientific articles devoted to the analysis of regional development, it can be noted that with all the variety of ongoing research on econometric modeling of the dynamics of economic indicators of regional development and the identification of growth factors for regional economies, the topic of this article continues to be relevant due to the constantly changing economic situation and the presence of crisis phenomena in the global economy, which were not taken into account by previous researchers.

MATERIALS AND METHODS

To study the effectiveness of government support measures for the regions, econometric models were developed to identify the relationship between the characteristics of the economic development of the district and the factors that have a significant impact on these indicators.

Initially, it was assumed that the analysis of the economic development of the region can be carried out using the Menges macro econometric model [19, 20], which can be successfully used to model both national economies and individual regions.

Hypothesis 1. Measures of government support measures for the economic development of the Northwestern Federal District can be assessed by the results of identifying the relationship between the socio-economic indicators of the development of the district using regression analysis based on the Menges model, the essence of which is that:

- the current level of regional domestic product can be explained by the value of GRP at the previous point in time and investments in fixed assets;
- investments in fixed capital are explained by the value of the regional domestic product and the gross profit in economics;
- current consumption depends on the previous level of consumption, the cost of the standard of living, and the value of the regional domestic product;
- the gross profit in economics depends on its previous value and the volume of industrial production.

It should be noted that in this model, not all exogenous factors are associated with the government and their influence cannot be interpreted from the standpoint of evaluating the effectiveness of government support measures to stimulate regional development. However, the presence of these variables in the equations is necessary to obtain unbiased effective, and consistent estimates of the regression coefficients.

Sample Description

To conduct the study, data were collected on the main indicators of development and standard of living of the population of ten subjects of the Northwestern Federal District for 2015–2020. Thus, the total sample size is 60 people. Panel data for estimating the parameters of econometric models are taken from the Russian Statistical Yearbooks of Rosstat.[2]

[2] Regions of Russia. Socio-economic indicators. URL: http://www/https://rosstat.gov.ru/folder/210/document/13204 (accessed on 23.08.2021).

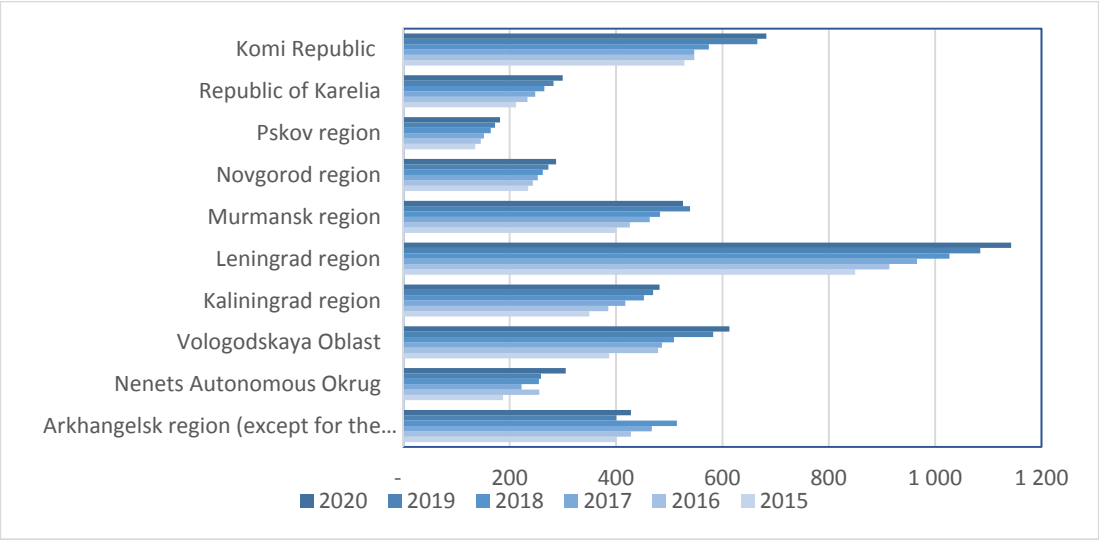

Fig. 1. **Regional domestic product, 2015–2020, billion rubles**

Source: compiled by the authors. Regions of Russia. Socio-economic indicators. URL: http://www/https://rosstat.gov.ru/folder/210/document/13204 (accessed on 23.08.2021).

The dynamics of the regional domestic product for various subjects of the district are shown in *Fig. 1*.

The mathematical notation of the classical Menges model is a system of four simultaneous equations:

$$Y_t = a_0 + a_1 \cdot Y_{t-1} + a_2 \cdot I_t + \mu_t, \quad (1)$$

$$I_t = b_0 + b_1 \cdot Y_t + b_2 \cdot Q_t + \vartheta_t, \quad (2)$$

$$C_t = c_0 + c_1 \cdot Y_t + c_2 \cdot C_{t-1} + c_3 \cdot P_t + \varphi_t, \quad (3)$$

$$Q_t = d_0 + d_1 \cdot Q_{t-1} + d_2 \cdot R_t + \varepsilon_t. \quad (4)$$

The following designations are used in the classical model: Y — the national income; I — investments; C — personal consumption expenditures; Q — the gross profit in economics; P — the cost of living index; R — the volume of industrial production.

The first equation (1) of the Menges model shows the impact of investment and the lagged value of national income on the current value of national income. The second equation (2) of the model reflects the dependence of investments on national income and the gross profit in economics. The third equation (3) reflects the impact of national income, cost of living index, and previous consumption on the current value of the consumption function. The last equation (4) allows modeling the current value of the gross profit of the economy depending on its lagged value and the volume of industrial production. It should be noted that the system of equations (1)–(3) are simultaneous equations, the coefficients of which can be estimated, for example, by the two-stage least squares method (2SLS). Equation (4) contains variables independent of equations (1)–(3). Estimates of the coefficients of equation (4) can be found using the method of ordinary least squares (OLS). An alternative to the use of 2SLS can be a technique for transforming a system of simultaneous equations to a reduced form when each equation contains only one endogenous variable.

For greater convenience in interpreting the simulation results, we used our own notation for variables. Some variables have been replaced by their counterparts. With regard to the panel data of the Northwestern Federal District, the list of variables used to model the economy of the region, their description, and their dimension are given in *Table 1*.

The index t denotes the current moment of time, and the index i — is the number of the subject of the district.

Table 1

Indicators used in the econometric equations of the Menges model

Variable abbreviation in the classical model	Variable abbreviation in the developed model	Description of the variable in the developed model	Dimension of a variable
Endogenous variables			
Y_t	GRP_{it}	Regional domestic product	Billion rubles
I_t	I_{it}	Investments in fixed assets	Billion rubles
C_t	C_{it}	Consumption expenditure per capita	Thousand rubles
Q_t	$Profit_{it}$	Profit of organizations	Billion rubles
Predefined variables			
Y_{t-1}	GRP_{it-1}	Regional domestic product, lagged value	Billion rubles
C_{t-1}	C_{it-1}	Consumption expenditure per capita, lagged value	Thousand rubles
Q_{t-1}	$Profit_{it-1}$	Profit of organizations, lagged value	Billion rubles
R_t	Vol_{it}	Volume of industrial production	Billion rubles
P_t	CPI_{it}	Consumer price index	Percentage points
Random perturbation			
$\mu_t, \vartheta_t, \varphi_t, \varepsilon_t$		Reflects the influence of all factors not taken into account in the model	Has the dimension of the dependent variable

Source: compiled by the authors.

It should be noted that the "Cost of Living Index" indicator in the classical model was replaced by the "Consumer Price Index". This is possible since the cost of living index in the methodology of Rosstat is understood as an indicator that measures the relative cost of a set of goods and services in individual cities compared to its average Russian value. The result of comparing these indicators allows us to calculate how much more expensive (or cheaper) the same specific set of consumer goods and services will be with the same volumes of their consumption in different cities of Russia, which, in fact, coincides with the consumer price index indicator. Statistics on the cost of the living index are conducted only by cities and are not provided for individual subjects of federal districts. That's why we used CPI instead of the Cost of Living Index.

Model parameters (1) were estimated taking into account their panel structure. General methods for estimating the parameters of a linear regression equation, as well as the features of estimating regression parameters, taking into account their spatial structure, are given in the work of I.V. Tregub [21]. In this paper, we used the ordinary least squares algorithm modified to take into account the structure of panel data and the presence of an autoregressive component in the models [22].

RESULTS OF ECONOMETRIC ANALYSIS AND DISCUSSION

The analysis of state support measures is based on the results of modeling the development of the economy of the Northwestern Federal District using the Menges model.

Since the Menges model is a system of interrelated equations, at the first stage of modeling, the system of equations (1–3) was estimated by a two-stage least squares method with the choice of instrumental variables from a list of predefined variables (*Table 1*). This approach is justified since when building

Table 2

Results of testing the classical Menges model on data of the Northwestern Federal District

	GRP_{it}	I_{it}	C_{it}	$Profit_{it}$
Const	–4.087	–103.025***	–555.756	41.5
GRP_{it-1}	1.080***	–	–	–
I_{it}	–0.034	–	–	–
GRP_{it}	–	0.485***	–0.014	–
C_{it-1}	–	–	1.862	–
Vol_{it}	–	–	–	–1.306*
CPI_{it}	–	–	529.175	–
$Profit_{it}$	–	0.25*	0.28	–
$Profit_{it-1}$	–	–	–	0.968***
R^2-*adjusted*	0.98	0.82	**0.13**	0.85

Source: compiled by the authors.

Note: * – the coefficient is significant at α = 0.1; ** – the coefficient is significant at α = 0.05; *** – the coefficient is significant at α = 0.01.

panel data models, they usually start with the pooled regression model, which does not take into account the structure of panel data. After that, the fixed and random effects models are evaluated and the presence of individual effects is checked.

It should be noted that tests for the presence of intragroup and intergroup individual effects in the Menges model showed their absence in the sample of panel data for the Northwestern Federal District.

According to *Table 2*, the results of the equation for modeling the regional domestic product, investments in fixed assets, and profits of organizations have high explanatory power. Thus, the dynamics of the regional domestic product are 98% explained by the change in investments in fixed assets and the previous value of GRP. However, the only significant factor in this equation is the lagged value of the regional domestic product.

The amount of investment in fixed capital, in turn, depends on the values of the regional domestic product and the profit of organizations by 82%. The profit of organizations in the Northwestern Federal District is explained by the past value of profit and the volume of industrial output by 85%.

At the same time, the consumption level equation in the Menges model is absolutely inapplicable for analysis, since it has low explanatory power (only 13%). Also, the variables in the equation are not significant.

The absence of asterisks next to the coefficient in *Table 2* means that this coefficient is not significant for an acceptable level of significance. Sign "–" in *Table 2* means that this coefficient is absent in equations (1–4) of the Menges model.

Due to the low explanatory power of individual equations of the Menges model and a large number of insignificant variables, it was decided to modify the model by adding additional variables to the equations for the consumption function and the regional domestic product function. Equation (2) for the investment function of the classical Menges model and equation (4) for the gross profit of the county economy are left unchanged. The impact of the pandemic was also further studied to justify the need to include structural shift dummy variables in the model.

Table 1 shows that, despite the pandemic and the economic downturn of the Russian economy in 2020, there are no obvious

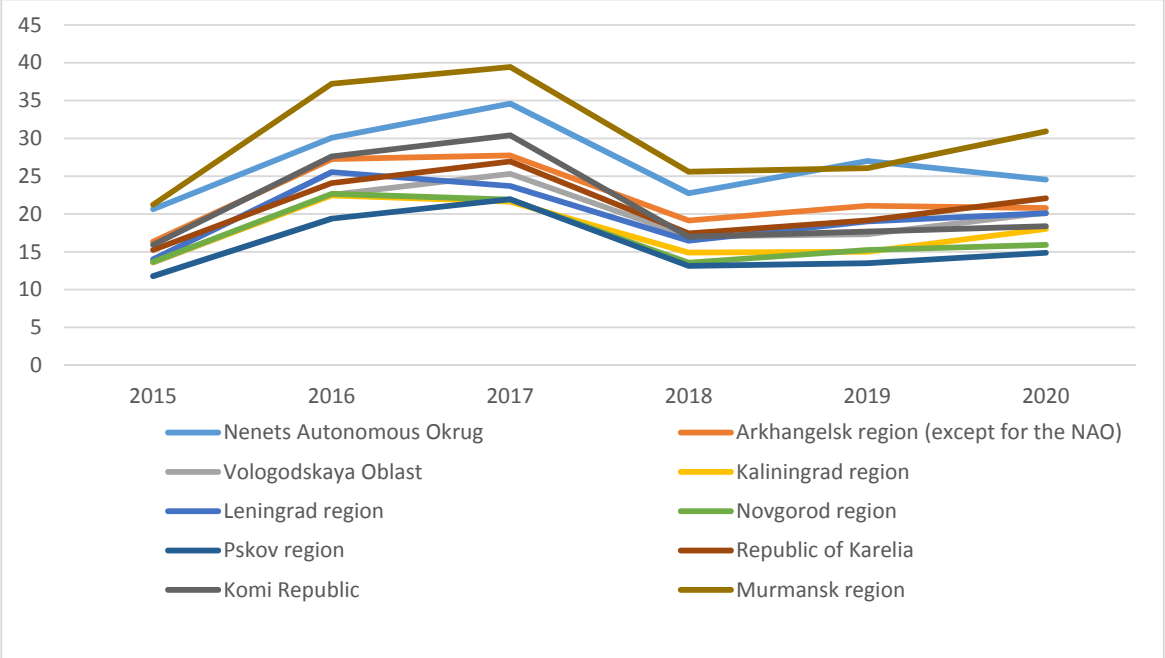

Fig. 2. **Analysis of the impact of the pandemic on the consumption functions of residents of particular regions of the Northwestern Federal District. Consumption per capita, thousand rubles**

Source: compiled by the authors. Data Regions of Russia. Socio-economic indicators. URL: http://www/https://rosstat.gov.ru/folder/210/document/13204 (accessed on 23.08.2021).

structural shifts in the data in individual subjects of the Northwestern Federal District. This allows us to conclude that there is no need to include dummy shift variables when modeling the district's regional domestic product.

To study the impact of the pandemic-related crisis on the level of consumption, a graph of the consumption function was plotted, which is shown in *Fig. 2*. We see that in 2020 there was no sharp drop in consumption compared to 2019. On the contrary, in some areas, such as the Murmansk region, there was an increase in consumption. This means that the pandemic has not made significant adjustments to the dynamics of the process.

A new set of variables included in the equations of the Menges model is of research interest since it allows us to quantify the feedback on the measures taken to support the population and business.

For the consumption function and the function of the regional domestic product, the included additional factors, on the one hand, allow us to assess the degree of influence on consumption levels and regional domestic product, and on the other hand, they can be associated with measures of government support measures for the population. As a result, the following hypotheses were put forward:

Hypothesis 2. The value of the regional domestic product can be explained by the amount of investment, the level of consumption, the amount of taxes collected, the income of the population and business, and the volume of industrial production.

Hypothesis 3. The amount of investment in the economy of the Northwestern Federal District can be explained by factors within the framework of the classical Menges model, namely, the current values of the regional domestic product and the profits of organizations.

Hypothesis 4. In addition to the factors of the classical Menges model, the variables that influence per capita consumption levels are wages, social benefits, and interest rates on deposits and loans.

Hypothesis 5. The current value of the profit of organizations in the Northwestern Federal

District can be explained by the profit in the previous period and the volume of production, i.e. the assertion of the classical Menges model is valid.

Indeed, rising household incomes should increase the cost of acquiring additional goods that cannot be provided at low-income levels. The size of the interest rate on deposits should influence the decision on the advisability of saving on deposits for the purpose of deferred consumption. Interest rates on credit products, on the contrary, should influence the decision-making on spending in the current period. Thus, it can be assumed that an increase in interest rates on deposits should lead to a decrease in consumption in the current period since individuals will prefer to save. A decrease in interest rates on loans, on the contrary, should lead to an increase in consumption, since low-interest rates on loans can contribute to an increase in the processing of credit products, the funds from which are directed to consumption.

Hypothesis 3 refers to household income only as a part of income, the impact of which on consumption level is of research interest.

The specification of the model, taking into account the new notation and Hypotheses 2 and 3, has the form:

$$GRP_t = a_0 + a_2 * I_t + a_3 * C_t + a_4 * Tax_t + a_5 * SP_t + \\ + a_6 * Dep_t + a_7 * Cr_t + a_8 * Vol_t + \\ + a_9 * Bis_t + a_{10} * \Pr ofit_t + \mu_{1t}, \quad (5)$$

$$I_t = b_0 + b_1 * GRP_t + b_2 * \Pr ofit_t + \vartheta_{1t}, \quad (6)$$

$$C_t = c_0 + c_1 * S_t + c_2 * SP_t + c_3 * Dep\_Rate_t + \\ + c_4 * Cr\_Rate_t + c_5 * GRP_t + c_6 * CPI_t + c_7 * C_{t-1} + \varphi_{1t}, \quad (7)$$

$$\Pr ofit_t = d_0 + d_1 * \Pr ofit_{t-1} + d_2 * Vol_t + \varepsilon_t. \quad (8)$$

The new variables of the modified Menges model are presented in *Table 3*.

Tables 4 and *5* present the results of estimating the coefficients of equations (5–8) for the pooled regression model and the fixed effects (FE) model.

For the regional domestic product dynamics represented by equation (5), the significant variables in the pooled regression model were investments, consumption expenditures per capita, industrial production, household income, taxes, and business profits. Within the framework of this model, changes in the regional domestic product are explained by changes in the specified set of variables by 97%. The quality of the model specification based on the results of the F-test is high, and the prerequisites of the Gauss-Markov theorem are fulfilled.

The simulation of the regional domestic product represented by equation (5) using the fixed effects (FE) model includes fewer significant factors (variables in *Table 4* with asterisks after the coefficient). The explanatory power of the model is also lower, only 79%.

The Hausman test to choose between the Pooled and FE models concludes that at a significance level of 0.01 for the regional domestic product represented by equation (5), a pooled regression model can be applied.

It can be argued that Hypothesis 2 is confirmed. A pooled regression model can be used to predict the economic development of the Northwestern Federal District and analyze the effectiveness of managerial decisions.

The evaluation of the parameters of the investment function represented by equation (6) showed that the variable GRP_t turned out to be insignificant at any reasonable level of significance. As a result, it was decided to replace the current value of the regional domestic product with its lagged value. The output statistics of the simulation results are presented in *Table 5*. The explanatory power of the pooled regression model is 82%, the regression is generally significant, and the residuals of the model are heteroscedastic and non-autocorrelated. The model is adequate and suitable for forecasting. Hypothesis 3 was partially confirmed.

For the model of consumption expenditure per capita, represented by equation (7), the results are presented in *Table 4*. Then pooled regression model and a fixed effects model for

Table 3

Predefined variables of the modified model

Regional Domestic Product Function. Equation 5		
I	Investments	Billion rubles
C	Consumption expenditure per capita	Thousand rubles
Tax	Taxes	Billion rubles
Sp	Social payments	Million rubles
Dep	Household deposits	Million rubles
Cr	Personal loans	Million rubles
Vol	Volume of industrial production	Million rubles
Bis	Business income	Million rubles
Profit	Profits of organizations	Billion rubles
Consumption Function. Equation 7		
S	Salary per worker	Thousand rubles
Sp	Social payments	Million rubles
Dep_Rate	Interest rate on household deposits	%
Cr_Rate	Interest rate on consumer loans	%
GRP	Regional domestic product	Billion rubles
CPI	Consumer price index	%
C_{t-1}	Consumption per capita in the previous time period	Thousand rubles

Source: compiled by the authors.

the consumption function gave similar results. Both models explain consumption levels by a set of variables included in the equation by 66%, which is significantly higher than in the classical Menges model (13%). The quality of model specifications based on the F-test results is high. The residuals of the models are homoscedastic and non-autocorrelated. There is no multicollinearity.

Thus, hypothesis 4 is confirmed, which allows us to analyze the simulation results and draw new important conclusions, which are given in the section "Interpretation of the results of the empirical study".

Testing Hypothesis 5 on the significance of the coefficients of the profit function equation of organizations in the Northwestern Federal District showed that for the pooled regression model and the model with fixed effects, the output variable is not significant. In addition, there is the autocorrelation of residuals in the model. To be able to use this model to analyze the economic situation in the area, it is necessary to choose exogenous variables that will improve the output of statistics. However, the explanatory power of the pooled model is quite high (85%) and the regression is generally significant. Thus, we can conclude that Hypothesis 5 cannot be confirmed.

INTERPRETATION OF THE RESULTS OF THE EMPIRICAL STUDY

Regional domestic product function

The modified model of the regional domestic product is represented by equation (5). The hypothesis put forward was confirmed, which allows us to draw important and new conclusions regarding the identification

Table 4

Results of regional domestic product and consumption modeling

Model Variables	GRP_{it}		C_{it}	
	Pooled	*FE*	*Pooled*	*FE*
GRP_{it}	–	–	–0.0075	–0.02
I_{it}	0.39*	0.089	–	–
C_{it}	1.79**	0.27	–	–
C_{it-1}	–	–	0.16**	0.004
Vol_{it}	0.00017*	4.53e-05	–	–
CPI_{it}	–	–	–29.7*	–103.23**
S_{it}	–	–	0.27***	0.17
Sp_{it}	0.0027***	0.0040***	8.3e-05*	33e-05**
Dep_{it}	0.13***	0.11***	–	–
Cr_{it}	–1.02***	–2.73***	–	–
Dep_Rate_{it}	–	–	–191.19**	–147.5
Cr_Rate_{it}	–	–	251.57***	193.9**
Tax_{it}	0.00095***	0.00043*	–	–
Bis_{it}	–0.00058	0.0038	–	–
$Profit_{it}$	–0.3***	0.001	–	–
Const	8.7	12.9	6.76	96.5
R^2-*adjusted*	0.97	0.79	0.660	0.659

Source: compiled by the authors.

Note: * the coefficient is significant at α = 0.1; ** the coefficient is significant at α = 0.05; *** the coefficient is significant at α = 0.01.

Table 5

Results of the investment function and profit of the district economy modeling

	I_{it}		$Profit_{it}$	
	Pooled	*FE*	*Pooled*	*FE*
GRP_{it-1}	0.47***	0.58***	–	–
Vol_{it}	–	–	–1.3	44.21
$Profit_{it}$	0.25*	2.66	–	–
$Profit_{it-1}$	–	–	0.96***	0.29*
Const	–85.7***	–132.1**	4.15	23.1
R^2-*adjusted*	0.82	0.44	0.85	0.18

Source: compiled by the authors.

Note: * the coefficient is significant at α = 0.1; ** the coefficient is significant at α = 0.05; *** the coefficient is significant at α = 0.01.

and justification of key factors that have a significant impact on the economic development of the region.

First, according to the results of *Table 4* for the model of the pooled regional domestic product function, the increase in consumption has a positive impact on the economic development of the region. Thus, an increase in the expenses of each resident of the region by 1 thousand rubles per year leads to an annual increase in the regional domestic product of the Northwestern Federal District by 1.79 billion rubles.

Second, the tax variable also accounts for consumption indirectly, since it includes, among other things, the value-added tax that each buyer pays when purchasing goods or services. The growth of tax revenues to the regional budget, according to the results of *Table 4* also boosts the county's economy.

Of particular interest is the analysis of the impact of household income on the economic growth of the region. The study of the impact of wages on the regional domestic product showed that, despite the inclusion of the variable *S* in various versions of the equation for the regional domestic product function, in all cases, it turned out to be insignificant and led to a deterioration in output simulation results statistics.

Third, significant variables indirectly related to household income were social payments and the amount of household deposits and loans. As follows from the results of *Table 4*, the funds of the population, concentrated in bank accounts, do not work for the development of the region's economy. Increase in the volume of deposits of the population by 1 million rubles leads to a decrease in the regional domestic product by 191 billion rubles per year. On the other hand, the volume of borrowed funds of the population leads to economic growth. But in this case, attention should be paid to the possible risks for the economy and social well-being of the population associated with the degree of debt burden.

Income from doing business in both variants of the intra-regional product model (Pooled and FE) turned out to be insignificant. The non-exclusion of the variable from the model, on the one hand, is associated with research interest in the degree of influence of government support measures for business on the growth of the region's economy, on the other hand, with ensuring the properties of the residual model that satisfy the prerequisites of the Gauss-Markov theorem.

The volume of industrial production has a positive impact on the economy of the region. An increase in output by 1 million rubles leads to an increase in the regional domestic product by 0.17 million rubles. One billion investments lead to an increase in the regional domestic product by 0.39 billion rubles.

Investment function

The results of modeling the investment function represented by equation (6) are given in *Table 5*. For the consumption function and the regional domestic product, pooled regression model approaches and fixed effects models were applied to the investment function. The pooled model explains the dynamics of the investment function by changes in the exogenous variables of the model by 82%, while the FE model explains only by 44%.

A new result of the study of the economic development of the Northwestern Federal District is the conclusion that, in contrast to the classical Menges model, in which the current value of the regional domestic product is included in equation (2) for the investment function, in the modified model this variable turned out to be insignificant, therefore, in equation (6), we included the lagged value of the regional domestic product. At the same time, the volume of investments depends on the economic development of the region. The regional domestic product increased by 1 billion rubles at present can attract investments in the amount of 0.44 billion rubles in the next period of time. Increasing the profit of organizations by 1 billion rubles leads to the growth of the region's economy by 0.25 billion rubles per year.

Consumption Function

Estimation of the coefficients of equation (7) for the modified consumption function is given in *Table 4*. It can be noted that consumption increases with the growth of wages and the increase in the amount of social benefits received. An increase in the wages of an individual employee by 1 thousand rubles leads to an increase in consumption expenditure per capita by 0.27 thousand rubles, which, taking into account the population of the district, gives an increase in consumption by 3.7 billion rubles per year. At the same time, an increase in social payments provided to individual subjects of the Northwestern Federal District by 1 billion rubles leads to an increase in total consumption expenditure by 1.37 billion rubles.

An increase in the interest rate on loans does not lead to a decrease in consumption, while the size of the interest rate on deposits leads to a decrease in current consumption. Moreover, if the level of expenses at the current moment of time increases by 1 thousand rubles, then we can expect an additional increase in expenses in the next period of time by 0.16 thousand rubles. This can be interpreted as follows: making decisions on consumption or savings by the population of the Northwestern Federal District is based on the propensity to consume. The more a person consumes, the more he will consume in the future, even if, in the absence of his own funds, he will have to use borrowed funds (an increase in the interest rate on loans does not lead to a decrease in consumption). At the same time, with an increase in the interest rate on deposits by 1%, the value of consumption expenditure per capita decreases by 191.19 thousand rubles per year, indicating that, holding all other factors constant, the decision to save prevails over the decision to spend if the deposit rate increases. At the same time, as noted earlier, an increase in consumption expenditure per capita leads to economic growth. Thus, the value of interest rates on loans and deposits can be one of the determining factors in the development of the region's economy. It is worth noting that an increase in consumption can lead to an increase in inflation, which has a negative impact on economic growth.

Fourth, changes in the consumer price index have a negative impact on consumption expenditure. When the cost of goods and services rises, the consumer can buy fewer of them for the same amount of money. An increase in inflation by 1% leads to a decrease in private consumption by 29.7 thousand rubles per year, which in general in the Northwestern Federal District leads to a decrease in consumption by 414 million rubles per year. This result can be explained as follows: if other factors are not taken into account, then when the cost of goods increases, their purchase is postponed for the following periods of time, and current consumption decreases.

Profit of Organizations Function

According to the results presented in Table 5 of the current value of the profit of organizations in equation (8) of the Menges model using a pooled regression model, we can conclude that an increase in current profit by 1 billion rubles in the current year may lead to an increase in profit by 0.96 billion rubles in the next period. It should be noted that due to the non-fulfillment of the third premise of the Gauss-Markov theorem, the standard error of the coefficient estimate can be underestimated, as a result of which the t-statistics, on the basis of which the conclusion about the significance of the linear regression coefficients, can be overestimated, and the conclusion about the significance of the coefficients may be unreasonable. At the same time, the pooled regression model is 85% explained by its lagged value, and the quality of the model specification is high. The fixed effects model for the profit of organizations function gives a significantly worse result. The explanatory power of the model is only 18%. The rest of the statistics are the same.

It should also be emphasized that the profit of organizations is included in the regional domestic product model as a significant

explanatory variable. On the one hand, an increase in the profits of organizations, according to the results obtained, does not lead to the growth of the region's economy, on the other hand, an increase in the profits of organizations leads to an increase in tax revenues, which positively affects the economic development of the region.

CONCLUSIONS

This study made it possible to identify the key factors that have a significant impact on the economic development of the Northwestern Federal District, the quantitative characteristic of which is the function of the regional domestic product. These variables are both factors included in well-known classical macro-econometric models (investment, consumption, taxes, inflation) and a new set of exogenous socio-economic variables that were not previously taken into account in the regional development analysis (household incomes, interest rates on deposits, and loans). The developed model allows us to draw important economic conclusions about the influence of each factor on the growth of the region's economy and the effectiveness of the government support measures.

An important research result is the developed model of the consumption function, which allows estimating the consumption expenditure levels depending on the change in the factors of the model. The study also made it possible to analyze the regulatory and government measures taken to curb inflation and support the population and businesses.

The paper proves that interest rates on loans and deposits can be one of the controlling factors in the development of the region's economy. In this regard, we can conclude that the government policy aimed at reducing interest rates, for example, on mortgage loans, aimed at supporting the industry, will, on the one hand, lead to an improvement in the social situation, an increase in the standard of living, and on the other hand, the debt burden of the population, which may adversely affect the economy of the region in the future.

At the same time, an increase in consumption can lead to an increase in inflation, which negatively affects the growth of the economy. The regulator's measures aimed at curbing inflation, including those associated with an increase in the key interest rate, lead to a change in interest rates on loans and deposits, which also affects the growth of the Northwestern Federal District's economy. The developed model makes it possible to evaluate the impact of the regulator's action on the growth of the economy of the Northwestern Federal District.

The revealed relationship between consumption expenditure per capita and the function of the regional domestic product of the Northwestern Federal District allows us to quantify the effectiveness of the measures taken to curb inflation and support the socio-economic development of the region. The models developed in the study make it possible to quantify the impact of social support measures for the population and business on the economic growth of the region. According to the data received, support for entrepreneurs and businesses did not have a significant impact on the economic growth of the region. Thus, it can be concluded that these support measures are ineffective. At the same time, the increase in social payments to the population and wages led to economic growth. If we compare the influence of each of the socio-economic factors on the growth of consumption and, as a result, the growth of the region's economy, then the return from wage increases is greater than from an increase in social payments. Consequently, measures aimed at raising wages are more effective for the economy of the Northwestern Federal District than measures related to increasing social benefits.

Answers to all the questions posed in the study were given, and all the hypotheses put forward were tested. In this paper, certain results have been achieved that determine the novelty of the research. For the first time, the paper investigates the relationship between socio-economic indicators of the Northwestern Federal District using panel

data and an analysis of the effectiveness of government measures to support the population and business, as well as the impact of the crisis associated with the pandemic on the socio-economic indicators of the region. For the calculations, we used data for the last 6 years (from 2015 to 2020), which made it possible to identify a clear pattern between the analyzed indicators within the region's economy. As a result, we can conclude that the modified Menges model is applicable to the analysis of the economic development of the Northwestern Federal District of the Russian Federation. This makes this paper important from both theoretical and practical perspectives.

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