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Methodological Approaches to the Formation of the Applied Models for Panel Data Analysis to Forecast the Resource Region Economic Development under Conditions of Spatial Asymmetry (Exemplified by the Krasnoyarsk Territory)

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Through the example of the Krasnoyarsk Territory, the longitudes formation for forming and processing of the dynamic information decision-making database on the basis of the panel regional studies of the economic indicators for the representative at the subregional level samples, based on the official statistical information available on the portal of the Territorial Authority of the Federal State Statistics Service for the Krasnoyarsk Territory, is studied in the article. This approach gives an opportunity to study spatial development of the economy of the region as a whole as well as its individual components – the municipalities, and to assess the effect of individual administrative decisions influence on the level of the region development and system changes. This paper gives a rationale for the use of the panel data analysis techniques by the means of the regression model with deterministic effects for forecasting economic growth of the region under conditions of the spatial asymmetry, and the obtained adequate model is presented.

Keywords: resource economy, regional development, spatial asymmetry, social and economic development of the region, panel data analysis, regression model with deterministic effects.

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Introduction

Strategic development of the resource Siberian regions is faced with the complex of economic challenges, specific to Russia, and is carried out against the background of the typical tendencies: the dependence of economic growth upon the scale of natural resources extraction; the Russian space socio-economic inequalities strengthening or, in other words, the asymmetry of social and economic development between the regions – subjects of the Russian federation and within the large Siberian regions with resource economy and increasing competition for investment resources.

In this context, the development of the resource regions of Siberia, including the Krasnoyarsk Territory, is within the scope of the country's economic and geopolitical interests' priorities and requires the introduction of new modern scientific methods and tools for making effective management decisions.

In the world the decision-making practice in the field of territorial administration, economic and mathematical, as well as econometric models, based on the panel (longitudinal) data that give opportunity to study spatial development of both the region's economy as a whole and its individual components, and to assess the effect of influence of both private individual management decisions and system changes upon the level of the region development, are widely used. At the same time, conducting panel studies taking into account the international practice of spatial development analysis, allows to carry out statistically significant comparisons with the regions of other countries.

One of the key problems of the econometric methods application for the decision-making modeling in the Russian region management is connected with the choice of the models type and construction that will give and opportunity to take into account the specific features of the socio-economic development of individual regions and promptly reflect the impact of the institutional decisions changes factors at the level of the country as a whole.

Materials and Methods

The methodological approach to the problem solution is of complex nature, and includes the development of the model apparatus for decision-making.

The contemporary studies on the spatial economy by the foreign scholars are largely based on the econometric modeling methods, what is reflected in the fundamental works of the European School representatives: "Applied Spatial Analysis and Policy" (J. Stillwell, M. Birkin, 2013); "Statistical and Scientific Database Management" (M. Rafanelli, J. Klensin, R. Svensson, 1988); "Spatial Econometrics" (G. Arbia, 2013) "The Spatial Data Analysis" (M. Fisher, J. Wong); "Agglomeration Economies" (J. Claesson, B. Johnson, C. Karlsson), etc. In the works "Liberalization, Growth and Spatial Disparities" (N. Ghosh, 2014) and "Opportunities, Economic Growth, Regional Disparities" (V. Jiang, 2013) the problems of the regions' economic development asymmetry are analyzed on the basis of the analysis of the econometric dependencies of economic factors in the region.

A significant contribution to the development of the ideas about the methods of territorial socio-economic dynamics forecasting and modeling in the Russian economic science was made by the fundamental works of A.G. Granberg, V.V. Kuleshov, M.K. Bandman, V.E. Seliverstov, V.I. Suslov and other representatives of the Novosibirsk scientific school of the territorial planning, as well as theoretical and applied works of the members of "The Council for the Study of Productive Forces" (CSPF) N.N. Mikheeva, A.N. Pelyasov and others. In their studies the great attention is paid to the strategic role in ensuring economic and resource security of the country.

The analysis of the region economic development as an independent economic subject involves the economic growth rate assessment, the regional economy structure analysis, the analysis of financial and economic efficiency of the economic activities in the region as a whole and the key subsystems of the regional economy.

Despite the long list of scientific papers related to the search for the possible solutions to the problem of balancing the socio-economic development of territories, some important aspects have remained virtually unexplored.

In particular, issues related to the improvement of the mechanisms for leveling the socio-economic development of municipalities require special consideration. The alternative ways of solving this problem, such as giving a special status to the regions or municipalities that are behind in their economic development are virtually not considered in the scientific literature.

Longitudinal (panel) studies are a special kind of social (economic, sociological, socio-psychological, etc.) study, which means "continuous study", when measuring of one or more variables of the social object under consideration are repeated on the material of the same or similar observation groups. The main goal of such a research is to study the tendencies of a social process or phenomenon development or modification through time.

Panel data consist of repeated observations of the same units in the aggregate (or sampling units), which are carried out in the successive periods of time within a single program and using a common methodology and data analysis procedures. Therefore, panel data combines the possibilities of both time series analysis and spatial observations.

For panel (longitudinal) studies there is a possibility to consider and analyze the individual differences between the economic units that cannot be done within the framework of the standard regression models. In addition, the panel data use allows taking into account the individual heterogeneity of the units of observation; provides less collinearity and greater assessments efficiency; it provides an opportunity to study the dynamics of the individual characteristics changes of the units in the aggregate. The "panels" are better able to identify and measure the effects which are not definable only in time series, or only in the spatial data; allow to design and test more complex models of behavior and avoid the shift associated with the data aggregation.

Longitudinal studies are relatively rare, as they require a long time period of observation. However, broad time frames of the longitudinal studies are only practical inconvenience, and do not threaten the validity. The fact of the obsolete methods used may adversely affect the duration of study. In the case of this study, it may be associated with the changes in the methods for the primary statistical data collection by the Territorial Body of the Federal Service of State Statistics, or when switching to a new classification of the Russian Classification of Economic Activities (OKVED).

Longitudinal sample in many parameters do not always meet the criterion of representativeness, they give an opportunity to avoid systematic bias in the course of selection for the initially nonequivalent groups comparison. If each factor of the social study is compared with itself, no systematic bias of selection is possible. However, there is a possibility of selective knock-out (or elimination), which also takes place in practice.

Study Results

In this study longitude is determined by the municipalities of the Krasnoyarsk Territory, however, due to the absence of systematic data, a number of closed administrative-territorial formations (CATF) were excluded, and the number of observation objects is 57. The period

of observation and data analysis is from 2007 to 2014, with the possibility of further information updating on municipalities. The choice of the start for the observation period is determined by the ability to ensure the comparability of panel data, related to changes in the administrative-territorial division of the Krasnoyarsk Territory and fullness of the official statistical information provided by the Territorial Body of Federal State Statistics Service of the Krasnoyarsk Territory. For this reason, the data for 2015 were not included into the panel, as at the time of the survey, there was no official statistics on the majority of indicators.

Gross Regional Product (GRP) is a major comparative and analytical indicator characterizing the scale of the region's economy, its degree of economic development and its contribution to the national economy. GRP measures the gross added value created by all the residents of the region in its territory for a certain period of time.

GRP's analog at the level of municipalities is "The Volume of Shipped Goods of Own Production, Works and Services on Their Own" indicator in ml. rubles (variable Var_1), for this reason it was taken as a resultant characteristic with the panel data regression modeling.

In the process of the independent variables (factors) selection the authors were guided by the aim to reflect the effects of various spheres of economic growth on the effective indicator of production, investment and financial activity of municipalities.

As a result, the following a set of indicators was formed[1]:

Var_2 – the share of manufacturing in the total output of the shipped products, %;

Var_3 – the share of the average annual number of employees as a part of the resident population, %;

Var_4 – investments into the fixed capital per capita (at current prices), rub.;

Var_5 – fixed assets (according to the gross book value at the end of the year), ml. rub.;

Var_6 – the level of the fixed assets depreciation, %;

Var_7 – municipality budget spending, ml. rub.;

Var_8 – agricultural production volume (at current prices), farms of all categories, ml. rub.

The transition to the selected factors logarithms was made to reduce the asymmetry of the econometric variables distribution, as well as for the approximation of the regression residuals distribution to the normal distribution. The following regression models were successively built on the basis of the selected factors logarithms:

– pooled regression for all the years of the analyzed period of 2007 – 2014 and all 57 municipalities of the Krasnoyarsk Territory. This model is assessed with the use of the least square method and does not take into account the panel data structure;

– regression, time-averaged values of variables, comparing the effect of changes of the time-averaged indicators for each municipality with the influence of temporary fluctuations of these indicators relative to the average ones;

– regression model with deterministic individual effects, comparing the power of influence of the municipalities' individual and dynamic differences.

In the course of the obtained regression models assessment, the hypothesis of all the individual equal-zero effects using the Wald test, was tested and rejected. As a result, for the studied longitude regression, the model with deterministic individual effects turned out to be the most appropriate one (see Table 1).

A part of the initial vector of independent variables was not significant and was excluded from the analysis. The final set of factors includes "Investments into Fixed Capital per Capita (at Current Prices)", "Fixed Assets (According to the

Gross Book Value at the End of the Year)" and "Municipality Budget Spending". The limitation of significant factors included into the model is determined by to lack of through data for the entire observation period for the Krasnoyarsk Territory municipalities.

Since the determination coefficient R-sq is equal to 0.3605, that is twice lower than under the conditions of regression, the time-averaged values of the variables, therefore, interindividual differences for the obtained model are manifested stronger than the dynamic ones. This argues for the necessity to address individual effects.

Uncorrelatedness between the factor values and the individual effects is not required for the assessment consistency of the model with deterministic individual effects, so the value of corr(u_i, X_b)=0.6604 is acceptable.

The coefficients for all the variables are positive, which really reflects the existing cause and effect relations between the factors and performance indicator. The model has demonstrated that the amount of the municipalities budgets' expenditure part and investments into the fixed assets has the greatest impact on the volume of shipped goods of own production, works and services, within the framework of the set of factors under consideration.

For the temporal effects consideration, temporary dummy variable (d07, d08, ..., d14) in accordance with the number of years in the analyzed period were added in the model (see Table 2).

It is necessary to note that with the dummy variables addition, the coefficient of determination is increased, what improves the original model. The coefficients of the dummy variables in the resulting model are significant, with the exception of the coefficients for the 2010 – 2011. The coefficient for 2012 can be ignored, since it is close to zero. Thus, the volume of shipped goods of own production in 2007 – 2009 had a tendency to decrease, and only since 2013 a positive tendency has appeared.

Table 1. Results of calculations for the models with deterministic effects

Fixed-effects (within) regression — Number of obs = 456
Group variable: var10 — Number of groups = 57

R-sq	within =	0.03605	Obs per group:	min=	8
	between=	0.7847		avg=	8.0
	overall=	0.7375		max=	8
			F(3,396)	=	74.41
corr(u_i, Xb) = 0.6604			Prob > F	=	0.0000

lvar1	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
lvar4	0.165492	0.0249159	6.64	0.000	0.1165081	0.2144759
lvar5	0.0695669	0.0118543	5.87	0.000	0.0462617	0.0928722
lvar7	0.6779062	0.0929396	7.29	0.000	0.4951895	0.8606228
_cons	2.450286	1.195894	2.05	0.041	0.0991907	4.801382
sigma_u	1.3458998					
sigma_e	0.44615781					
rho	0.90099155	(fraction of variance due to u_i)				
F test that all u_i=0:		F(56, 396) = 39.72			Prob > F = 0.0000	

Table 2. Results of calculations for the model with dummy variables

Fixed-effects (within) regression Group variable: var10			Number ofobs = 456 Number of groups = 57		
R-sq	within =	0.4596	Obs per group:	min=	8
	between=	0.8121		avg=	8.0
	overall=	0.5479		max=	8
			F(10, 389)	=	33.08
corr(u_i, Xb) = 0.6130			Prob > F	=	0.0000

lvar1	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
lvar4	0.092635	0.0259206	3.57	0.000	0.0416729	0.1435971
lvar5	0.0500306	0.0116847	4.28	0.000	0.0270576	0.0730036
lvar7	0.1873468	0.120872	1.55	0.122	-0.0502973	0.4249909
d07	-0.3977234	0.1079483	-3.68	0.000	-0.6099585	-0.1854884
d08	-0.3189441	0.0843105	-3.78	0.000	-0.4847054	-0.1531829
d09	-0.3264626	0.0858191	-3.80	0.000	-0.49519	-0.1577352
d10	-0.1519392	0.085533	-1.78	0.076	-0.320104	0.0162257
d11	-0.0978795	0.0784619	-1.25	0.213	-0.252142	0.056383
d12	0			(omitted)		
d13	0.20935	0.0781569	2.68	0.008	0.0556872	0.360128
d14	0.2708128	0.0781667	3.46	0.001	0.1171308	0.4244948
_cons	10.23508	1.713552	5.97	0.000	6.866099	13.60406
sigma_u	1.7507519					
sigma_e	0.41380173					
rho	0.94709128	(fraction of variance due to u_i)				
F test that all u_i=0:		F(56, 389) = 45.65			Prob > F = 0.0000	

The regression model with deterministic effects gives an opportunity to assess unobservable individual effects, that is, the characteristics of the object under observation, eliminated directly from the model. Individual effects can be calculated for each municipality separately, for example (see Figure 1).

Conclusion

The panel data econometric modeling gives an opportunity to study socio-economic phenomena and mechanisms in the space-time continuum and is becoming one of the most important tools for the well-grounded decisions in the field of regional management. Through the example of the economic sphere of the Krasnoyarsk Territory, the method of longitudinal study with the use of the regression model with deterministic effects that was selected in the course of analysis as the most qualitative one when considering non-invariant in time regressors, was applied in the article. Regression coefficients were calculated and estimated, the possibility of the individual differences assessment of the region municipalities was demonstrated. It has been found out that the amount of budget expenditures (var7) and investments into the fixed capital per capita (var4) have the greatest impact on the economy of the Krasnoyarsk Territory municipalities, the corresponding coefficients in the model with the permanent

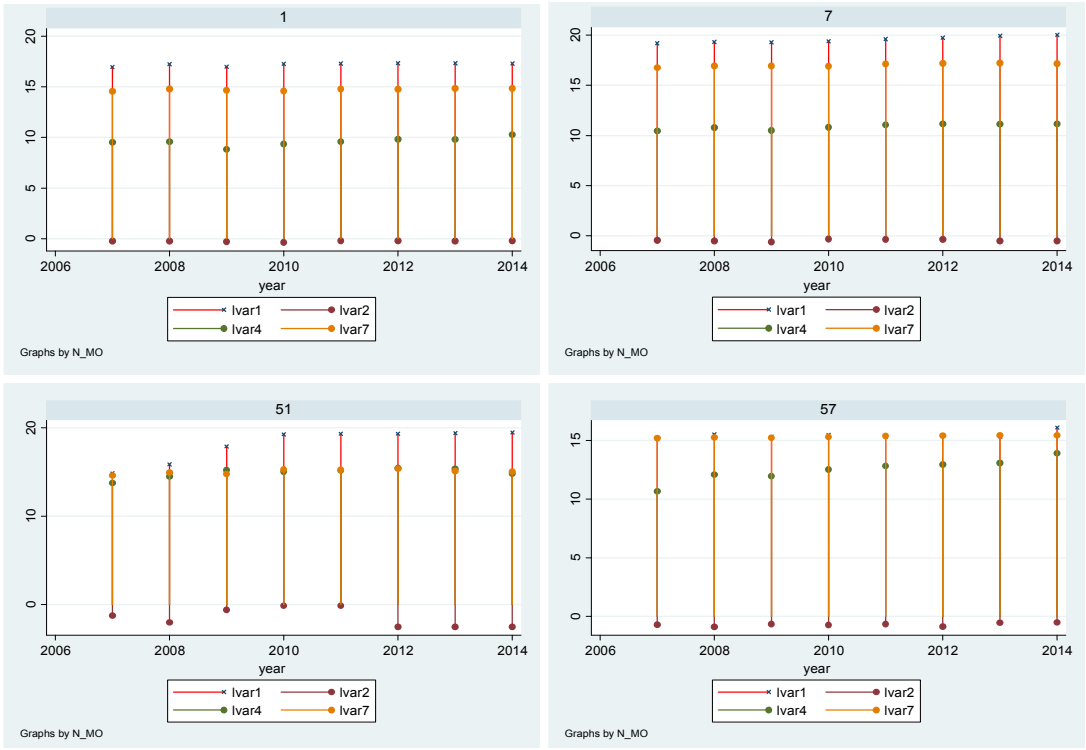

Fig. 1. Distribution of individual deterministic effects for municipalities: 1 (the town of Achinsk), 7 (the city of Krasnoyarsk), 51 (Turukhansk district) and 57 (Evenkia) in the period from 2007 to 2014

effects are equal to 0.187 and 0.0926; the economy is subjected to changes in the fixed assets value (var5) to a lesser extent.

The approach enables to study the spatial development of both the economy of the region as a whole and its individual components, to assess the power of influence of the administrative decisions in separate areas and economy sectors, as well as the system changes at the level of the region development.

[1] According to statistical data of the Municipalities Indicators Database of the Krasnoyarsk Territory (DB MID) http://www.gks.ru/dbscripts/munst/munst04/DBInet.cgi

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Методологические подходы к формированию прикладных моделей анализа панельных данных для прогнозирования развития экономики ресурсного региона в условиях пространственной асимметрии (на примере Красноярского края)

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В статье на примере Красноярского края рассматривается создание лонгитюдов для формирования и обработки динамической информационной базы принятия решений на основе панельных региональных исследований по экономическим показателям по репрезентативным на субрегиональном уровне выборкам на основе официальной статистической информации, размещенной на портале Территориального органа федеральной службы государственной статистики по Красноярскому краю. Такой подход позволяет исследовать пространственное развитие как экономики региона в целом, так и отдельных ее составляющих – муниципальных образований, а также оценить силу влияния на уровень развития региона отдельных управленческий решений и системных изменений. В статье дано обоснование применения методики анализа панельных данных с помощью регрессионной модели с детерминированными эффектами для прогнозирования экономического роста региона в условиях пространственной асимметрии и представлена полученная адекватная модель.

Ключевые слова: ресурсная экономика, региональное развитие, пространственная асимметрия, социально-экономическое развитие региона, анализ панельных данных, регрессионная модель с детерминированными эффектами.

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