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Hierarchical and Spatial Effects in the Development of Municipalities*

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Abstract. The paper presents the results of analysis of the influence of separate levels of public administration hierarchy (regional, municipal) and neighboring territories on the indicators of socio-economic condition of municipal entities. The study was conducted in the context of 300 municipal entities of six subjects of the Russian Federation. The hierarchical and spatial effects were determined in several stages. The impact of separate administration levels on the results obtained by municipal entities was assessed with the use of hierarchical linear modeling (HLM), which is applied in other scientific fields to analyze group and inter-group relations. The connectedness of municipalities was evaluated with the use of spatial statistics methods (Moran Index). The analysis has shown that both vertical and horizontal connections of municipal entities are important. They determine spatial and hierarchical effects. Assessing the change in a given indicator, taking into account both the internal potential and the existing external horizontal and vertical links simultaneously is the most difficult but necessary step in the formation of management decisions regarding municipal entities. Within the present paper, the existence of spatial and hierarchical effects allowed us to build a model that links the change in the volume of social payments and taxable incomes of the population per resident of the municipal entity to the volume of shipped products in the municipal entity and neighboring municipal entities, taking into account their hierarchical subordination. Calculations showed that the role of the regional level of ownership is 21.1%. The change in the volume of social payments and taxable money incomes of the population on average per resident is related to the actions of the municipal authority by 78.9%. The results obtained with the use of the proposed methods would make it possible to make substantiated managerial decisions in regional economic policy and determine the powers of various levels of public administration hierarchy.

Key words: management hierarchy, multi-level analysis, spatial effect, regional administration.

Introduction

A country's administrative-territorial structure consists of its division into certain parts hierarchically subordinated for effective functioning of the vertical of government. A head of a municipality should take into account not only the internal factors in development, but also the regulatory impact of the regional authorities including the possibility of support and funding from budgets of higher authority, especially the development of the neighboring territories. In fact, all three elements are simultaneously taken into account by municipal leaders at the intuitive level. This is largely due to underdeveloped assessment tools which take into account vertical and horizontal links of municipalities in one model. The research carried out in the framework of this work is aimed at expanding the tools of analyzing spatial and hierarchical relations necessary to improve the management of municipalities. The research hypothesis is that the differentiation of socio-economic development of individual territories is determined by joint influence of both internal and external factors carried out within the existing management hierarchy. The scientific novelty of the study lies in substantiating the importance of vertical (management hierarchy) and horizontal (territory) relations of municipalities by constructing a model to distinguish both spatial and hierarchical effects. This provides better understanding of the spatial organization of economic activity, gives an opportunity to take a fresh look at the problem of the country's connectivity, and move to a multi-level planning of territories' development.

The issues of managing hierarchical systems at the national level, or the so-called multi-level public administration, have been raised by researchers around the world [1, 2, 3]. Modern studies show that the mechanism of the structure-level system of economic management "is determined by the system of levers used both at the federal (macro) and regional (meso) level of economic space formation" [4]. The scope of managing socio-economic processes at the municipal level is determined by the state, regional, and municipal policy. To carry out complex analysis it is important to understand the role of all levels of the management hierarchy. At the municipal level, it should strive to meet the needs of people living on the territory of a municipal unit as fully as possible, taking into account the peculiarities of its development. A higher level of power also affects the development of the territory, as indicated by various empirical studies [5, 6, 7]. In turn, the central government, as a rule, determines the general path of the country's development. At a lower level – regional – within the framework of the covered management options, decisions are made to most effectively use the existing potential of territories. The development of each separate local territory (municipality) depends on how regional authorities convey the general concept of federal power to the lower management level (municipal, local) and link it with the region's capacity.

In turn, the development of specific territories is determined by the vertical of power, as well as by own internal factors in development. The development of the surrounding territories has a significant impact. In this regard, more and more studies are aimed at assessing the impact of differentiation in the development of territories [8, 9, 10] and assessing spatial effects. For example, M.A. Haddad and Z. Nedović-Budić conducted a spatial analysis of the human development index for municipal districts of São Paulo [11], X. Ye and Y.D. Wei – of production, investment, and inequality of standard of living in rural areas of municipal districts in the province of Zhejiang, China [12], A.R. Fazliev estimated changes in the price index in constituent entities of Russia [13], E.A. Gafarova conducted a comparative analysis of various types of spatial models of economic growth [14].

The analysis of these works shows that they mainly compare data on spatial differentiation at certain levels of the management hierarchy (for example, only regional or municipal) without determining the interaction of these levels. If the study touches upon the problems of multilevel and spatial development at the same time, the methods of spatial econometrics are usually limited. For example, the work by X.B. Zhao and S.P. Tong examines the problem of differentiation of standards of living in China at several levels (province, region, urban and rural district) using the indicators of inter-level variation measurement [15]. J. Antikainen and V. Perttu assess regional gross production, employment, and migration in the context of districts and regions based on index analysis limited to comparison of indicator change rate [9]. L. van de Laan determines the impact of changes in the urban system on the regional employment structure using multiple regression but does not take into account the spatial nature of data [16]. Thus, the studies of municipalities do not provide a complete picture of their spatial and hierarchical relations, which largely determines the unrealized potential of inter-municipal interaction.

The review of publications by domestic and foreign researchers highlights the methods of studying spatial and hierarchical effects in territorial development and demonstrates the variety of indicators analyzed in the context of territories and levels of the management hierarchy. It is impossible to cover all aspects of socio-economic development of a territory, but the most common in the above studies are the standard of living and the state of the real sector of economy. In turn, the assessment of standards of living, as a rule, begins with the study of income of the population, and the study of the real sector of the economy includes analysis of production [17]. Indicators "production of goods and services" and "cash income of the population" in one or another interpretation are reflected in regions' rankings[1] and are taken into account when assessing the activities of heads of regions and municipalities[2].

Thus, analysis of indicators presented in the work will help test the proposed tools which imply a multilevel study of the territories' socio-economic development based on combining spatial and hierarchical (multilevel) models.

1. Description of research methods

The method for selecting hierarchical and spatial effects is arranged in several stages.

At the first stage, the average values and variation of indicators of socio-economic development of municipalities in the context of six Russian constituent entities with common borders with Bashkortostan were analyzed. Within the framework of this stage, we tested the hypothesis of the presence of intergroup differentiation, i.e. the difference of Russian constituent entities in the achieved indicators of municipalities located on their territory. Taking into account the features of formation of statistical values of indicators at the level of municipalities, "volume of social payments and taxable monetary income of the population per 1 resident of a municipal area (city district)" was considered in analysis of population's income. "The volume of shipped own goods, works and services per 1 person in municipalities" was taken as an indicator characterizing production. Both indicators are officially registered by state statistics bodies and are available at the official website of the Federal State Statistics Service in the database of indicators of municipalities[3].

The hierarchical (two-level, nested) nature of data helps build a multilevel unconstrained regression model:

a) for social payments and taxable cash income of the population per 1 resident of a municipality:

Level 1 (lower):

$$NDSV_{ij} = \beta_{0j} + r_{ij}; \quad (1)$$

Level 2 (upper):

$$\beta_{0j} = \gamma_{00} + u_{0j}; \quad (2)$$

general joint-level model:

$$NDSV_{ij} = \gamma_{00} + u_{0j} + r_{ij}; \quad (3)$$

[1] Quality of life regional ranking in Russia. Available at: http://riarating.ru/infografika/20160225/630010958.html;

The ranking of Russian constituent entities by socio-economic status. Available at: http://riarating.ru/infografika/20150616/610658857.html

[2] On the assessment of efficiency of activity of executive authorities of Russian constituent entities. *Presidential Decree no. 548*, dated 14.11.2017; On the assessment of efficiency of activity of local governments of city districts and municipal areas. *Presidential Decree no. 607*, dated 28.04.2008.

[3] Database of indicators of municipalities. Available at: http://www.gks.ru/dbscripts/munst/).

b) for volume of social payments and taxable monetary income of the population per 1 resident of a municipal area:

Level 1 (lower):

$$OT_{ij} = \beta_{0j} + r_{ij}; \quad (4)$$

Level 2 (upper):

$$\beta_{0j} = \gamma_{00} + u_{0j}; \quad (5)$$

general joint-level model:

$$OT_{ij} = \gamma_{00} + u_{0j} + r_{ij}, \quad (6)$$

where $NDSV_{ij}$ – social payments and taxable cash income of the population per 1 resident of the i-th municipality of the j-th region in Russia, RUB;

OT_{ij} – volume of shipped own goods, works and services performed per 1 person in the i-th municipality of the j-th region in Russia, thousand RUB;

β_{0j} – function of a general intercept (γ_{00}) for all municipalities, and error of interregional variance (u_{0j}) that explains differences between regions in values of indices achieved by their constituent municipalities;

r_{ij} – error of regional (inter-municipal) variance explaining differences between municipalities within individual regions;

j – index for affiliation of a municipality to a specific Russian constituent entity, (j=1, 2,...,6);

i – index for affiliation to a particular municipality, (i=1, 2,...,300).

Models of this type are constructed by both foreign and domestic researchers [18, 19, 20]. According to this model, two parameters are estimated: inter-regional (σ_{00}) and intra-regional (inter-municipal) variance (σ_j).

The analysis evaluated how between-group variance significantly differs from zero and why the model without intercept variability. The analysis of variance was conducted to compare the models. If a statistically significant difference is found between the models the inter-group variance is non-zero, otherwise the difference is considered insignificant. The interclass correlation coefficient (ICC) is used to test the corresponding hypothesis:

$$ICC = \frac{\sigma_{00}^2}{\sigma_{00}^2 + \sigma_j^2}, \quad (7)$$

where σ_{00} – inter-regional variance;

σ_j – intra-regional (inter-municipal) variance.

This coefficient demonstrates the share of the total variance that can be explained by mean variation in groups (in this study – in Russian constituent entities), i.e. assess the impact of the region on the development of municipalities. The coefficient value varies in the range from +1, where variation is determined directly by the difference between groups in the absence of variation within the groups, to $\frac{1}{(n-1)}$, , where variation is predominantly intra-group (where n – number of municipalities). The coefficient value close to zero indicates that the upper level of the management hierarchy does not affect the development of objects of the lower level, in our case, municipalities. V. Huta notes that if Intraclass Correlation Coefficient (ICC) has a value of less than 5%, it is not advisable to construct hierarchical models [21].

The statistical significance of the model and, as a consequence, the hypothesis of appropriateness of using hierarchical modeling tools can be tested using the χ^2 criterion which is determined for random effects and involves testing the null hypothesis of absence of group effects [22].

At the second stage of the research, spatial statistical analysis was carried out to test the hypothesis of connection between the neighboring municipalities. Evaluation of the spatial aspect in territorial development was based on the theory of spatial econometrics [23, 24, 25]. Spatial autocorrelation in the

distribution of indicators of socio-economic development of municipalities was estimated for both indicators using Moran's I:

$$Im_{NDSV} = \frac{N}{\sum_i \sum_p w_p} \times \times \frac{\sum_i \sum_p w_{ip}(NDSV_i - \overline{NDSV})(NDSV_p - \overline{NDSV})}{\sum_i (NDSV_i - \overline{NDSV})^2}, \quad (8)$$

$$Im_{OT} = \frac{N}{\sum_i \sum_p w_p} \frac{\sum_i \sum_p w_{ip}(\mathrm{OT}_i - \overline{\mathrm{OT}})(\mathrm{OT}_p - \overline{\mathrm{OT}})}{\sum_i (\mathrm{OT}_i - \overline{\mathrm{OT}})^2}, \quad (9)$$

where N – number of municipalities, units;

$\overline{NDSV_i}$, – average social payments and taxable cash income of the population per 1 resident of the *i*-th municipality, RUB;

$\overline{OT_i}$, – average volume of shipped own goods, works and services per 1 person in the *i*-th municipality, thousand RUB;

w_{ip} – elements of distance weight matrix between the *i*-th and *p*-th municipalities.

The resulting Moran's I value was compared with the expected value E(Im)=-1/(n-1). If Im>E(Im), there is positive spatial autocorrelation, i.e., in general, the values of observations in the neighboring territories are similar. If Im<E(Im) – negative autocorrelation tales place, i.e., in general, the values of observations in the neighboring territories differ. If Im = E(Im), the values of observations in the neighboring territories are random.

The spatial weight matrix is set exogenously so its specification is the most complex and controversial issue in modeling spatial relations. The matrix of adjacency of municipalities was used for calculation:

$$w = \begin{cases} 1, \text{ if municipalities } i \text{ and } p \text{ have a common border;} \\ 0, \text{ if } i = p; \\ 0, \text{ if municipality } i \text{ has no common border with municipality } p. \end{cases}$$

At the third stage, the constructed hierarchical (multilevel) model was complicated by including an explanatory variable which is the average value of the analyzed indicator among neighboring municipalities in relation to the *i*-th municipality:

$$W\_OT_{ij} = \frac{\sum_{j=1}^{n} \sum_{i=1}^{n} \sum_{p=1}^{n} (w_{ip} \times OT_{ij})}{k}, \quad (10)$$

where k – number of municipalities defined according to adjacency matrix w_{ip} as neighboring for each *i*-th municipality.

As a result, it has become possible to construct the following second class-model (random intercepts) linking changes in social payments and taxable cash income of the population per 1 resident of a municipality with the volume of shipped products in a municipality and neighboring municipalities. At the same time, the indicators of the volume of shipped products in a municipality and in the neighboring areas was not taken into account, but their deviation from the regional average:

Level 1 (lower):

$$NDSV_{ij} = \beta_{0j} + \beta_{1j} \times \left(W_{OT\,ij} - \overline{W_{OT_j}}\right) + + \beta_{2j} \times \left(OT_{ij} - \overline{OT_j}\right) + r_{ij}, \quad (11)$$

Level 2 (upper):

$$\beta_{0j} = \gamma_{00} + u_{0j}, \quad (12)$$

$$\beta_{1j} = \gamma_{10}, \quad (13)$$

$$\beta_{2j} = \gamma_{20}. \quad (14)$$

General joint-level model:

$$NDSV_{ij} = \gamma_{00} + \gamma_{10} \times \left(W\_OT_{ij} - \overline{W\_OT_{ij}}\right) + + \gamma_{20} \times \left(OT_{ij} - \overline{OT_j}\right) + u_{0j} + r_{ij}, \quad (15)$$

where $NDSV_{ij}$ – social payments and taxable cash income of the population per 1 resident in an *i*-th municipality of a *j*-th region in Russia, RUB;

OT_{ij} – volume of own shipped goods, works and services per 1 person in an i-th municipality of a j-th region in Russia, thousand RUB;

W_OT_{ij} – average volume of shipped own goods, works and services per 1 person in muni-cipalities defined as neighboring to the i-th muni-cipality of the j-th region, taking into account the adjacency matrix, thousand RUB;

β_{0j} – function of a general intercept (γ_{00}) and error of interregional variance 1 (u_{0j});

β_{1j} – slope of regression W_OT_{ij} is constant term γ_{10};

β_{2j} – slope of regressor OT_{ij} is constant term γ_{20};

r_{ij} – error of regional (inter-municipal) variance;

j – index for affiliation to a particular Russian constituent entity (j=1, 2,...,6);

i – index for affiliation to a particular municipality (i=1, 2,...,300).

The idea of including population income as a production factor in this territory is not new. The studies often note that "the income of a unit of society (group of households, household, family or individual) is part (and the corresponding value) of the product. It is obtained as a result of the economic activity of this unit" [26, 27]. When testing this hypothesis and building regression models, the researchers note there is a close relation between the income level and the economic activity of the region, which is estimated by the volume of GRP per capita [28], largely determined by the volume of goods and services. Thus, the proposed model develops the achieved to date provisions taking into account the spatial and hierarchical aspects of changes in the indicators under review.

Constructing the final model makes it possible to take into account the impact of internal factors and the spatial and hierarchical effects of subordination on the standard of living.

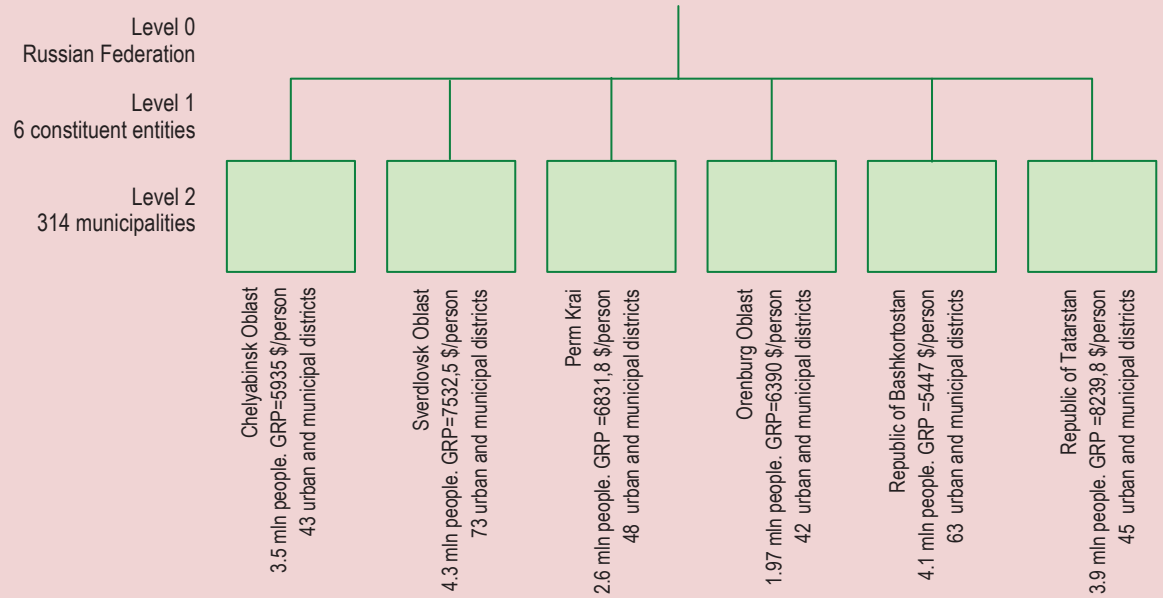
In order to determine the role of individual management levels in the development of the Russian territories, the paper analyzes 300 municipalities, six constituent entities (regions) belonging to two federal districts of the Russian Federation (*Fig. 1*). The entities under review are on a conditional border between the European and Asian part of the country. The total area of their territory is 777.6 thousand km^2. 20.4 million people live on the territory of these six constituent entities, which is almost 13.9% of the total population.

Three out of six analyzed regions are often on top of ten constituent entities according to the results of the all-Russian ranking. The main source of statistical information is data provided by the Federal State Statistics Service. Data on closed territorial entities were not taken into account so the analysis used data on 300 municipalities out of 314.

2. Hierarchical effects in territory's development

The manifestation of features of territory's development can be studied using statistical indicators: average, variation, minimum-maximum indicator value. Analysis of results presented *in tables 1 and 2* demonstrates that the variation in values of indicators of socio-economic development in constituent entities can be in a fairly wide range. This is to the greatest extent manifested in the indicator "volume of shipped own goods, works and services per 1 person in municipalities" (SG). The average values within individual constituent entities for this indicator differ significantly from the sample average, the gap between the minimum and maximum value in a number of subjects is 500-fold, which indicates serious differences between the entities in the achieved values of the indicator of municipalities located on their territory.

Figure 1. Hierarchy tree of the management system in the Russian Federation for territories under review in 2016



Source: compiled by the authors based on data from the official website of the Federal State Statistics Service. Available at: http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/accounts/#.

Table 1. Social payments and taxable cash income of the population per 1 resident of a municipality, RUB/person

Item	Chelyabinsk Oblast	Sverdlovsk Oblast	Republic of Bashkortostan	Perm Krai	Orenburg Oblast	Republic of Tatarstan
Minimum value, RUB	109047.8	125842.6	97436.4	100896.6	103063.6	116113.3
Maximum value, RUB	394419.9	422245.2	321001.7	348935.9	246082.7	403969.1
Average, RUB						
In all sample	176510,8					
In a region	182307.0	205407.9	143190.9	172935.2	161560.8	189980.7
Variation, %						
In all sample	32,5					
In constituent entity of Russia	35.8	27.3	30.6	30.1	23.0	31.8
Standard deviation in municipalities from average indicator value in neighboring areas (taking into account adjacency matrix), thousand RUB						
In constituent entity of Russia	72850.4	66686.8	39082.8	46869.9	43567.6	55615.4

Source: compiled by the authors based on data from official website of the Federal State Statistics Service. Available at: http://www.gks.ru/free_doc/new_site/bd_munst/munst.htm

Table 2. Volume of shipped own goods, works and services per 1 person in municipalities

Item	Chelyabinsk Oblast	Sverdlovsk Oblast	Republic of Bashkortostan	Perm Krai	Orenburg Oblast	Republic of Tatarstan
Minimum value, RUB	7,4	4,7	11,9	8,3	16,9	36,0
Maximum value, RUB	1097,7	2749,0	1332,2	2649,6	2624,6	2817,7
Average, thousand RUB						
In all sample	289,1					
In a region	278,2	345,4	142,1	374,7	222,4	387,4
Variation, %						
In all sample	150,3					
In constituent entity of Russia	96,4	152,8	150,2	129,2	192,9	129,2
Standard deviation in municipalities from average indicator value in neighboring areas (taking into account adjacency matrix), thousand RUB						
In constituent entity of Russia	327,1	559,0	212,5	460,4	455,0	495,8

Source: compiled by the authors based on data from official website of the Federal State Statistics Service. Available at: http://www.gks.ru/free_doc/new_site/bd_munst/munst.htm

In general, the variation of municipalities in indicator "social payments and taxable cash income of the population per 1 resident of a municipality" (NDSV) is lower than in "volume of shipped own goods, works and services per 1 person in municipalities" (OT). This is mainly due to the fact that social payments and taxable cash income of the population are largely regulated by both regional and federal regulatory acts. Minimum wages and social benefits are clearly defined, while there are no such standards for the products shipped. The pricing mechanism on the labor market determined by the law of supply and demand also has a certain influence on the variation of the indicator. Empowering inter-regional labor migration and pursuit of higher wages contribute to population's mobility, especially of young people not dependent on a particular territory through property. Accordingly, if there are disparities in supply and demand for labor in one territory they are levelled off in a short period of time, with an equilibrium price (wage) being set, similar in municipalities and even regions. On the other hand, the condition why there is a difference between social payments and taxable cash income of the population per 1 resident of a municipality in the context of Russian constituent entities is the region salary coefficient established depending on climatic conditions and increasing the income of residents living in territories with "harsh" climate.

Table 3. Results of constructing unconstrained models

Item	Model 1 (for social payments and taxable cash income of the population per 1 resident of a municipality)		Model 2 (for volume of shipped own goods, works and services per 1 person in municipalities)	
	INTRCPT1, u_0	level-1, r	INTRCPT1, u_0	level-1, r
Standard deviation (σ)	21014.5	50888.3	78.37	431.5
Variation (σ^2)	441611241.5	2589620657.2	6142.2	186155.85
χ^2	56.26		13.5	
p-value	<0.001		0.019	
ICC	0.14		0.03	

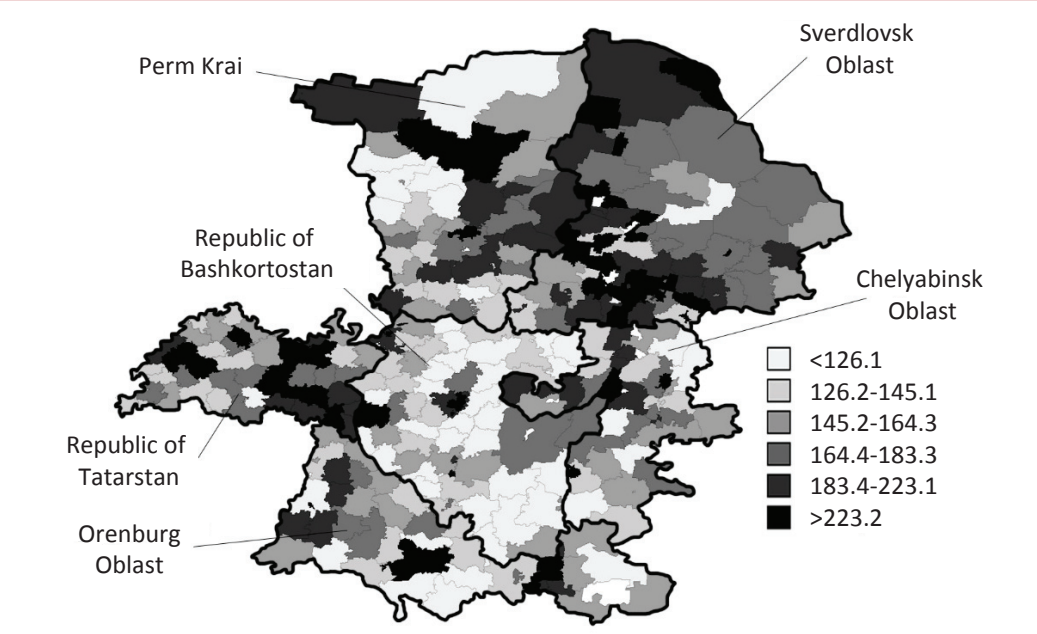
Source: compiled by the authors based on data from official website of the Federal State Statistics Service. Available at: http://www.gks.ru/free_doc/new_site/bd_munst/munst.htm

Differences in Russian constituent entities in terms of standard deviation of indicators in municipalities from the average value of these indicators in the neighboring areas indicate that in some entities, changes in the indicator are characterized by spatial lag autocorrelation to a greater extent, in others – to a lesser.

The one-way analysis of variance confirms that the variability of socio-economic development indicators at the top level of the hierarchy is significantly different from zero. Results of constructing two-level unconstrained regression models (*Tab. 3*) generally indicate that the differences between municipalities in NDSV are by 14% determined by the differences in Russian constituent entities and by 86% – by the differences in municipalities, while the role of regions does not exceed 3% in terms of OT indicator. The obtained value of chi-square statistics for both models indicates the rejection of null hypothesis ($p<0.05$) and the interclass variation coefficient equaling zero. The standard deviation values for residual components u_0 and r (for each level of the hierarchy) indicate that intraregional differences are higher than interregional ones.

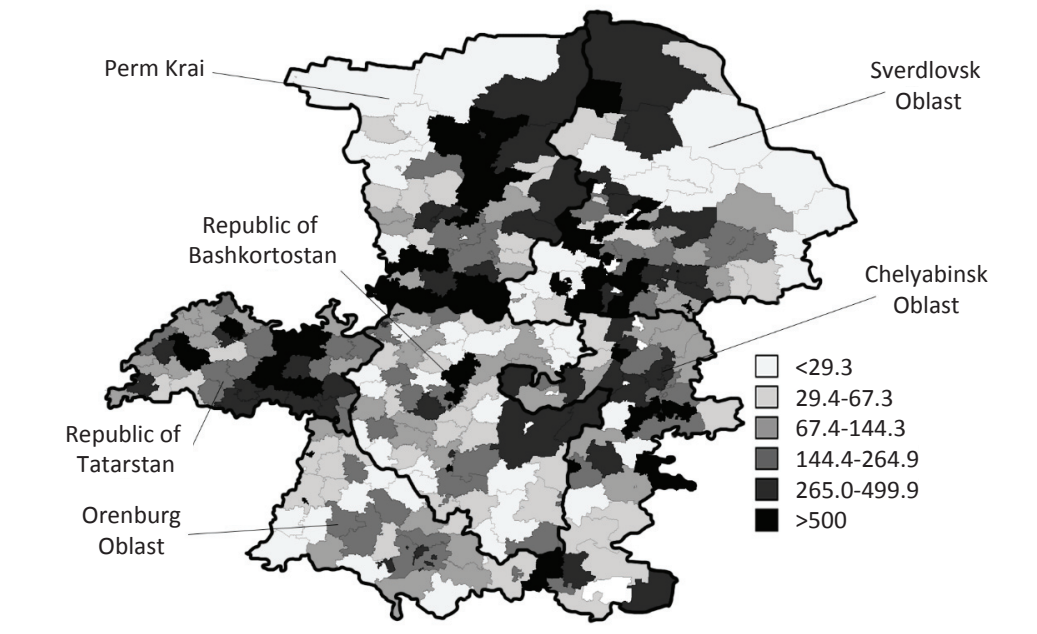
Intraregional differences are differences between municipal districts of separate Russian constituent entities, which, according to calculations, are greater than variations of regions in the average achieved value. Thus, we can say that the situation is similar in all regions under review: there are several leading municipal districts and those that are outsiders for regional authorities to work with. Such territories are financed through budget relations. They are provided with assistance in the implementation of special regional projects, search for investors through presenting a territory as a potential space for creating a cluster or a special zone. This, on the one hand, levels municipal districts in terms of economic development as such projects help improve the situation of backward municipal districts. On the other hand, it enhances the differentiation of emergence of territories of advanced development as "growth points" often with their own capabilities, including production, resource, and labor potential. This may be the reason for such a heterogeneous

Figure 2. Social payments and taxable cash income of the population per 1 resident of a municipality in 2016, thousand RUB/person



Source: compiled by the authors based on the official website of the Federal State Statistics Service. Available at: http://www.gks.ru/free_doc/new_site/bd_munst/munst.htm

Figure 3. Volume of shipped own goods, works and services per 1 person in municipalities in 2016, thousand RUB/person



Source: compiled by the authors based on the official website of the Federal State Statistics Service. Available at: http://www.gks.ru/free_doc/new_site/bd_munst/munst.htm

level of development of municipalities and their high dependence on their own capabilities.

The value of ICC for the second model less than 0.05 indicates that it is not feasible to construct hierarchical models for the volume of shipped products. The weak impact of the upper level on the index values in municipalities can also be manifested in higher variation of different municipalities in terms of the volume of shipped products in the framework of constituent entities of Russia in comparison with the interregional variation. Thus, the variation of average regional values for shipped products is 27.7%, within the regions the variation ranges from 96.4 to 192.9%, while the gap is not so large in terms of social payments and taxable cash income per 1 resident of a municipality: the variation of average regional values for shipped products is 10.9%, ranging from 23 to 35.8% within the regions. Thus, for further study of the hierarchical relations of the socio-economic development of municipalities it is advisable to use the indicator "social payments and taxable cash income of the population per 1 resident of a municipality".

The calculations indicate that interregional differences are less intense than intraregional. Based on regional statistics, many note a decreased differentiation in the development of the country's territory, but this is not completely true. Average values for regions are improved due to high values of growth points with the weakening of the rest of the country. As a result, differentiation is shifted to the municipal level and lies in average values of Russia's constituent entities. Spatial analysis helps identify prosperous municipal districts and their relations with the neighboring territories.

3. Spatial effects in territory's development

In order to determine the relations between the neighboring municipalities, spatial statistical analysis is carried out in the framework of the second stage. Quantile maps presented in *Figure 2* and *3* indicate that there is a spatial relation in the change in development indicators: as a rule, municipalities with high and average indicator values group around municipalities with high values of the indicator under review.

The Moran's I is calculated to confirm the hypothesis of spatial autocorrelation dependencies. The index value comprises:

– by social payments and taxable cash income of the population per 1 resident of a municipality: 0.27;

– by volume of shipped own goods, works and services: 0.13.

Both values are positive, i.e. there is a positive spatial autocorrelation and the values of observations in the neighboring territories are generally similar. At the same time, in terms of NDSV spatial relationship is more marked. Thus, the location of municipal districts with high values of indicators under review is not chaotic. Municipal districts with a favorable situation are as a rule adjacent to those with a similar situation, implying high values of indicators under review. The location of areas with low indicator values surrounded by areas with high values is quite rare. It can be assumed that the development of one area as a whole has a positive impact on the development of the neighboring areas and vice versa. Territory connectivity is noted, which determines the potential of inter-municipal interaction.

In order to determine the average value of the analyzed indicator among the neighboring municipalities in relation to the *i*-th

municipality, a Random intercepts model is constructed:

$$NDSV_{ij} = \gamma_{00} + \gamma_{10} \times \left(W\_OT_{ij} - \overline{W\_OT_{ij}}\right) + \\ + \gamma_{20} \times \left(OT_{ij} - \overline{OT_j}\right) + u_{0j} + r_{ij}, \quad (16)$$

where $NDSV_{ij}$ – social payments and taxable cash income of the population per 1 resident of the i-th municipality in the j-th region in Russia, RUB;

OT_{ij} – volume of shipped own goods, works and services per 1 person in the i-th municipality of the j-th region in Russia, thousand RUB;

W_OT_{ij} – average shipped own goods, works and services per 1 person in municipalities adjacent to the i-th municipality in the j-th region taking into account the matrix of adjacency, thousand RUB;

β_{0j} – function of a general intercept (γ_{00}) and error of interregional variance 1 (u_{0j});

β_{1j} – линейный наклон регрессора W_OT_{ij} eclinear slope of regressor W_OT_{ij} is a constant γ_{10};

β_{2j} – slope of regressor OT_{ij} is constant term γ_{20};

r_{ij} – error of regional (inter-municipal) variance;

j – index for affiliation of a municipality to a specific Russian constituent entity (j=1, 2,..., 6);

i – index for affiliation to a particular municipality (i=1, 2,...,300).

When identifying the hierarchy effects of type 3 regression model we accounted robust estimates (*Tab. 4*).

The resulting regression coefficients indicate a positive relation between social payments and taxable cash income of the population per 1 resident and the volume of shipped own goods, works and services in a municipality (slope coefficient $\beta_2 = 66.04$; $p<0.001$) and the neighboring municipalities (slope coefficient $\beta_1 = 30.0$; $p<0.001$). Thus, an increase in the volume of shipped own goods, works and services per capita by 1 thousand rubles increases population income by average 66 rubles per 1 resident of a municipality, while the change in this indicator by 1 thousand rubles in the neighboring areas increases incomes by 30 rubles per 1 resident in a municipality.

The correlation between indicators "social payments and taxable cash income of the population per 1 resident of a municipality" and "volume of shipped own goods, works and services in a municipality (a) and the neighboring municipalities (b)" in 2016 is graphically presented in *Figure 4*. As can be seen in the figure, the trajectories in the regional context have the same slope, but do not coincide.

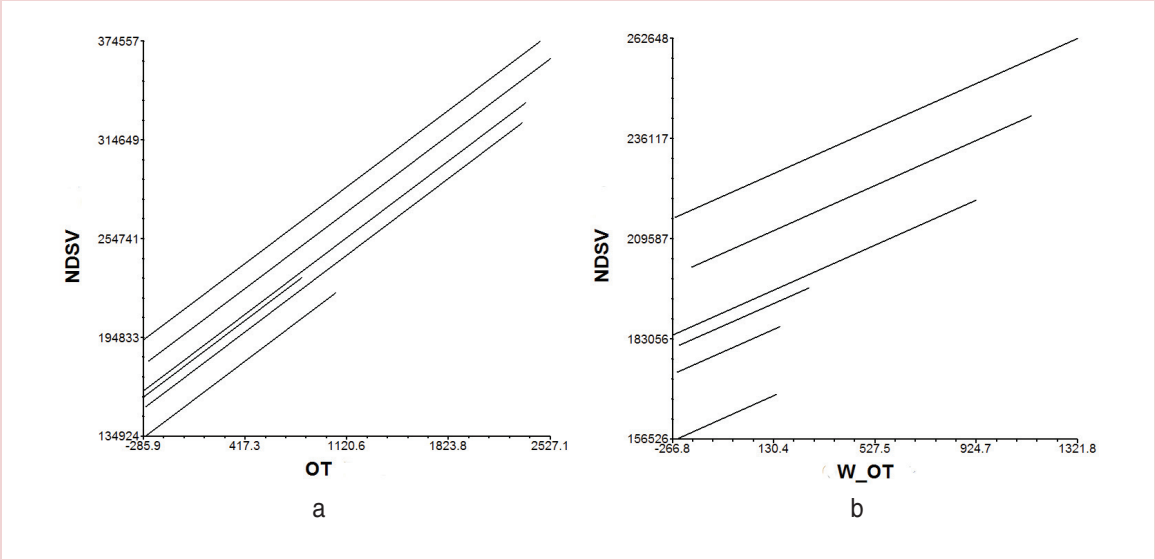
Variation values obtained in model 1 (see Tab. 3) and models 3 (*Tab. 5*) help determine the influence of factors on changes in variance of the dependent variable due to the level of hierarchy [29]:

$$r^2 = \frac{\sigma^2_{j\,(\text{model1})} - \sigma^2_{j\,(\text{model3})}}{\sigma^2_{j\,(\text{model1})}} = 0.35.$$

Table 4. Results of fixed effects evaluation (with robust standard errors)

Fixed effects	Coefficient	Standard error	*t*-ratio	*p*-value
For β_0				
γ_{00}	173744.782	8236.242	21.095	<0.001
Slope coefficient for W_OT, β_1				
γ_{10}	30.008	4.7481	6.320	<0.001
Slope coefficient for OT, β_2				
γ_{20}	66.039	10.792	6.119	<0.001
Source: compiled by the authors based on data from official website of the Federal State Statistics Service. Available at: http://www.gks.ru/free_doc/new_site/bd_munst/munst.htm				

Figure 4. Predicted trajectory of changes in social payments and taxable cash income of the population per 1 resident of a municipality as a result of changes in factors by region



Source: compiled by the authors based on the official website of the Federal State Statistics Service. Available at: http://www.gks.ru/free_doc/new_site/bd_munst/munst.htm

Table 5. Results of constructing the random intercepts model

Random Effect	Standard deviation (σ)	Variation (σ^2)	χ^2	*p*-value
INTRCPT1, u_0	21287.42	453154442.64	86.697	<0.001
level-1, *r*	40997.73	1680814087.24		

Source: compiled by the authors based on data from official website of the Federal State Statistics Service. Available at: http://www.gks.ru/free_doc/new_site/bd_munst/munst.htm

Thus, the volume of shipped own goods, works and services in a municipality and the neighboring municipalities explains 35.1% of dispersion of social payments and taxable monetary income of the population per 1 inhabitant of a municipality.

The calculated value of ICC for model 3 shows that the role of the regional level of affiliation, taking into account its influence on both *NDSV* and *OT*, is 21.1%. Thus, the change in social payments and taxable cash income of the population per 1 resident is 78.9% associated with the actions of municipal authorities.

Thus, the income level of a separate municipality is determined not only by production development in its territory, but also by production development in the neighboring municipalities. The ratio may be different. The model shows that for the area under review it is 2:1 (a *66 RUB* increase in income per 1 resident in a municipality at a *1000*

RUB increase in the volume of shipped own goods, works and services per capita per 1 resident *in a municipal district* to *30 RUB* per 1 resident in a municipality at a 1000 RUB increase in the volume of shipped own goods, works and services per capita *in the neighboring municipalities*). Therefore, municipal districts should pay more attention to inter-municipal interaction as the development of the neighboring territories raises the income of the local population. Thus, the model not only assesses the impact of certain levels of hierarchy on the incomes of the population in a municipality, but also indirectly assesses the connectivity of the territory under review as a result of determining the positive role of neighboring municipalities in its development. Such quantitative assessment provides a more reasonable approach to building inter-municipal cooperation and assessing its potential. The highlighted role of the regional level indicates that the actions of regional authorities have a significant impact on these processes. At the same time, very high ICC values, in our opinion, can be considered as a negative phenomenon manifested in excessive dependence of the development of a municipality, including financial, on the actions of regional authorities.

Conclusions

Studies of domestic and foreign researchers point to the existing interregional differences. The regional differences in the level of development and failure to realize the potential of inter-municipal cooperation are noted as one of the main problems in the draft Strategy for spatial development of the Russian Federation up to 2025. The decision of the latter problem is complicated by its underdeveloped evaluation tools. Moreover, inter-municipal and inter-regional cooperation is not considered in this Strategy as a complex, hierarchically related phenomenon, especially manifested in the interaction of municipal districts located on the borders of the neighboring constituent entities. As a consequence, the proposals to implement the potential of inter-municipal cooperation are poorly presented in the draft Strategy.

In the framework of the current paper, a municipality is considered as a system having horizontal (territory) and vertical (management hierarchy) ties. The authors highlight inter-municipal and inter-regional variance, as well as the spatial and hierarchical effects. It is determined that the influence of the neighboring municipalities and a higher level of the management hierarchy is manifested in the formation of some indicators more than for others. Thus, the value of the indicator "social payments and taxable cash income of the population per 1 resident of a municipality" depends to a greater extent than the value of the indicator "volume of shipped own goods, works and services in a municipality" on steps taken at the regional level (the ICC value for the first indicator – 0.14, for the second – 0.03). Spatial autocorrelation, i.e. similarity of values in the neighboring territories, is also more evident in indicator "social payments and taxable cash income of the population per 1 resident of a municipality" (Moran's I for the first indicator – 0.27, for the second – 0.13).

The authors have made an attempt to combine both hierarchical and spatial effect within the framework of one model by including the indicator "volume of shipped own goods, works and services in a municipality" in a two-level model of "social payments and taxable

cash income of the population per 1 resident of a municipality" both for a municipality itself (in order to take into account internal factors of income formation) and the average value of the neighboring territories in order to take into account the features of a number of located municipalities.

The results suggest that the variation of "social payments and taxable cash income of the population per 1 resident of a municipality" is associated with the results achieved by the neighboring territories, and the activities of the regional government of a constituent entity a municipality is located in.

The presented approach to analyzing the development of territories simultaneously from the standpoint of spatial opportunities of the district's (region's) economic growth and management functions of authorities depending on the hierarchy of decisions enriches the system of theoretical and applied knowledge of spatial economy. The practical application of the presented model for assessing spatial and hierarchical effects will help improve the system of developing strategies for socio-economic development of territories, as well as eliminate the problem of underdeveloped and sometimes inefficient measures of regional authorities related to inter-municipal cooperation.

The proposed comprehensive view of the problem of socio-economic development differentiation of separate territories involves further study of various indicators characterizing the socio-economic development of territories. This is necessary to identify indicators determined by internal and external (spatial, hierarchical) factors. The choice of indicators for analysis is largely dictated by the objective to develop proposals for public administration bodies at the regional level in terms of improving the strategies for socio-economic development. First of all, these are indicators of human development. At the same time, further development of the research methodology is hindered by lack of tools for reliable assessment of the quality of complex models due to the need to take into account the spatial and nested data structure.

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