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MECHANISMS OF SPATIAL CONCENTRATION AND DECONCENTRATION OF ECONOMIC ACTIVITY IN YAKUTIA

Abstract

The paper is devoted to the analysis of the main trends in the spatial distribution of various types of economic activity in Yakutia. A matrix of transport distances by land in winter period was developed for the region. On its basis, panel data on the geographical potential were obtained, and the reverse indicator – agglomeration effect – was proposed. The analysis of heterogeneity in the spatial distribution of different types of economic activity was carried out on the basis of the calculation of the Theil indices. For the first time in Yakutia, the geographically weighted regression method was used to test hypotheses: on the relationship between the volume of agricultural production and the availability of markets, as well as the provision of agricultural land; on the impact of people's income and agglomeration influence on the dynamics of small business; on the relationship between the volume of production of large and medium-sized enterprises, agglomeration influence and investment.

Keywords: economic activity, settlements, small business, agriculture, regression analysis.

Introduction

Spatial development of Yakutia, located in the North-East of Russia, is marked by dispersed pattern of settlements, underdeveloped logistics, and high costs of life-support caused by extreme climatic conditions. The area of the region exceeds 3.0 million square kilometers. Studying spatial structure is of interest in terms of verification of global historical trend of spatial concentration. Shrinking of spatial settlement Yakutia in 1939-2016 yielded such positive results as: modernization of economy, reduction in mortality, higher quality of living standards. At the same time, it has had a controversial impact on agricultural indicators, the region has lost its food self-sufficiency.

Contemporary period is characterized by changes in the settlement system and the spatial distribution of economic activity. Concentration processes are supported by market mechanisms and have a global nature. Whereby, transformation of the settlement system in Yakutia over the last decades has been homogeneous, in many ways compensating for inefficient decisions of the Soviet period. While the urban system of the republic is showing concentration of population and agglomeration center is being distinguished, the size of rural settlements, on the contrary, shows a trend towards convergence. Political decisions aimed at curbing these trends and conservation of spatial proportions will be associated with high costs. In this regard, the leadership of the republic is facing a challenging task of combining high overall economic efficiency, including low costs for development and maintenance of infrastructure, with preserving territorial integrity and solving issues of social guarantees [Gavrilyeva, Kolomak, 2017]

The object of the study are various types of economic activity in the Sakha Republic (Yakutia).

Database: open and analyzable data from Federal State Statistics Service in the Sakha Republic (Yakutia), Strategic Studies Center of the SR(Ya), municipal statistics, as well as publicly available information for 411 settlements in Yakutia. The data are panel, as they contain information about one and the same set of objects over a series of consecutive periods of time.

1. Geographical Potential and Agglomeration Influence of Settlements

New economic geography sees regions as open systems, therefore not only local demand is important for development of economy in a region (district), but also the demand of surrounding territories, in other words, the region's market potential. To assess the processes of concentration and deconcentration of economic activity, gravity model was used [Combes, et al., 2008, Kolomak, 2013, Trubekhina, 2014].

Geographical units of analysis or sampling are 2 urban districts (city of Yakutsk and settlement of Zhatay), 48 urban and 361 rural settlements of Yakutia. To build the model, a matrix of distances was developed, with the following key parameters:

– urban districts were merged into Yakutsk agglomeration; until 2004, Zhatay settlement was part of Yakutsk, both settlements are economically interconnected. Territory of Zhatay settlement urban district is completely surrounded by the city of Yakutsk urban district. Therefore, the number of objects in the sample made 410 settlements;

– to determine distances between settlements i and j ($dist_{ij}$), the shortest ground distances by public roads, including winter roads, were used. Thus, seasonality was excluded; the resulting matrix reflects conditions during the most favorable period for ground transportation;

– 500 km was taken as the maximum possible distance between 2 points; this is a restriction for delivery of goods to the local market;

– for Yakutsk agglomeration, the 500 km restriction was ignored, due to its pivotal position in the system of goods-and-materials supply of the region;

– the following were used to calculate the distances: roadmap of Yakutia, as well as map data of Yandex Maps web service, http://yakutia-map.ru/ and дорогиарктики.рф/ sites. Insignificant deviations from actual data are possible, since the distances between remote points were calculated by summing up the lengths of roads connecting nodal points (transportation hubs).

Geographical potential of a settlement i is calculated as the sum of population in neighboring settlements, weighted by distance between cities [Kolomak, 2013; Trubekhina, 2014]:

$$GP_i = \sum_{i \neq j}^{n} \frac{p_j}{dist_{ij}}, \text{ where}$$

GP_i – geographical potential of a settlement i;

p_j – population of a settlement j;

$dist_{ij}$ – distance between settlements i and j *;

n – number of settlements in sample.

The authors propose a ***reverse indicator – agglomeration influence*** of a settlement i, which is calculated as the sum of population ratios in a settlement i, weighted by distance between settlements:

$$AI_i = \sum_{i \neq j}^{n} \frac{p_i}{dist_{ij}}, \text{ where:}$$

AI_i – agglomeration influence of a settlement i;

p_i – population of a settlement i;

$dist_{ij}$ – distance between settlements i and j.

The more accessible the neighboring markets are for a settlement, the higher is the geographic potential (hereinafter – GP), which is a direct reference to the Palander model [Melnikova, 2015]. In our case, the potentials are estimated by population size, which is a convenient, statistically transparent, and well-monitorable indicator. 'Agglomeration influence' (hereinafter – AI) indicator that we propose, allows to consider a settlement as a product sales market for neighboring settlements, which is a reference to the Thünen model. Accordingly, GP and AI reflect changes in population size of neighboring settlements and the settlement in question, taking into account transport accessibility. According to property of the matrix:

$$\sum_{i=1}^{n} GP_i = \sum_{i=1}^{n} AI_i$$

In 2006-2017, both indicators demonstrated growth (110%), which suggests that the trend for compression of settlement system is a long-term one. At the same time, behavior of these indicators is multidirectional. The data show that (Table 1):

– among all the settlements of Yakutia in 2006-2017, the maximum value of GP is registered at the urban settlement of Nizhny Bestyakh, which, thanks to construction of the Amur-Yakutsk Mainline railroad, is becoming the largest transportation hub of the region. Here, we see growth of both GP at 117% (in 2006 – 11,386.7, in 2017 – 13,363.3), and AI at 115% (in 2006 – 4,841.6, in 2017 – 5,550.3). This case confirms a stronger role of agglomeration effect in case of a large infrastructure project implementation.

Table 1. Distribution of Yakutia's Settlements by Behavior of Geographical Potential and Agglomeration Influence in 2006-2017.

	Number of Settlements	
	GP growth	**GP fall**
AI growth	64	10
AI fall	300	36
	Average population of settlements	
AI growth	1644,0	35828,4
AI fall	1084,6	4873,0

Source: Calculated based on the study database

– the minimum value of GP is registered in the rural settlement of Saskylakhsky community of Anabarsky Ulus (District). Overall growth of GP makes 120% (in 2006 – 115.9, in 2017 – 138.8). In 2017 the GP of settlements in the Arctic districts of Yakutia and in a number of settlements in Southern and Western Yakutia did not exceed 500-600, which reflects their transport isolation and inaccessibility, and can be used in future to develop a special indicator of economic security – connectedness of space;

– only 64 out of 410 settlements of Yakutia show growth in both GP and AI, with some sustainable prospects for growth. These are mainly district centers, including Arctic districts (Anabarsky) and rural settlements of Central Yakutia (Namsky, Ust-

Aldansky, Megino-Kangalassky, Tattinsky, Khangalassky). Significant representation of Central Yakutia's settlements can be explained by growing quality of road network, thanks to repair and reconstruction of federal highways (Lena, Amga) in recent years, which is important for ensuring mobility and quality of life of the population. Average population of settlements in this group is 1,644 people, which corroborates the conclusion about resilience of settlements with about 2,000 people in Yakutia [Gavrilyeva, Myreyev, 2015];

– 300 settlements (about 75% of the total number) show a decreasing AI along with growing GP. This indicates that a number of multidirectional trends is present in the settlement system of Yakutia. First one is continuing outflow of population to other regions of Russia. Secondly, it is migration of population from smaller to larger settlements. It also indicates that Yakutsk is attractive as the core of the spatial structure of the region [Gavrilyeva, Kolomak, 2017];

– growth of AI against decrease of GP is observed only in 10 settlements, including Yakutsk agglomeration, due to presence of which, the average population in this group makes 35,828.4 people. The group is heterogeneous, population growth is ensured by both natural and migratory increment. Yakutsk agglomeration shows the largest growth of AI – 121%, which balances the GP decrease;

– a total of 36 settlements demonstrate a decline in both GP and AI. Here, two groups of settlements can be singled out. First group is represented by small (from 200 to 900 people) rural settlements of Western and Southern Yakutia, where implementation of large-scale industrial projects leads to displacement of rural population from territories previously available for traditional economic activity. Agglomeration effect is also pronounced here, in form of increasing attractiveness of industrial settlements and cities. Second group consists of settlements and cities of Aldansky, Mirninsky, and Neryungrinsky districts, which are historical industrial districts. These settlements are mono-industrial, which requires special support measures. Due to the settlements of the second group, average population of this type of settlements makes 4,873 people.

Thus, introduction of market mechanisms has led to different effects in settlement structures; spatial concentration processes have intensified in the urban system, while in rural areas they have been weakening.

To establish correlation between obtained GP and AI indicators and economic activity, a standard statistical method was used — correlation analysis of panel data (Table 2). Due to unavailability of municipal statistics for a number of years, time intervals vary.

Table 2. Correlation Coefficients of GP and AI to Economic Activity Indicators

	Period	GP	AI
Cargo turnover, thousand tons km	2011-2016	-0.0084	0.5726
Own-produced goods shipped, works and services performed with own resources (small enterprises, including micro-enterprises), RUR thousand	2006-2016, exclusive of 2015	0.0043	0.9095
Own-produced goods shipped, works and services performed with own resources (large and medium enterprises), RUR thousand	2006-2016	-0.0333	0.5335
Small enterprises turnover, RUR thousand	2006-2017	0.0026	0.9158
Investments in fixed capital from all sources of financing (excluding small businesses and parameters of informal activities), RUR thousand	2006-2017	-0.0329	0.4380
Investments in fixed capital from municipal budget, RUR thousand	2010-2017	0.0031	0.5209
Commissioning of individual housing, square meters	2010-2017	0.0506	0.9543
Total land area – agricultural land, hectares	2010-2017	-0.3068	-0.0144
Average number of employees (without external part-timers and unlisted workers), people	2006-2016	-0.0029	0.9500
Average monthly wage of employees within full range of organizations, RUR	2006-2016	-0.0801	0.0592
Agricultural production in then effective prices, RUR thousand	2013-2016	0.1209	0.9312

Source: Calculated based on the study database

As the data show, the AI indicator, due to the fact that it was calculated using population size, is directly correlated with almost all indicators of economic activity available for analysis. Conversely, the GP indicator practically does not correlate with these indicators; it is possible that the GP is relevant only for territories with a higher population density.

2. Assessment of Spatial Heterogeneity in Yakutia

The result obtained required additional investigation of heterogeneity of economic activity. For this, Theil method was used, which allows to obtain a decomposition of processes of spatial concentration into the interdistrict and the intradistrict components. The formula for calculating Theil index is as follows:

$$T = \sum_{r=1}^{R} \left(\frac{Y_r}{Y} ln \frac{Y_r}{Y/R} \right), Y = \sum_{r=1}^{R} Y_r$$

where Y_r – indicator value in a settlement r, Y – indicator value for a region as a whole, and R – number of settlements.

Theil index varies from *0* to *lnR*. Extreme values correspond to an even distribution of a phenomenon across settlements ($Y_r=Y/R$), and to its concentration in just one settlement, respectively. The higher the index value, the higher the level of spatial concentration. From the general level of spatial concentration, it is possible to single out contributions from the indicator distribution between districts and between settlements within each one of them:

$$T = T_{between} + T_{within},$$

$$T_{between} = \sum_{m=1}^{M} \frac{Y_m}{Y} ln \frac{Y_m/R_m}{Y/R}.$$

Here Y_m – indicator value for a district m, R_m – number of settlements within a district m, and $Y_m = \sum_{r=1}^{R_m} Y_r$.

$$T_{within} = \sum_{m=1}^{M} \frac{Y_m}{Y} T_m,$$

where T_m – Thiel index, calculated for settlements, falling within a district m:

$$T_m = \sum_{r=1}^{R_m} \frac{Y_r}{Y_m} ln \frac{Y_r}{Y_m/R_m}.$$

Derived estimates of heterogeneity are presented in Table 3. The results show that trends in spatial concentration of economic activity largely depend on sector-specialization. Productions linked to immobile resources (agriculture, mining) or to immobile demand are less responsive to economy of scale.

The T-index for shipped goods, works and services performed by large and medium-sized enterprises shows a much higher level of concentration; in 2016 it made 3.1804 versus 2.9554 for small businesses. This confirms a correlation between location of a large-scale production and supply of labor resources; the larger the production, the higher the number of employees and, accordingly, the larger the population in a settlement. The T-index behavior for shipped goods, works and services performed by large and medium-sized enterprises was also affected by market cyclicity; in crisis conditions of 2009 it manifested a fall, after which the pattern gradually smoothed out.

In contrast to the mentioned sector, small and micro-businesses are more likely to show a trend towards concentration within municipal districts or, in terms of new economic geography, an 'effect of spillover' of enterprises to large settlements, mainly district centers, in 2010-2016. Until 2010, the trend was different, and both the T-index for shipped goods, works and services by small and micro-enterprises, and the T-index for small businesses' turnover, showed convergence. Among possible reasons is shrinkage of public support programs for small businesses.

Analysis of the T-index behavior for agricultural products shows that this domain is extremely inert; it is linked to such immobile resource as land, accordingly, there is no economy of scale (settlement population size). This confirms the conclusion drawn by E.A. Kolomak in 2013, that revealed a negative correlation of population density with the end product of agriculture. In case of high costs, economic activity is dispersed.

The T-index behavior of investment in fixed capital from all sources of financing, excluding small and medium-sized businesses, shows that they are distinguished by a high degree of concentration. The maximums occur in 2008-2009 (period of ESPO-1 oil pipeline construction), and in 2016-2017 (construction of Power of Siberia gas pipeline).

Table 3. Theil Indices for Indicators of Economic Activity in the Sakha Republic (Yakutia)

Resident population size														
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2018/2010**
T within	-	-	-	-	0,6257	0,6257	0,6266	0,6307	0,6334	0,6407	0,6481	0,6552	0,6593	**105,4%**
T between	-	-	-	-	0,7495	0,7514	0,7725	0,7944	0,8148	0,8242	0,8346	0,8419	0,8522	**113,7%**
T, total	-	-	-	-	1,3752	1,3771	1,3991	1,4251	1,4482	1,4649	1,4827	1,4971	1,5115	**109,9%**
Average number of employees														
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2016/2006**		
T within	0,9138	0,9564	0,9282	0,9097	0,9077	0,9182	0,9036	0,9103	0,9228	0,9335	0,9305	**101,8%**		
T between	0,7370	0,7356	0,7495	0,7594	0,7876	0,8081	0,8211	0,8326	0,8604	0,8748	0,9089	**123,3%**		
T, total	1,6508	1,6920	1,6777	1,6690	1,6953	1,7263	1,7247	1,7429	1,7832	1,8083	1,8394	**111,4%**		
Investments in fixed capital from all sources of financing (excluding small businesses and parameters of informal activities)														
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2017/2006**	
T within	1,5561	1,7227	1,7583	1,7502	1,5922	1,5672	1,7342	1,6689	1,6528	1,6149	1,7240	1,8861	**121,2%**	
T between	1,6550	1,7748	1,9021	2,0964	1,6483	1,6785	1,5471	1,5328	1,4465	1,6277	1,6491	1,6961	**102,5%**	
T, total	3,2112	3,4975	3,6603	3,8466	3,2404	3,2457	3,2812	3,2017	3,0993	3,2426	3,3731	3,5822	**111,6%**	
Own-produced goods shipped, works and services performed with own resources (large and medium enterprises)														
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2016/2006**		
T within	1,6875	1,6188	1,5725	1,4849	1,6215	1,6497	1,6324	1,6617	1,6890	1,7145	1,6612	**98,4%**		
T between	1,5828	1,5101	1,4644	1,3223	1,4144	1,4337	1,4466	1,4891	1,4640	1,4872	1,5192	**96,0%**		
T, total	3,2703	3,1289	3,0369	2,8073	3,0359	3,0834	3,0791	3,1508	3,1530	3,2017	3,1804	**97,3%**		
Own-produced goods shipped, works and services performed with own resources (small enterprises, including micro-enterprises)														
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2016/2006**		
T within	1,0697	1,0689	1,0830	1,0441	1,1125	1,0351	1,1051	1,1011	1,1379	-	1,3583	**127,0%**		
T between	1,7026	1,6918	1,6155	1,7140	1,7530	1,8104	1,6273	1,5210	1,6426	-	1,5971	**93,8%**		
T, total	2,7723	2,7608	2,6986	2,7581	2,8655	2,8455	2,7324	2,6221	2,7805	-	2,9554	**106,6%**		
	Small enterprises turnover including micro-enterprises													
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2017/2006**	
T within	1,0422	1,0241	1,0427	1,0267	1,0661	1,0290	1,0819	1,1678	1,2744	1,4345	1,3526	1,3410	**128,7%**	
T between	1,8725	1,7962	1,7185	1,8033	1,8270	1,8397	1,7020	1,7851	1,9367	1,9000	1,7144	1,7964	**95,9%**	
T, total	2,9147	2,8203	2,7612	2,8300	2,8931	2,8687	2,7839	2,9529	3,2111	3,3345	3,0670	3,1374	**107,6%**	
Agricultural production in then effective prices														
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2016/2013**		
T within	-	-	-	-	-	-	-	0,2457	0,2383	0,2637	0,2595	**105,6%**		
T between	-	-	-	-	-	-	-	0,4479	0,4452	0,4450	0,4529	**101,1%**		
T, total	-	-	-	-	-	-	-	0,6936	0,6835	0,7087	0,7124	**102,7%**		

Source: Calculated based on the study database

During the periods of investment ‘calm’, the T-index approaches its natural level, which can be seen from a smoothed behavior pattern.

Behavior of spatial concentration in the republic’s settlement system reflects a strong influence of urbanization process. Behavior of the intradistrict T-index, and behavior of the interdistrict T-index for population are positive; which means that intra-regional migration flows are aimed at moving from smaller to larger settlements, primarily to district centers; and Yakutsk agglomeration (city of Yakutsk and settlement of Zhatay) remains the core of spatial system of the region. Districts with agricultural specialization show a more stable situation compared to others due to a high natural population growth. Large industrial cities and settlements that were established during the period of Soviet economy’s extensive growth, lost a significant part of their population.

The T-index behavior for the size of employed population is almost completely consistent with the behavior for the size of population. Heterogeneity slightly increased at the intradistrict level (2016 to 2006 – 101.8%) due to optimization of the social domain branches during the reviewed period, and divergence significantly increased at the interdistrict level (2016 to 2006 – 123.3%). Accordingly, urbanization not only leads to concentration of population in large settlements, but also promotes the creation of new jobs there; the reverse is also true: people move to larger settlements because of a greater availability of jobs.

3. Mechanisms of Economic Activity Distribution in Yakutia

To determine the nature of effects that multidirectional trends have on the spatial distribution of economic activity in Yakutia, ***the following hypotheses*** were formulated and tested using geographically weighted regression method:

1. Output of large and medium-sized enterprises of Yakutia is formed mainly by means of mining industry and local power generation. In both cases, immobility of either production factor (anchoring to a deposit) or demand (electricity and heat supply to settlements) is observed. Therefore, the hypothesis is to study the degree of dependence

of large and medium-sized enterprises' output from population size and geographical location, since large-scale production facilities are concentrated in settlements with good transport accessibility and high population density, as well as from investment activity. The dependent variable is the volume of shipped goods of own production, works and services performed using own resources within range of large and medium-sized enterprises. Independent variables: agglomeration influence of settlement and investment in fixed capital from all sources of financing without small businesses and parameters of informal activity.

2. Unlike large and medium-sized businesses, small businesses attract payment-capable demand. After the financial crisis of 2008-2009, small businesses are likely to concentrate in larger settlements. In this case, the hypothesis being tested implies that the volume of shipped goods of own production, works and services performed using own resources within range of small and micro-enterprises depends on the size of the local market and its attractiveness for neighboring settlements (the first independent variable is agglomeration influence of a settlement), as well as on the population's income level. Average monthly wage of employees available for analysis within full range of organizations in rubles was taken as the second independent variable.

The main task was to obtain statistically significant models on various samples, characteristics of which can be used to derive indicators of economic security (or resilience) of settlements in regions with low population density.

Results obtained based on modeling using geographically weighted regression method.

1. Hypothesis. Regression equation obtained based on panel data over the period from 2006 to 2016 looks as follows:

$$y = e^{\alpha_0} \cdot {x_1}^{\alpha_1} \cdot {x_2}^{\alpha_2}, \text{ where:}$$

y – volume of shipped goods, works and services performed using own resources for large and medium-sized enterprises, RUR thousand;

x_1 – agglomeration influence of a settlement;

x_2 – investment in fixed capital from all sources of financing (without small businesses and parameters of informal activity), RUR thousand;

α_n – coefficients.

As the data show, the values of standardized determination coefficient R^2 are sufficiently large; the equation is in relatively good agreement with the sample available. As shown by the data in Table 4, agglomeration effect influences volume of shipped goods of own production, works and services performed using own resources within range of large and medium-sized enterprises; the value of determination coefficient grows with increasing agglomeration influence of a settlement, which is achieved by reducing the sample

Table 4. Model Calculations on Hypothesis 1

Sample by agglomeration influence	all AI values	AI above 100	AI above 200	AI above 300	AI above 500	AI above 1000	AI above 2000
Number of settlements in sample	410	310	260	211	154	64	31
Multiple R	0,650814	0,728952	0,746450	0,760679	0,786618	0,808004	0,886427
R-squared	0,423558	0,531371	0,557188	0,578632	0,618767	0,652871	0,785753
Standardized R-squared	0,423303	0,531096	0,556878	0,578269	0,618316	0,651881	0,784485
Standard error	2,624027	2,345921	2,305226	2,281984	2,254767	2,125991	1,488109
Observations	4510	3410	2860	2321	1694	704	341
a0	1,492034	-2,943646	-3,598308	-4,830379	-5,731960	-1,831268	-2,001150
a1	0,325860	1,039550	1,055455	1,207806	1,282920	0,657230	0,703655
a2	0,575395	0,527502	0,589155	0,597300	0,625422	0,761493	0,738076

Values of α_1 and α_2 coefficients are positive in all calculations, however, while in sample below 500 the AI significance prevails, above 500 investment factor plays a greater role.

2. Hypothesis. Regression equation obtained based on panel data over the period from 2013 to 2016 (except for 2015 due to lack of data) looks as follows:

$$y = e^{\alpha_0} \cdot {x_1}^{\alpha_1} \cdot {x_2}^{\alpha_2}, \text{ where:}$$

y – volume of shipped goods of own production, works and services performed using own resources within range of small and micro-enterprises, RUR thousand;

x_1 – agglomeration influence of a settlement;

x_2 – average monthly wage of employees within full range of organizations, RUR;

α_n – coefficients.

As a result of calculations, a non-linear regression model was derived. The model was tested on several AI samples (Table 5). As the data show, standardized determination coefficient R^2 becomes significant only within AI sample exceeding 1,000. If sample length is reduced, standard error value decreases. However, lack of data on the volume of investment in small and micro-businesses does not allow a comparison with the model developed under hypothesis 2. Positive relation between agglomeration influence, reflecting the size and the availability of local market, and volume of goods shipped, works and services performed using own resources within range of small and micro-enterprises has been confirmed, which can be considered the main result. Thus, agglomeration effect positively influences small business sector, promotes its concentration in settlements with large population size or good transport accessibility.

Table 5. Model Calculations on Hypothesis 2

Sample by agglomeration influence	all AI values	AI above 100	AI above 200	AI above 300	AI above 500	AI above 1000	AI above 2000
Number of settlements in sample	410	310	260	211	154	64	31
Multiple R	0,533997	0,606737	0,614313	0,626803	0,654376	0,727127	0,760331
R-squared	0,285153	0,368130	0,377380	0,392882	0,428207	0,528714	0,578103
Standardized R-squared	0,284804	0,367722	0,376900	0,392306	0,427463	0,527234	0,575355
Standard error	3,792846	3,554805	3,522545	3,468349	3,384926	2,804965	2,102622
Observations	4100	3100	2600	2110	1540	640	310
a0	-24,74849	-33,28685	-35,42504	-36,60523	-38,24578	-38,97766	-32,00438
a1	1,090997	1,774731	1,801871	1,883855	1,968272	1,699246	1,610336

a2	2,428183	2,840608	3,037806	3,094721	3,189857	3,497509	2,889238

Thus, the main results are as follows:

– structuring of GP and AI indicators allowed to substantiate the existence of multidirectional trends in the spatial system of the region;

– GP and AI indicators can be used to assess transport isolation and inaccessibility of settlements in Yakutia, which, in long term, will allow to generate a number of indicators of economic security (resilience) of settlements in regions with low population density;

– correlation analysis of panel data at various time intervals allowed to substantiate that the AI indicator is in direct and significant correlation with the behavior of main indicators of economic activity, in contrast to the GP, which has previously been tested by a number of authors in regions of Russia with higher population density;

– a study of heterogeneity of economic activity was undertaken based on the Theil method. It has been substantiated that trends in spatial concentration of economic activity are largely determined by specialization and by connection with various dissimilar factors;

– the influence of agglomeration effect on production patterns of both large and medium-sized businesses, and small and micro-enterprises has been substantiated.

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