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Development of scientific framework to prepare resource regions in Russia for integrated subsoil use: Quantitative assessment

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Abstract. The degree of preparedness of Russia's resource regions for integrated subsoil use and transition to a balanced development model is revealed. The quantitative assessment has shown that regions dependent on natural reserves are the "locomotives of growth" and, for the most part, have medium and high economic potential. At the same time, the organization of mineral mining must be accompanied by a gradual transition to integrated development of subsoil, which includes efficient use and processing of natural resources. An important aspect of comprehensive exploitation of mineral reserves will be the localization of production in the regions capable to create conditions for the development of internal market and an interconnected economic space in Russia.

1. Introduction

Exhaustion of the traditional growth sources in resource regions dictates finding of a new model of sustainable development. Integrated subsoil use and efficient mineral wealth management are the main sources of balanced advancement. The scientific world has no common perception of resource regions. In the English-language literature, such regions are discussed as the *resource curse* or the *resource abundance* understood as the phenomenon of slower pace of development in countries holding ample natural resources as against countries which lack the environmental assets [1, 2]. Nonetheless, some researchers show that specialization of resource regions is in many ways dependent on the initial economic and institutional conditions as well as on the right-on regional policy accounting for both general regulations and local context [3–5]. The second approach is more sound and relevant, to this paper authors' opinion.

Resource regions have a special path of development, which is a stable replication of an enclave dual economy. This singularity shows itself as formation of a supernormal, isolated, highly productive and export-oriented sector represented by large vertically integrated mining and allied companies in a region. The export-oriented mining and processing sectors of industry concentrate increasingly much more resources, become and remain *engines* of economy in Russia, and, thus, govern, the economic development and place of the country in the global division of labor [6, 7]. Permanent and stable *replication* of enclaves rich in natural and mineral resources ends with extensive inefficient utilization of natural wealth and causes considerable environmental damage [7, 8]. The problem of supersession of the extensive economic development model in Russia is connected with the preparedness and of resource regions to pass on the sustainable development path [9].



2. Features of the region development in Russia

Russia is composed of regions extremely different in social and economic characteristics. For example, in terms of the research and development cost share in the gross products, mismatch of some regions reaches 143–148 times, while in terms of the application of the advanced production technologies, this gap exceeds 1000 times [10]. For this reason, it is important to find regions best prepared for transition to the sustainable development model and, moreover, to specify range of available development paths in every specific case. This requires rejecting a space-neutral approach and switch on to a place-based approach [11–13]. On the other hand, introduction of local context in the analysis of resource regions inevitably raises question on the limits and methods of its inclusion in economic research. It is unallowable that the place-based approach results in complete abortion of search for any general regularities. A way out is the type science which makes it possible to take into account qualitative and quantitative characteristics of resource regions.

Building typology (typological analysis) is a method of studying complex geographical and socio-economic objects with a view to revealing relevant uniform and distinct groups of objects characterized by a set of criteria or properties [14]. In this connection, we have analyzed data on 35 resource regions in Russia, selected within the previous researches [15].

For the economic potential evaluation of a region, index K_1 is calculated as a ratio of GDP per capita in the region to average GDP per capita in Russia. In the case under analysis, K_1 ranged from 0.26 (Republics of Ingushetia and Chechnya) to 11.2 (Nenets Autonomous Region).

Resource-dependence on regions was defined by the share of mining sectors in the regional GDP. The resource-dependence index is the index K_2 calculated as a ratio of mining industries in the regional GDP to a share of the mining industries in GDP of Russia. In the discussed analysis, K_2 ranged from 0.107 (Ingushetia) to 6.05 (Khanty-Mansi Autonomous Region).

Primarily, evaluation criteria were represented by linguistic variables (LV) with term-sets: economic potential {Te1—low, Te2—moderate, Te3—high} and resource-dependence {Tr1—weak, Tr2—moderate, Tr3—high}. The membership functions (MF) of the terms were the functions of triangular and trapezoid forms. Such MFs are advantageous for the least information required for their determinations as compared with other functions [16].

Table 1. Exact and fuzzy evaluation criteria per regions.

Region	Economic potential index K_1				Resource-dependence index K_2			
	Exact	T1	T2	T3	Exact	T1	T2	T3
Kursk	0.675	0.416	0.584	0	0.766	0.053	0.947	0
Nenets	11.24	0	0	1	6.01	0	0	1
Karelia	0.753	0.155	0.845	0	0.735	0.1	0.9	0
Ingushetia	0.261	1	0	0	0.107	1	0	0
Tatarstan	1.069	0	1	0	1.927	0	0.716	0.284
Tyument	1.407	0	0.741	0.259	1.291	0	1	0
Kemerovo	0.697	0.342	0.658	0	2.284	0	0.477	0.523
Krasnoyars Territory	1.273	0	0.908	0.092	1.562	0	0.959	0.041
Tyva	0.338	1	0	0	0.871	0	1	0
Khakassia	0.721	0.263	0.737	0	1.152	0	1	0
Tomsk	0.992	0	1	0	2.631	0	0.246	0.754

Table 1 gives a fragment of the analysis performed for the selected group of resource regions with initial (exact) and fuzziness (fuzzy values) indicators. In the fuzzy analysis, mismatch of objects can be calculated using the notion of confusing similarity of objects in some property. The similarity of objects A and B in a criterion is calculated from the formula:

$$d_{AB} = \frac{1}{2} \sum_{i=1}^k |\mu_{iA}(x) - \mu_{iB}(x)|, \quad (1)$$

where k is the number of terms in LV.

Table 2. Fuzzy clustering of resource regions (territories) by integrated subsoil use preparedness.

Economic potential	Resource-dependence		
	Tr1—weak (1; 0; 0)	Tr2—moderate (0; 1; 0)	Tr3—high (0; 0; 1)
Te1—low (1; 0; 0)	Readiness condition 1 Kalmykia (0.956); Ingushetia (1); Chechnya (1); Buryatia (0.671)	Readiness condition 2 Trasnabikalia (0.495); Buryatia (0.523); Kalmykia (0.044)	Readiness condition 3
Te2—moderate (0; 1; 0)	Readiness condition 5 Bashkortostan (0.717); Arkhangelsk (0.763); Volgograd (0.523); Kaliningrad (0.053); Buryatia (0.468); Karelia (0.1); Khabarovsk (0.734)	Readiness condition 8 Arkhangelsk (0.237); Volgograd (0.478); Transbaikalia (0.505); Irkutsk (0.56); Kaliningrad (0.25); Krasnoyarsk (0.726); Kemerovo (0.477); Tyumen (0.282); Kursk (0.947); Karelia (0.9); Belgorod (0.926); Murmansk (0.686); Irkutsk (0.78); Astrakhan (0.503); Samara (1); Perm (1); Bashkortostan (0.283); Buryatia (0.329); Tatarstan (0.765); Khakassia (1); Amur (1); Tomsk (0.591); Udmurtia (0.495); Khabarovsk (0.747)	Readiness condition 7 Astrakhan (0.497); Irkutsk (0.44); Komi (0.341); Tatarstan (0.549); Orenburg (1); Udmurtia (0.505); Kemerovo (0.523); Krasnoyarsk (0.267); Tomsk (0.845)
Te3—high (0; 0; 1)	Readiness condition 10 Khabarovsk (0.253)	Readiness condition 9 Belgorod (0.074), Krasnoyarsk (0.733), Magadan (0.285), Murmansk (0.314), Tatarstan (0.451), Tomsk (0.155), Tyumen (0.719), Khabarovsk (0.266)	Readiness condition 6 Krasnoyarsk (0.275); Magadan (0.715); Nenets (1); Komi (0.659); Sakha (1); Tatarstan (0.235); Sakhalin (1); Tomsk (0.409); Khanty-Mansi (1); Yamalo-Nenets (1); Chukotka (1)

Then, the mismatch of two objects in criteria n is found as follows:

$$r_{AB} = \frac{1}{n} \sum_{i=1}^n d_{AB} . \quad (2)$$

To find which cluster an objects belongs to, the distance between the object to a reference point r_j is calculated.

The grade of membership is found as:

$$Cl_j = 1 - r_j . \quad (3)$$

Table 2 reports clustering results of resource regions, and it is seen that one of potential clusters is empty. None of the regions appears in the cluster with weak economic potential Te1 (1; 0; 0) and high resource-dependence Tr3 (0; 0; 1). Only one region—Khabarovsk Territory—belongs in the cluster with high economic potential Te3 (0; 0; 1) and weak resource-dependence Tr1 (1; 0; 0) at the grade of membership 0.253. On the whole, this is reflective of the fact that resource regions in Russia are the *growth engines*—they mostly have medium and high economic potential. Vacancy of the second cluster implies than the enclave dual economic model gradually exhausts itself, and even high mineral production output is incapable to maintain high economic potential of regions.

In four out of nine clusters, there are clear top-level regions. The majority of the regions (22) concentrate in the cluster with moderate economic potential Te2 (0; 1; 0) and resource-dependence Tr2 (0; 1; 0). Moreover, this cluster accommodates regions with different dynamics and prospects of mining industries. For instance, this cluster embraces regions at the stage of exhaust of the old development model based on extensive mineral mining. These regions are Kemerovo (0.477), Krasnoyarsk (0.726) and Tyumen (0.282). In addition, this cluster holds regions developing new reserves: Khakassia (1), Amur (1), as well as regions with same traces of the model based on integrated subsoil development: Kursk (0.947), Belgorod (0.926), Tatarstan (0.765), Samara (1), Perm (1) and some other. It is interesting that these regions have different grades of membership in this cluster and fall within some neighbor clusters. This fact points at the feasibility for these regions to develop along a wide range of growth paths, which calls for additional quantitative assessment of preparedness of resource regions for transition to the sustained development model based on integrated subsoil management.

Table 3. Integrated subsoil development preparedness quantification of resource regions.

Region	Preparedness	Region	Preparedness
Tyumen	8.718505	Magadan	6.854531
Murmansk	8.314166	Volgograd	6.432392
Belgorod	8.07358	Komi	6.34095
Amur	8	Nenets AR	6
Perm	8	Sakha (Yakutia)	6
Khakassia	8	Sakhalin	6
Samara	8	Khanty-Mansi (Yugra)	6
Krasnoyarsk	7.958581	Chukotka	6
Kursk	7.841851	Yamalo-Nenetsk AR	6
Tatarstan	7.715557	Bashkortostan	5.84921
Karelia	7.701004	Kaliningrad	5.75
Irkutsk	7.560286	Arkhangelsk	5.709743
Astrakhan	7.502865	Transbaikalia	5.029613
Udmurtia	7.495099	Buryatia	3.365686
Kemerovo	7.477396	Tyva	2
Khabarovsk	7.284379	Kalmykia	1.043956
Tomsk	7.24589	Ingushetia	1
Orenburg	7	Chechnya	1

At the second stage of research, the integral index of regional preparedness for transition to sustained development based on integrated subsoil management is calculated. Table 3 offers the quantitative assessment of resource regions by their readiness to multipurpose subsoil use.

3. Conclusions

Evaluation of the economic potential of resource regions has disclosed their unequal preparedness for transition to sustainable development model. The main source of economical growth in these regions is mineral mining and processing industries. The integrated subsoil management conditions transition from the stage of mining and rough processing of minerals to deeper conversion and by-production. The main obstacle for projects capable to eliminate the enclave nature of a resource region economy is, first, readiness of the vertically integrated companies to implementation of such projects, second, technical preparedness of resource regions to create by-products, and, third, availability of infrastructure for such production.

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