Spatial development of Russia: the role of its Asian regions

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Abstract. We analysed the balance of environmental, social and economic development of the regions of Asian Russia, assessing the level of adjusted net savings. Using the selected indicators and the assessment of natural, social and production capital values, the typology of territorial production and resource structures of the regions of Asian Russia has been created. Based on the k-means method, using 'Statistica 12' software, the clustering and structural zoning by the ratio of natural, productive and human capital in the regions of Asian Russia was carried out.

1. Methods and Results

1.1. Balance of environmental-socio-economic development in terms of adjusted net savings

The basic concept, according to which the balance of the ecological-socio-economic development of the territory is determined, was formulated by us earlier [1,2]. It was shown that sustainability [2] (in the regional context – balance) is defined, in this case, as a non-negative derivative of the per capita net stock of natural resources and human heritage (both quantitatively and qualitatively). The calculation of sustainability for the regions of Asian Russia was made on the basis of the index of adjusted net savings for 1995-2017. As a result, three groups of regions according to the level of genuine savings (GS) were identified: low, medium and high [1,2].

The Republic of Buryatia is given as an example of calculations for the first group of regions with a low level of genuine savings; the rate and acceleration of change (1 and 2 derivatives) of these dynamics were revealed for it. In its initial form, the speed and acceleration of the indicator in question are insufficiently informative and difficult to analyse. This result is a consequence of the uncertainty of the annual dynamics. In order to address this weakness, a smoothing of the three-year moving average was carried out. In general, the rate of change of the smoothed GS dynamics shows that the sustainability of the ecological-economic system is observed in the period 2009 to 2016, when the indicator started to increase. Between 1995 and 2008, the rate of genuine savings declined each year, which does not meet the condition of system sustainability. The rate of acceleration characterises the rate of change of the indicator. The rate does not have a strictly increasing or decreasing trend, which also indicates that the system is unsustainable.
Khabarovsk Krai is given as an example of calculations for the second group of regions with an average level of GS. Compared to the regions of Asian Russia in the first group, the regions in the second group are characterized by smoother dynamics of the considered indicators, indicating a relatively steady, although insufficiently sustainable development of the regions of this group.

As an example of calculations for the third group of regions with an average level of genuine savings, Novosibirsk Oblast is given as an example. This group is characterized by a higher level of sustainability among the regions of the Asian Russia.

1.2. Typology of territorial production and resource structures (TPRS)
This typology was built as an enlarged typology of TPRS in relation to the following functions – active natural capital, productive capital and human capital. The Analytical Hierarchy Process (AHP) method and the triangular illustration method have been applied to construct this typology [1]. Using these methods, a typology of TPRS was constructed according to dominant or priority (one function with sub-functions), predominant (two functions with sub-functions) and balanced (three functions with sub-functions) types.

We examined the TPRS system and calculated the three types of capital for 27 regions from 2000 to 2018. Overall, a TPRS diagram (Figure 1) was created based on human, productive and natural capital data for the 27 regions of Asian Russia for 2018 (Table 1).

![Figure 1. TPRS diagram for active natural capital, productive and human capital, 2018.](image-url)
### Table 1. Human, productive and natural capital of the regions of Asian Russia in 2018.

| Regions of Asian Russia                  | Human capital | Productive capital | Natural capital | Human capital | Productive capital | Active Natural capital |
|------------------------------------------|---------------|--------------------|-----------------|---------------|--------------------|------------------------|
|                                          | in million RUB, in 2000 prices. | %                  |                 | %             |                    |                        |
|                                          | 1          | 2                  | 3               | 4             | 5                  | 6                      |
| **Ural Federal District**                |             |                    |                 |               |                    |                        |
| Kurgan Oblast                            | 114 134     | 111 388            | 2 832           | 50%           | 49%                | 1%                     |
| Sverdlovskaya Oblast                     | 1 054 217   | 980 673            | 60 583          | 50%           | 47%                | 3%                     |
| Tyumen Oblast                            | 762 833     | 3 996 658          | 983 718         | 13%           | 70%                | 17%                    |
| Including:                               |             |                    |                 |               |                    |                        |
| Khanty-Mansi Autonomous                 | 476 766     | 1 885 235          | 579 147         | 16%           | 64%                | 20%                    |
| Yamalo-Nenets Autonomous                | 148 817     | 1 748 259          | 359 100         | 7%            | 77%                | 16%                    |
| Chelyabinsk Oblast                      | 543 613     | 499 637            | 64 076          | 49%           | 45%                | 6%                     |
| **Siberian Federal District**            |             |                    |                 |               |                    |                        |
| Republic of Altai                        | 29 803      | 20 748             | 532             | 58%           | 41%                | 1%                     |
| Republic of Buryatia                    | 107 151     | 109 203            | 24 975          | 44%           | 45%                | 10%                    |
| The Republic of Tuva                    | 37 788      | 16 859             | 4 690           | 64%           | 28%                | 8%                     |
| The Republic of Khakassia                | 73 008      | 68 952             | 14 141          | 47%           | 44%                | 9%                     |
| Altai Krai                               | 400 496     | 161 926            | 17 940          | 69%           | 28%                | 3%                     |
| Zabaikalsky Krai                         | 123 745     | 145 372            | 26 306          | 42%           | 49%                | 9%                     |
| Krasnoyarsk Krai                         | 661 542     | 584 114            | 152 377         | 47%           | 42%                | 11%                    |
| Kemerovo Oblast                          | 444 726     | 457 708            | 107 677         | 44%           | 45%                | 11%                    |
| Novosibirsk Oblast                      | 429 907     | 414 306            | 208 690         | 41%           | 39%                | 20%                    |
| Omsk Oblast                              | 596 015     | 375 508            | 28 182          | 60%           | 38%                | 3%                     |
| Siberian Federal District                | 271 882     | 181 042            | 11 916          | 58%           | 39%                | 3%                     |
| Tomsk Oblast                             | 181 469     | 203 487            | 36 301          | 43%           | 48%                | 9%                     |
| **Far Eastern Federal District**         |             |                    |                 |               |                    |                        |
| Republic of Sakha (Yakutia)              | 187 348     | 351 494            | 129 711         | 28%           | 53%                | 19%                    |
| Kamchatka Krai                           | 52 085      | 83 504             | 5 031           | 37%           | 59%                | 4%                     |
| Primorsky Krai                           | 477 126     | 510 907            | 21 224          | 47%           | 51%                | 2%                     |
| Khabarovsk Krai                          | 276 365     | 268 082            | 23 001          | 49%           | 47%                | 4%                     |
| Amur Oblast                              | 140 835     | 172 240            | 15 189          | 43%           | 52%                | 5%                     |
| Magadan Oblast                           | 21 432      | 54 480             | 18 464          | 23%           | 58%                | 20%                    |
| Sakhalin Oblast                          | 114 637     | 454 670            | 143 379         | 16%           | 64%                | 20%                    |
| Jewish Autonomous Area                   | 32 727      | 37 099             | 2 190           | 45%           | 52%                | 3%                     |
| Chukotka Autonomous Area                 | 14 196      | 27 692             | 10 369          | 27%           | 53%                | 20%                    |

Using the above methods, we have charted the distribution of regions in Asian Russia according to the proportion of active natural capital, production capital, and human capital. The diagram clearly shows the predominance of human capital in all regions, a small share of active natural capital, and a large dispersion of regions in terms of productive capital. Clustering and structural zoning by ratio of natural capital, production capital and human capital.
1.3. Clustering and structural zoning of regions according to the ratio of natural, productive and human capital

Based on data on natural, productive and human capital, the 27 regions were clustered into five groups in 2018. The clustering of the regions of Asian Russia (27 regions) was made according to three characteristics:

- Human potential;
- Productive potential;
- Active natural potential.

Clustering was carried out using the $k$-means method with “Statistica 12” software. The clustering was carried out according to the following parameters:

- number of clusters: 5;
- initial set-up of the cluster centres: random;
- distance between points: Euclidean.

All data were normalised for adequate clustering. The quality of the constructed cluster models of the regions was assessed by the criteria of analysis of variance (parametric F-criterion and Kruskal-Wallis ranking criterion). According to the F-criterion, the differences between the cluster mean values of the regions are highly significant (at the $p_F$ level $< 0.0005$). The small sample size of the clusters suggests that the results obtained are controlled for by the Kruskal-Wallis rank test [3]. Thus, the distribution of regions into clusters is significantly heterogeneous in terms of these indicators.

The first cluster includes the seven largest industrial regions with a high level of personal income and economic potential (Krasnoyarsk Krai, Irkutsk Oblast, etc.)

The second cluster includes regions with an average level of human, industrial and natural potential (Republic of Sakha (Yakutia), Tomsk Oblast, Khabarovsk Krai, etc.)

![Figure 2. Regionalisation of the Asian part of Russia by identified clusters.](image-url)
The third cluster is characterised by the least typical pattern: the highest involvement of active natural capital and a high level of production potential. The third cluster includes three regions that are leaders in oil production not only in the Asian part of Russia, but in the entire Russian Federation: Tyumen Oblast, Khanty-Mansiysk Autonomous District-Yugra, Yamal-Nenets Autonomous District. The human potential is slightly lower than that of production and natural resources, although it is at a high level.

The fourth cluster includes regions with relatively low levels of human, industrial and natural capital (Buryatia, Zabaikalsky Krai, etc.).

The last fifth cluster comprising 6 regions, is characterized by the lowest values in all three indicators: human, industrial and natural capital (Kamchatka Krai, Chukotka Autonomous Okrug, etc.). Figure 2 presents a map of the distribution of regions in the identified 5 clusters.

2. Conclusion

In this study, we have used the basic approaches to the assessment and analysis of natural and social objects in the studied territory. We define balanced regional development as a process supported by a complex of natural, economic and social factors and conditions. It is this basic concept that determines the balance of environmental, social and economic development of the territory. These factors and conditions – both external and intra-regional – form an integrated environmental-socio-economic development at the meso-level. They also regulate the process of preserving and creating a favourable natural environment, increasing the level of economic development of the territory and the quality of life of the population.

Based on the developed system of indicators (and relevant statistical information on spatial development) the analysis and assessment of the transformation of socio-economic development of Asian Russia and adjacent territories were carried out, taking into account the balance of regional development. Dependence between the level of true savings and regional specialization was determined. On the basis of the obtained estimates of natural, human and productive capital the typology of TPRS was built. Based on the \( k \)-means method, using ‘Statistica 12’ software, the clustering and structural zoning by the ratio of natural, production and human capital in the regions of Asian Russia was carried out.

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