

The effect of imbalance in resource management on regional social economic development

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Abstract. Socio-economic consequences in oil-producing regions are defined by the balance in subsoil use developed under the influence of different factors. The research hypothesis suggests that imbalances in resource management, the key criterion of which is a balance between reserve addition and oil recovery, differentially influence the social and economic development of the regions involved, the choice of which is conditioned by similarity of geologic, industrial and economic criteria. The research methods are descriptive statistics, variance analysis (ANOVA), Cobb-Douglas regression function, Data Envelopment Analysis with MPI (Malmquist productivity index). The research results have shown that the part of reserve addition and oil recovery in per capita gross regional product vary from negative to positive, which is explained by the degree of depletion and exploration of a field and is a result of the effect of existing institutional environment. According to the DEA method, the efficient boundaries are formed by the Russian Federation entities where the potential of oil-and-gas industry has not been fully used as a driving force of socio-economic development, which is supported by the results of the Cobb-Douglas regression model and variance analysis. The research results are an additional confirmation of interregional imbalance in socio-economic development, one of the factors of which is an imbalance in resource management.

1. Introduction

Depletion of the mineral resource base is one of the key challenges not only in regional sustainable long-term economic growth (figure 1) but also a factor contributing to “differentiation of regions and municipal entities at the levels and rates of socioeconomic development”, which constitutes the problem of the constant addition of mineral resource base (MRB).

Moreover, regional addition processes differ quantitatively and qualitatively, which is conditioned by not only the natural factor of MRB availability but also the existing institutional and macroeconomic environments. This, as a whole, misbalances resource management functioning, which, in turn, has a negative effect on the sustainability of regional development.

It is worth noting that balanced resource management is a multidimensional process, including the solution of a complex of interrelated problems (legislation, engineering, economic, environmental, etc.), and, as a consequence, in research and legislative areas, there is a wide range of investigations and interpretations, the imperative of which is the necessity of a balance between:

- addition and production of mineral resources [1];
- consumption, export, and forced import of minerals, which is achieved by timely addition and rational use of mineral resources [2] that allows meeting the demands of the domestic market;



- public interests and resource management interests in subsurface management, which is, by no means, important for local communities and observation of their rights for high life standards [3];
- state interests and resource management interests in the distribution of revenues from resource management on the objective economic basis [4];
- restrictive measures and finance-economic stimulation [5];
- natural resource intensity (production) and environmental technology intensity of the region, i.e. the key reference is environmental safety in resource management achieved with exclusion of excess in technogenic load over environmental technology intensity, which reflects self-renewing potential of the regional natural system [6];
- general development factors (resources, economic, social, and environmental) in a definite region and their use in accordance with strategic and tactic objectives of interregional development and geopolitics, programs of regional social and economic development management focused on the assessment of mineral and fuel resource provision, social stability, economic growth, and environmental safety in a region to achieve sustainable development, which is the basis for resource management to support the reasonable interaction of human activity and the environment [7, p. 240].

The authors rely on the latest definition and suppose that the basis for balanced resource management is addition processes, including mineral resource exploration and production as well as its dynamics defining the rates of socioeconomic development. The aim of the research is a comparative analysis of this phenomenon in different regions.

This research is a part of the continuous investigation, as a result of which, the imbalance in resource management has been explained in historical-geologic, regional, industrial, engineering aspects, leading in general to territorial differentiation of development [8]. It has been revealed that a destabilizer of the balance is a mineral extraction tax incentive for oil recovery that, together with prices in the world market of hydrocarbons (HC), contributes to declining addition processes in the investment cycle, which is particularly evident in Tomsk Oblast [9].

2. Materials and methods

The statistical data for the research is official information of the Federal Agency in Resource management (Rosnedra) and its local offices, The Federal State Statistic Service for the chosen RF regions over 2008-2018. The choice of the RF oil-producing regions for study (the Tatarstan Republic (TR) and the Udmurt Republic (UR) and Komi Republic (KR), Samara (SO) and Tomsk (TO) Oblasts) is based on geological, economic, and industrial criteria. The main input indicators (resources) are oil reserve addition (ORA) and oil recovery (OR), whereas the output ones (results) are GRP per capita (GRP_{pc}) reduced to the level of 2008 adjusted for inflation.

The research methods are as follows.

- The descriptive statistical method that additionally supports the results of empirical analysis.
- Variance analysis allowing us to study heterogeneities of resource management indicators in the regional aspect and compare ORA and OR in each region.
- A two-factor model of the Cobb-Douglas production function [10] that allows estimating the contribution of each resource to the development of socioeconomic indicators within the research period (temporary approach):

$$GRP_{pc} = \gamma(ORA)^\alpha(OR)^\beta \quad (1)$$

linearized by taking logarithm for further use of the least square method as a way to estimate the parameters of production function:

$$\lg(GRP_{pc}) = \lg\gamma + \alpha\lg(ORA) + \beta\lg(OR) \quad (2)$$

where γ is the technological coefficient showing the influence of unaddressed factors, in addition to the chosen ORA and OR per GRP_{pc} , in particular, the influence of regional economy differentiation. In this case, the higher the γ value, the more the effect is; α and β are

elasticity coefficients, interpretation of which is traditional: when increasing the ORA and OR values by 1%, the GRP_{pc} values increase by α % and β %, respectively, in this case, if $\alpha > \beta$, the value of GRP_{pc} has the greatest effect on ORA and, vice versa, that allows for conclusion on necessity of growth in volumes of this or that resource.

- The DEA method [11] allows for comparison of the RF regions based on statistical technical efficiency (TE) that is a generalized efficiency and indicator per a year (spatial approach), and dynamic efficiency estimating the changes (decrease, constant state, or increase) in function efficiency over the research period by Malmquist productivity index, MPI [12] (temporary approach).

Calculations were carried out using the DEAP and STATISTICA software [13].

The comprehensive application of these methods allows us to draw a more concise and generalized conclusion, despite the lack of facts about regional statistics, which is constantly faced by the researchers.

3. Results

In terms of the resource base, small, very small and medium-size fields are predominant in all regions, though major fields characterized by the late stage of their development still make up a high share of the recovery. The number of small and very small fields discovered in recent time is increasing, and this trend gives the reason to consider the development prospects of oil and gas industry with due regard to these fields in Volga Federal District characterized by the highly-developed industrial infrastructure. Tomsk Oblast and the Komi Republic are regarded as regions with high resource potential, with new fields expected to be discovered (table 1); however, the transport and industrial infrastructure fail to reach the appropriate standard. Currently, the additions to reserves result from the extension of the fields and new assessment methods applied.

Oil and gas sector plays a key role in the industrial development of the above-mentioned regions. The balance criterion in the system of mineral resources management is based on the correlation between hydrocarbon recovery and replenishment, and it is this criterion that determines many socioeconomic effects in the regions.

According to the data obtained via descriptive statistics and empirical analysis methods, in all regions, there is an obvious imbalance between the dynamics of ORA and OR (figure 1), which is predictable, taking into account the extent of exploration and reserves depletion. In the Republic of Tatarstan and Samara Oblast, the ORA dynamics is more stable, whereas in Tomsk Oblast, there has been a negative trend since 2011 and, consequently, in 2018, the OR value was 7.5 times as much as the ORA value. There is also a significant difference between the dynamics of the ORA and OR values in the Udmurt Republic and the Komi Republic, though the trends change slightly.

According to the data obtained via analysis of variance (figure 2), it should be noted that:

- firstly, the differences between the ORA and OR values in different regions are highly significant ($p < 0.001$), in particular, the OR value in Samara Oblast, on the one hand, is lower than that in the Republic of Tatarstan, and the difference is highly significant; on the other hand, this value is higher than that in Tomsk Oblast, again with the highly significant difference. The ORA value in the Republic of Tatarstan is higher than that in the Udmurt Republic and the Komi Republic, with the highly significant differences (in particular, $p = 0.0064$ in the latter region);
- secondly, the differences between the ORA and OR values within one region (except for Samara Oblast) are not statistically significant ($p > 0.10$), which results from volatility of ORA in relation to that of OR over the 11-year period of record. As for Samara Oblast, the ORA value is higher than the OR value, with the highly significant differences ($p = 0.0013$).

The results of comparative analysis based on the Cobb-Douglas production function are as follows:

- the technological coefficient is high (> 1.5) in all regions;
- the share of ORA in the GRP_{pc} is higher than that of OR in the Komi Republic and the Udmurt Republic (figure 3), whereas, in the other regions (the Republic of Tatarstan, Samara Oblast,

and Tomsk Oblast), the share of ORA in the GRP_{pc} is lower than that of OR, which can be explained by: firstly, the low extent of exploration in the Komi Republic (47%); secondly, the geological survey efficiency that is high in Samara Oblast and relatively low in Tomsk Oblast and the Republic of Tatarstan; thirdly, the rate of reserves depletion ranging between 60 and 85% in Privolzhsky Federal District; and finally, the share of oil and gas sector in the regional industry;

Table 1. Characteristics of Oil Reserves (dated on January 01, 2019).

Constituent entity of the RF	Oil reserves, categories A+B+C ₁	Number of oil and gas fields	Major fields of the constituent entity	Share of resources recovered within major fields of the constituent RF entity, %	Number of discovered fields over the period from 2008 to 2018	Coefficient of resource additions over the period from 2008 to 2018	Share of hydro-carbon recovery in GRP _{pc} , %
Komi Republic	551.831	152	Yaregskoye oil field Usinskoye oil field Vozeyskoye field	53.0	20	1.28	37.2
Republic of Tatarstan	908.739	209	Romashkinskoye field Novo-Yelkhovskoye field Bavlinskoye field Arkhangelskoye field Akanskoye field Ashalchinskoye field The Steпноzerskoye field	37.8	24	1.03	21.3
Udmurt Republic	321.471	135	Chutyrsko-Kiengopskoye Mishkinskoye Yelnikovskoye Karsovayskoye	46.4	14	0.97	23.1
Samara Oblast	537.364	376	Borovskoye	7.34	93	1.9	15.3
Tomsk Oblast	332.113	134	Krapivinskoye Sovetskoye Luginetskoye Pervomayskoye Dvurechenskoye	34.1	26	1.25	27.2

- in Samara Oblast and the Komi Republic, there is a positive mutual impact of ORA and OR; in the Republic of Tatarstan and Tomsk Oblast, geological survey (according to the data obtained) is far from being complete. In Tomsk Oblast, the geological survey can be improved due to the currently limited extent of exploration (58%), and in the Republic of Tatarstan, the large scale exploratory work and resource depletion are expected to result in probable imbalance. However, this is the region where the fields with hard-to-recover reserves are developed, which causes a significant share of resource recovery in the GRP_{pc}.

Therefore, the definition of sustainable mineral resource management, which is proposed by I.G. Polyanskaya and V.V. Yurak and implies a confluence of factors to be taken into account, is quite adequate to the results obtained.

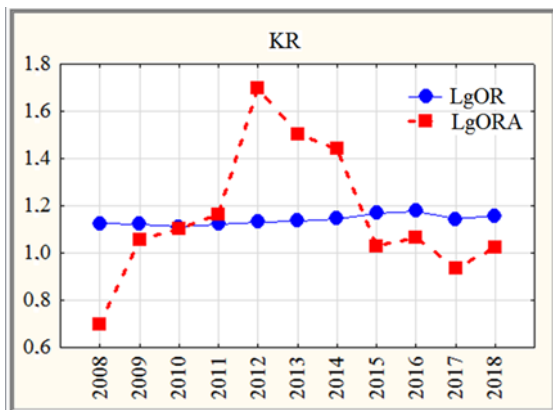


Figure 1. ORA and OR trends in the Komi Republic over the period from 2008 to 2018.

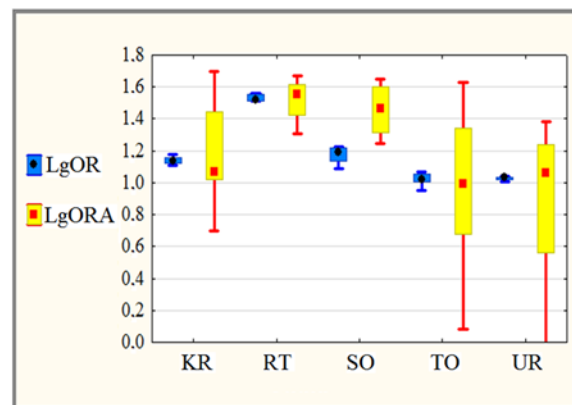


Figure 2. Box-and-whisker plot for OR (mln tons) and ORA (mln tons) in the regions (the point denotes the median, the box -, the interquartile range of 25%-75%, and whickers - the minimum and maximum of all of the data).

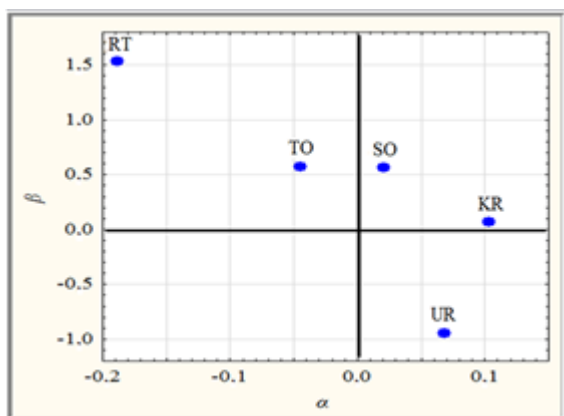


Figure 3. Cobb-Douglas production model.

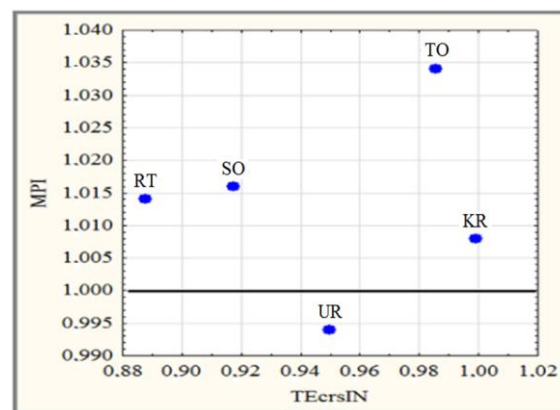


Figure 4. DEA-model designed to minimize costs for OR and ORA with the fixed GRP_{pc} value.

DEA method was applied to analyze models specified for:

- input (figure 4), when the regions are estimated in terms of minimizing the costs (for OR and ORA) with the fixed GRP_{pc} value;
- output, when the regions are estimated in terms of maximizing the GRP_{pc} value with the fixed costs (for OR and ORA).

The results obtained via the first model have indicated that the Republic of Kazakhstan and Tomsk Oblast that have the lowest costs for OR and ORA per unit of GRP_{pc} are the most effective in their performance. There is a downward trend in the performance efficiency in the Udmurt Republic over the period of record, which makes it an exception among the other regions. The results obtained via the second model, which was designed to estimate the regions in terms of maximizing the value of GRP_{pc} with the fixed costs (for OR and ORA), have indicated that the highest efficiency rates characterize the performance of the Udmurt Republic, Tomsk Oblast, and the Komi Republic.

4. Discussion

To provide an adequate interpretation of the outcomes, it is important to answer the following questions: what indicator, criterion or value provides evidence of imbalance in the resource management, which, in turn, leads to negative socioeconomic effects.

In our opinion, such criteria are as follows.

- Relatively stable share of ORA and OR in the GRP_{pc} , i.e. the amount of the recovered oil is compensated for by the amount of reserve additions, which ensures a relatively stable share as both geological survey and oil recovery result in value creation. None of the regions under the study can be characterized by such stability. Moreover, in the Republic of Tatarstan, the Udmurt Republic, and Tomsk Oblast, there have been both negative and positive impact because the amount of oil increased, whereas the amount of reserve additions failed to rise sufficiently.
- The positions of the regions on the efficiency map, which can remain the same or alter over the period of study. The research results indicate that the Republic of Komi, the Udmurt Republic, and Tomsk Oblast have the highest values of the technological coefficient: 2.35, 3.171, and 1.857, respectively. These regions also make up the efficiency frontier or occupy the positions within the immediate vicinity, which indicates the minimum required amount of OR and ORA for GRP_{pc} . However, in our opinion, this reflects the untapped potential of the region because, comparing the data on the role of oil and gas sector in the industrial development of the regions, one can expect that it is the Republic of Tatarstan and Samara Oblast which should have the highest values of the technological coefficient due to the diversified regional economy (table 1). Despite this fact, the greatest share of OR and ORA is characteristic for the Republic of Tatarstan and Samara Oblast, although the technological coefficient is lower than in the other constituent RF entities.
- It is worth noting that the data obtained via empirical analysis and DEA methods are controversial because, in terms of efficiency, the leaders are the regions where, according to the empirical data and the data obtained via analysis of variance, there is a great imbalance in the resource additions. It seems that such a controversy results from the DEA method that is based on the efficiency postulate. However, this can also be interpreted as a significant impact of the oil and gas sector on socioeconomic development.

5. Conclusion

The research outcomes indicate that there is a significant imbalance in the regional systems of resource management, which results in a great impact of the upstream (geological survey and oil and gas recovery) on socioeconomic indicators. Tomsk Oblast that was considered an outsider according to the previous research can be regarded as a region where the first stage in the technological process of exploration-recovery-processing-downstream sales has the most significant impact on the socioeconomic development. However, the untapped potential indicates that, in general, oil and gas sector failed to become a key factor (unlike in the Republic of Tatarstan and Samara Oblast) and plays a minor role in the economic development of the region.

Acknowledgements

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