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EVALUATION METHODS OF REGIONAL TRANSPORT SYSTEMS PERFORMANCE EFFICIENCY

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Abstract

The article considers the problems of the evaluation of the regional transport systems (RTSs) performance efficiency. A technique for its evaluation based on the Data Envelopment Analysis has been provided. The authors proposed an approach to the separation of similar RTSs for the comparative evaluation of their effectiveness. The cluster analysis and the data envelopment analysis were the main methods for the processing of statistical data on the activities and effectiveness of RTSs. An approach to the formation of a set of input and output parameters for RTS analysis and the principle of separation of RTS clusters in Russia have been provided, the methods of the evaluation of RTS functioning efficiency have been developed, which provide for the comparison of RTSs in the context of subjects and sub-sectors. The methods were tested on the basis of Russian RTSs: 5 RTS clusters have been distinguished, on the example of one of which the calculation of RTS efficiency has been shown; upon the results of the study, the authors emphasized the problems of collecting and processing of statistical data distributed by the Federal State Statistics Service of Russia, and also pointed out the principal features of the methods proposed to adapt flexibly to the challenges and the basic data of the study.

Keywords: **Regional Economy, Regional Transport System, Efficiency, Cluster Analysis, Data Envelopment Analysis**

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INTRODUCTION

The issue of the effectiveness and efficiency of the functioning of regional transport systems (RTSs) is one of the principal strategic transport management issues at the regional level [1]. Strategic planning and control in any system, including the regional transport system, should include the aspects of risk and efficiency of the object functioning, which will identify the targets for which it is required to operate under high-risk conditions at certain moments [2].

The level of RTS efficiency is determined by many parameters, covering its resources, costs and results of its functioning. Aggregate evaluation for object operations could not be done due to local effectiveness parameters. The integrated index calculation based on weighting factors is also impossible because efficiency factors had varied significance in different RTSs [3-5].

Comparative evaluation of Russian RTSs efficiency could not be processed correctly because of the large quantity of the regions [6,7], which involves the clustering of RTS upon the scope of their activities. We propose to use a DEA method (Data Envelopment Analysis) to evaluate the similar in the nature of operations and the level of economic

risk regions of single cluster.

The Data Envelopment Analysis is a quantitative analysis method for measuring performance efficiency of homogeneous economic system elements. Due to the analysis, the studied objects are described by a set of input and output parameters. Input parameters characterize their potential and resources, while the output parameters show the results of RTS activities.

A comparison of RTSs on efficiency level can be presented by using a concept of pareto-optimality by the following criteria – minimization of resources and maximization of results. The best regional systems are those, which simultaneously have fewer resources and maximum results. As for pareto-optimality, the best entities are those located on the pareto-optimal border. An objective to improve their performance can be formally described as a desire of each entity to take a position on the pareto-optimal border. This objective can be reached by reducing costs (an input-oriented model) – in this case, the result is the same and the value of resources is reduced; or by maximizing the effect (an output-oriented model) – the resources remain the same, the result is increased.

To calculate RTS performance efficiency ratios, the authors used a software program "KonSi Data Envelopment Analysis for Benchmarking", involving three stages of evaluation techniques [8]. For the purposes of our study, this technology has been modified in the method of RTS functioning efficiency evaluation by using a DEA method.

METHODS

To calculate the level of RTS performance efficiency, it is proposed to use a modified methodology for evaluating the efficiency of RTS activities by using the Data Envelopment Analysis (DEA) (Figure 1).

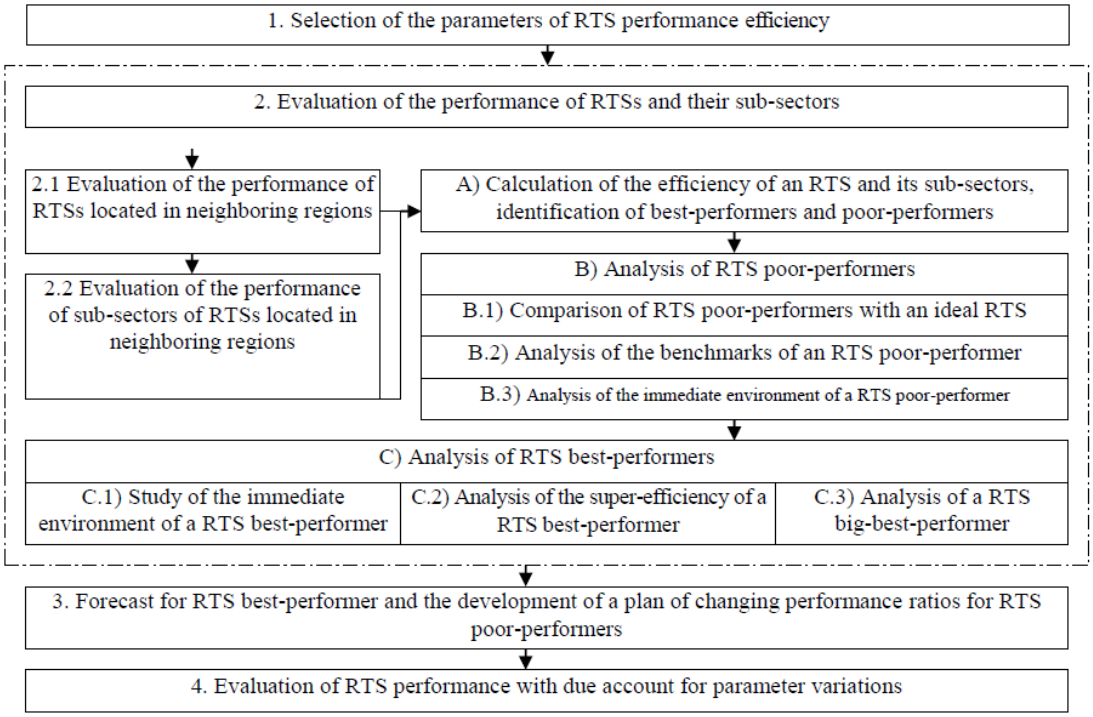
Input parameters (RTS resources or costs) and outputs parameters (RTS performance results) had been used to calculate the efficiency. The selection of input and output parameters of RTS performance efficiency, implemented at the first stage, takes into account the following features:

- The form of conducting the Data Envelopment Analysis includes a mathematical representation of the task, which leads to the use of quantitative indicators designating the different aspects of resource provision and RTS performance results;
- In calculating, it is possible to use different dimensions data, so the initial information does not need to be normalized;
- At the regional level, the problem involves the availability and completeness of the information, as well as its compliance with the object of study.

The pareto-optimality principle implemented in the calculation allows applying two approaches – to minimize resources (costs) and maximize results. The calculation of

the pareto-optimal border is performed using specialized software and on the basis of the data of RTS performance included in a particular cluster.

Figure 1: Methods of the evaluation of RTS performance efficiency by conducting the Data Envelopment Analysis.



The activities of each RTS are aimed at reaching the position on the pareto-optimal border. The efficiency is determined by the deviation of the RTS position from this border, which is calculated, based on the values of input and output parameters of a particular set of objects. At the level of regional economy, in case of application of an input-oriented model, a reduction of a number of resources is required, but in some cases it is impossible. Therefore, we propose to use for RTSs an output-oriented model, which focuses on a more efficient use of resources, without increasing their volumes.

Let us consider a set of basic concepts of DEA proposed by Kosterin [8], followed by the economic interpretation in the context of tasks to be solved:

1. A best-performer (efficient unit) is an RTS that works to maximum effect as compared to RTS included in the same cluster.
2. A poor-performer (inefficient unit) is an RTS, the activities and the use of resources of which are inefficient as compared to RTS best-performers included in the same cluster.
3. An ideal or a target is a hypothetical RTS located on the pareto-optimal border. This RTS is formed individually for each RTS poor-performer. In order to increase the efficiency and achieve the position on the pareto-optimal border, a poor-performer should perform its activities in the same way as its ideal does and

in compliance with benchmarks.

4. A benchmark, peer or a reference point is an RTS best-performer, which is involved in the construction of a linear combination of the ideal (target) for a RTS poor-performer.
5. Efficiency ratio is a parameter that serves as a measure of comparison for all RTSs of the cluster.
6. Super efficiency is a parameter describing the advantages of a RTS best-performer towards the rest of RTS best-performers of the cluster. This parameter is used to compare the best-performers against each other. An ideal/target of the RTS best-performer shows, whether it is possible and, if so, to what extent, to "decrease" the parameters of RTS performance, so that it remains a best-performer.
7. Reference set frequency of a best-performer is a number of RTS poor-performers, for which the RTS-best-performer under study is a benchmark model. A large number of references show that this RTS is an actual best-performer, not an accidental one.

At the first stage of methodology (Figure 1) to calculate the RTS performance efficiency, the following parameters were selected for our study:

1) Input parameters:
    - investment resources;
    - human resources;
    - fixed assets;
    - density of land transport routes;

2) Output parameters:
    - GRP produced by a regional transport system.

Publicly available information makes it possible to analyze the efficiency of the performance of regional transport systems based on a "resource" concept of efficiency. A cost-push concept of performance calculation requires obtaining further information on economic entities of an RTS, which would require a separate structural element in the system of monitoring of the RTS strategy, which will allow analyzing the effectiveness of measures on RTS development. Data for each of the parameters are collected over several years, which, firstly, make it possible to conduct an analysis for several dates, secondly, it would enable the forecast of these parameters [9-11].

The second stage (Figure 1), conducted in the context of two areas, covers the evaluation of the performance efficiency of RTSs and their sub-sectors for each of these areas. Let us consider in detail each of the sub-stages of evaluation of the RTS efficiency.

Since in the study only basic data differ at two stages, then we will consider the items A, B and C (Figure 1), which have actually been calculated by the same method of calculation.

A) Calculation of RTS efficiency and identification of best-performers and poor-performers. The RTSs under study are analyzed by DEA to calculate the efficiency of their performance. The calculated values of the level of efficiency allow to divide all RTSs under study into best-performers and poor-performers for further study.
The analysis of poor-performers is performed in item B) and the study of best-performers is conducted in item C).

B) An analysis and evaluation of the efficiency of a poor-performer.

Quantitative lagging of a RTS poor-performer is measured and evaluated with respect to the effectiveness of the cluster best-performers. The evaluation involves calculation of the difference between the indices of the poor-performer and indices of a benchmark RTS and best-performers. In addition, the study includes the analysis of immediate environment of an RTS poor-performer, which allows identifying the pros and cons of similar RTSs, which do not appear on the pareto-optimal border, but could be closer to this border on various parameters. Under this item the following measures are taken:

- Comparison of an RTS poor-performer with an ideal RTS. There can be two key reasons for the discrepancy of parameters of an ideal RTS and RTS poor-performer: a) RTS uses its resources inefficiently; b) more resources than required have been directed in the existing projects. In order that an RTS poor-performer could reach parameters of the corresponding ideal, it is necessary to rebuild the resource utilization technology;
- Analysis of benchmarks of an RTS poor-performer. The benchmarks involved in the formation of the ideal for the RTS poor-performer, are actual examples of RTSs with efficient performance;
- Analysis of the immediate environment of the RTS poor-performer, which is performed as follows: for each RTS benchmark, the list of all RTS poor-performers, which mention it as a benchmark, is compiled; for all benchmarks of the poor-performer under study, it is necessary to compare the compiled lists of RTS potential competitors and distinguish any entities among them that are found in all the lists: a poor-performer, the benchmarks of which are the same as those of the RTSs under study, will be an obvious competitor; as for the regional economy, the geographical location of the entity should be added; for all identified RTS competitors it would be required to find ideals and to compare them with the ideal of the poor-performer under study; if the competitor's ideal and the ideal of the poor-performers under study have similar values of parameters, such competitor will be considered a direct competitor for the poor-performer.

C) Analysis of the RTS best-performer. To compare the selected best-performers with each other, it is advisable to study the competitive environment of each best-performer and evaluate its super efficiency:

- Research of the immediate environment of the RTS best-performer. In order to study the immediate environment of the RTS best-performer, a concept of its reference is used – a number of RTS poor-performers which mention the best-performer as a benchmark. The calculation of the reference index for each RTS best-performer allows dividing them into "actual" and "accidental" best-performers. The following procedure is proposed to identify immediate competitors of the best-performer: compiling a list of all poor-performers, which refer to the best-performer under study; the ordering of this list by efficiency and significance of contribution of the best-performer's indicators to the ideal of a poor-performer;
- Analysis of the RTS best-performer's superefficiency. At this stage, the remoteness of the best-performer from the nearest RTSs is evaluated. Superefficiency reflects the benefits of the best-performer under study compared to the nearest RTS competitors;
- Analysis of big-best-performers. Among RTSs under study, we can find RTSs which cannot be compared to other entities, so-called big-best-performers. Their properties are different in that they cannot reach an ideal RTS and we cannot calculate a numerical value of superefficiency. In most combinations, big-best-performers are characterized either by a minimum value of the input parameters or by the maximum value of the output parameters compared to other RTSs. The following procedure should be used in the analysis of big-best-performers: an analysis of reference of a big-best-performer; an analysis of citing leaders.

The third stage of methodology (Figure 1) involves forecasting of parameters for RTS leaders and development of a plan for changing performance parameters for RTS poor-performers. After analyzing the position of each RTS, a plan for changing parameters for RTS poor-performers is developed in order to achieve the pareto-optimal border.

Forecasting of the basic parameters is performed for RTS leaders. This allows calculating their efficiency and a position in the space of various factors, provided that poor-performers change their activities some way or other.

The fourth stage of methodology involves the evaluation of efficiency of RTS performance with due account for changed parameters.

The state of the RTS cluster is evaluated on the basis of the expected changes in future activities of all entities. In case if no changes in RTS activities were proposed to increase their efficiency, then re-planning of improvements and evaluation of their effectiveness are performed.
The logic of the interaction of DEA analysis procedures under study in the evaluation of the RTS performance efficiency is supported by the software program KonSi – DEA Analysis [8].

RESULTS

To compare the efficiency of RTS performance, five clusters of Russian RTSs by using a method of k-means, which were similar in the composition of internal entities, have been primarily distinguished. Clustering was conducted upon 14 normalized parameters characterizing the volume of transport activities in the regions. The distinguished clusters were described upon the following features: high-volume RTS, investment RTS, capital-intensive RTS, poorly performing RTS, undeveloped RTS. Let us consider the efficiency of the performance of RTSs of the first cluster – high-volume RTSs. Then we will evaluate the performance efficiency of RTSs of each cluster. For calculation, the above parameters have been used.

The first cluster included basically regional transport systems of Siberia, the Moscow Region and some border regions (the Yaroslavl Region, the Rostov Region), through which in-transit cargo is transported. In the first cluster, 5 leaders have been distinguished – they retain their positions regardless of the selected analysis model (Table 1).

Table 1: Performance efficiency indicators of RTSs of the first cluster, the fact and forecast (high-volume RTSs) (calculated on the basis of [12-15].

RTSs of a territorial entity of the Russian Federation	**RTS performance efficiency**		**Efficiency based on the inclusion of superefficiency indicators in the model**	
	Fact	**Forecast**	**Fact**	**Forecast**
	Input-oriented model			
Voronezh Region	0.83	0.73	0.83	0.73
Kemerovo Region	0.824	0.84	0.824	0.84
Krasnoyarsk Territory	1.0	1.0	4.175	3.17
Moscow Region	1.0	1.0	1.521	1.51
Nizhny Novgorod Region	0.79	0.89	0.79	0.89
Omsk Region	1.0	1.0	3.802	big
Perm Territory	0.957	0.57	0.957	0.57
Republic of Bashkortostan	0.882	0.85	0.882	0.85
Republic of Tatarstan	0.745	0.85	0.745	0.85
Rostov Region	0.524	0.62	0.524	0.62
Sverdlovsk Region	0.676	0.88	0.676	0.88
Tumen Region	1.0	1.0	big	1.0
Chelyabinsk Region	0.618	0.72	0.618	0.72
Yaroslavl Region	1.0	1.0	1.452	1.52
	Output-oriented model			
Voronezh Region	3.679	2.67	3.679	2.67
Kemerovo Region	1.465	1.45	1.465	1.45

Krasnoyarsk Territory	1.0	1.53	big	1.53
Moscow Region	1.0	1.0	0.674	0.674
Nizhny Novgorod Region	1.479	1.79	1.479	1.79
Omsk Region	1.0	1.0	big	big
Perm Territory	1.069	1.86	1.069	1.86
Republic of Bashkortostan	1.126	1.26	1.126	1.26
Republic of Tatarstan	1.525	1.25	1.525	1.25
Rostov Region	2.4	2.22	2.4	2.22
Sverdlovsk Region	2.341	2.34	2.341	2.34
Tumen Region	1.0	1.0	0.086	0.086
Chelyabinsk Region	4.655	2.55	4.655	2.55
Yaroslavl Region	1.0	1.0	big	big

It should be noted that the most effective RTSs are those, which are included in resource areas with well-developed mining industry, which is now the "backbone" of the Russian economy. The effectiveness and efficiency of the RTS of the federal subject have an influence on transport.

The calculation of efficiency upon the minimization model with due account for superefficiency revealed one big-best-performer – the RTS of the Tyumen Region.

The maximization model revealed the same RTS leaders, indicating their effective performance both in resource utilization and in increasing and optimization of results. However, the model of maximization of results revealed three big-best-performers: the RTS of the Krasnoyarsk Territory, the RTS of the Omsk Region, and the RTS of the Yaroslavl Region.

Let us consider one of the poor-performers of the cluster – the RTS of the Kemerovo Region. Upon the results of the efficiency calculation by using the input-oriented model, the RTS of the Kemerovo Region could achieve the pareto-optimal border, if it achieved the same result by using fewer resources. Thus, in the RTS 17% of fixed assets, more than 60% of railway tracks, 17.64% of roads are used inefficiently; 40% of investments are made in unpromising projects (or they have not been covered), and 35% of the labor potential is used inefficiently. Thus, most of RTS resources are not used optimally in the region.

Calculation by using the output-oriented model shows that even an increase in revenue by almost 1.5 times (+46%) does not allow the RTS to fully and efficiently use its resources. The investment volume, the density of railway tracks and the number of employees should be reduced to attain an ideal RTS. A reduction of the number of employees is the most feasible measure in this situation.

The parameters of three leaders made it possible to form an ideal RTS for the RTS of the Kemerovo Region by using both models:

- RTS of the Moscow Region;
- RTS of the Omsk Region;
- RTS of the Tyumen Region.

The RTS of the Omsk Region has made the main contribution to the formation of the ideal (0.96 by using the input-oriented model and 0.902 by using the output-oriented model). The deviations of the parameters of the RTS of the Kemerovo Region from this model RTS are less important than the deviations from the other two RTS.

Further, we conducted an analysis of the reference of RTS benchmark. Upon the input-oriented model for the RTS of the Moscow Region, it amounted to 4, for the RTS of the Omsk Region – 9, for the RTS of the Tyumen Region – 7. RTS benchmarks of the Republic of Bashkortostan, Tatarstan and the Rostov Region are the same as the benchmarks of the RTS of the Kemerovo Region. Being geographically closer to the RTS of the Kemerovo Region and actually more conveniently located in the direction of North-South ITC, the first two RTSs, on the one hand, are its direct competitors and, on the other hand, serve as models, the operation methods of which could be adopted by the RTS of the Kemerovo Region. Two benchmark RTSs for the RTS of the Kemerovo Region are included in the number of the benchmarks of RTS of the Nizhny Novgorod Region, Perm Territory, Sverdlovsk Region (Table 2).

Table 2: Reference set frequency of RTS best-performers of the first cluster.

Input-oriented model		**Output-oriented model**	
Leaders	**Frequencies of mention**	**Leaders**	**Frequencies of mention**
Krasnoyarsk Territory	2	Krasnoyarsk Territory	0
Moscow Region	4	Moscow Region	8
Omsk Region	9	Omsk Region	9
Tumen Region	7	Tumen Region	9
Yaroslavl Region	3	Yaroslavl Region	1

Upon the output-oriented model, the number of references of the RTSs of the Moscow, Omsk and Tyumen Regions increases, which leads to a greater number of matches in the benchmarks of poor-performers. The analysis of ideals among poor-performers in the immediate environment of the RTS of the Kemerovo Region has been conducted by using both models.

Upon the input-oriented model, the RTS of the Republic of Bashkortostan is the closest to the ideal compared to other RTS under study. The RTS of the Rostov Region is far from ideal. Upon the output-oriented model, the situation is similar. The ideals of the RTS of the Rostov Region are the closest to the ideals of the RTS of the Kemerovo Region. However, the first RTS is much more distant from the ideal values. In addition,

as for the spatial aspect, these RTSs are not direct competitors, which allow using the proximity of their ideal parameters only in the positive direction of taking over the experience of problem solution.

Further analysis is reduced to the study of leaders. In this case, the best-performer's reference, i.e. the number of poor-performers, which mention it as a reference one, is a key parameter. Obviously, the RTSs of the Omsk and Tyumen Regions are the actual leaders, as they are most often mentioned in the construction of RTS-ideals. In addition, the RTS of the Moscow Region is among the leaders. Despite its federal significance, the efficiency of its performance leaves much to be desired.

Next, we analyzed the poor-performers who refer to these leaders.

The RTS of the Krasnoyarsk Territory is a benchmark for two RTSs, though its contribution to the formation of their ideals is insignificant (0.313 for the RTS of the Sverdlovsk Region and 0.051 for the RTS of the Chelyabinsk Region). The RTS of the Moscow Region is a benchmark for four RTSs; however, the contribution to the formation of the ideal of each of them is less than 0.1.The RTS of the Omsk Region made the most significant contribution to the formation of the ideals of RTS poor-performers of the cluster. It serves as a benchmark for 9 RTS poor-performers, among which in 6 entities the contribution of the RTS of the Omsk Region to the ideal is > 0.8. The RTS of the Tyumen Region served as a benchmark for seven poor-performers. However, the contribution to their ideals does not exceed 0.2.

The identification of the fifth RTS leader – the RTS of the Yaroslavl Region – seems interesting in terms of the ratio of spatial location and efficiency parameters. It serves as a benchmark for all three poor-performers, but for one of them (the RTS of the Voronezh Region) it forms the ideal by more than 0.75. These two RTSs are located in one federal district (Central Federal District) and, in fact, in one direction – North-South ITC. On the one hand, this escalates competition between RTSs; on the other hand, this makes it possible to identify more accurately the strengths of a leader in order that an poor-performer can adopt them.

It is obvious that in this cluster the RTS of the Omsk Region is an actual RTS. In addition, the RTS of the Yaroslavl Region is a significant benchmark for one of the poor-performers – the RTS of the Voronezh Region.

Efficiency calculation upon both models, taking into account the parameter of superefficiency, has revealed one big-best-performer (the RTS of the Tyumen Region) when using the input-oriented model, and three big-best-performers when using the output-oriented model (the RTS of the Omsk and Yaroslavl Regions and the Krasnoyarsk Territory).

As for the first model, let us focus on the RTS of the Omsk Region. In order to achieve a position of a big-best-performer, the Omsk Region should improve all initial parameters of RTS performance and significantly expand the investment policy in respect of railway

tracks.

A big-best-performer of the RTS of the Tyumen Region is cited by RTS poor-performers 7 times and, in addition, it serves twice as a benchmark for the formation of ideals for simple RTS leaders (the RTS of the Krasnoyarsk Territory, the Moscow Region).

Upon the output-oriented model, the RTS of the Omsk Region has become one of the big-best-performers. It serves as a benchmark for one simple RTS leader – the Moscow Region.

Thus, the RTS of the Omsk, Tyumen and Yaroslavl Regions are the obvious leaders of the first cluster.

For further formation of the strategy the following approach to the interpretation of results is proposed:

1) for RTS poor-performers:
- identifying the ways of increasing the efficiency of the use of each kind of resources;
- taking over the experience of the performance of RTS- benchmarks;
- search for the ways to improve results without increasing the cost of the resources;

2) for RTS leaders:
- search for the ways to strengthen their leading position.

As part of the strategic planning, it is necessary to determine the value of the RTS performance efficiency in the coming period, provided that RTSs would not be impacted by the regional government. This forecast will identify trends in RTS development, requiring an impact of the management entity.

As practice shows, forecasting a final integral performance efficiency indicator obtained using the DEA method is not reasonable, since in the efficiency evaluation the calculation is based on a number of factors, which are transformed into the result within a complex statistical model. Any small change in at least one of the basic parameters leads to a change in RTS in the space of efficiency parameters.

In this regard, for forecasting the RTS efficiency it is advisable to use the methods of extrapolation of time series of input and output parameters used in the efficiency evaluation by using the method of DEA.

In our study, time periods are presented by annual periods for 15 years (from 2000 to 2014). Thus, the sequence and order of observations at regular annual intervals are presented as a discrete time series.

The initial time series used for forecasting are presented by the data on the cost of resources and the value of RTS performance.

Each of the time series can be described by means of various regression models. The choice of a model often depends not only on indicators characterizing the closeness of interaction and the adequacy of the model, but also on the correspondence of calculated projected values to the nature and logic of the development of the research object.

The analysis showed that most of the parameters are described either by a hyperbolic or linear function. In some regions, the dynamics of a number of indices under study is unstable, the selection of regression equation presents considerable difficulties, while the correlation coefficient does not exceed 0.85.

These projected values of RTS performance parameters allow calculating its value in the long term.

Using the results of parameter forecasting, we calculated the RTS efficiency forecast by the DEA method. The calculation results for the first cluster are presented in Table 1.

The calculated projected values of efficiency have undergone some changes. In the calculation upon the input-oriented model, 4 RTS leaders have been distinguished, the same as upon the historical data. However, in the inclusion of a parameter of superefficiency in the model, only the RTS of the Omsk Region took a big-best-performer position.

The calculation of the output-oriented model with the use of a parameter of superefficiency has revealed two big-best-performers. In contrast to the previous calculation, the RTS of the Moscow Region did not appear among them. The analysis of the frequencies of mention demonstrates the stability of the position of identified leaders.

Thus, the forecast showed the stable dynamics of input and output parameters of RTS performance efficiency of the first cluster, which confirms the need to develop RTS development strategies, which will be based on changes aimed at improving the efficiency of their performance [16,17].

A similar analysis was performed on the remaining clusters. In general, RTSs are characterized by the stability of their positions in the space of efficiency parameters in relation to the pareto-optimal border.

DISCUSSION

The proposed method of the evaluation of RTS functioning efficiency has been evaluated on the basis of statistical data on the performance of Russian regional transport systems for the period of 2000-2014. The main problem of the study was to collect basic data, which, firstly, are often reviewed by the Federal Service of State Statistics in terms of collection methodology; secondly, they are often absent for a long period, which prevents their study in the dynamics; thirdly, they are regularly published

in fragments. In addition, an extreme differentiation of the level of development and volume of Russian RTS does not allow conducting a comprehensive analysis of all objects, but for the solution of this problem the cluster analysis has been proposed.

Due to the flexibility of mathematical tools (selection of a model depending on the objects and initial data), the possibility of correction of input parameters depending on the tasks solved, the study shows the possibility of adaptation of the methods used to the objective necessity of the study.

CONCLUSION

The RTS studies carried out using the proposed methods provide the basis for the development, implementation and modification of strategic decisions in the planning at federal and regional levels, taking into account the characteristics of the level of development of transport and its effectiveness, as well as RTS development options. The results of the study conducted on the basis of the proposed methods can serve as a basis for long-term plans in separate transport sub-sectors in the regions and identify strengths and weaknesses of regional transport systems. Comparative efficiency evaluation in the framework of the proposed methods can also be used for other regional sectors, provided the development of the appropriate system of indicators. In addition, a comparative analysis of the proposed scheme can be carried out in the context of transport sub-sectors in a separate region or in a federal district, which will serve as the basis for the development of regional and municipal development programs.

In our view, the proposed set of methods fully covers the key aspects of RTS performance, so it can be widely used in applied and theoretical research. Its modifications will make it possible to carry out a similar analysis of performance efficiency of other economy sectors. Application under monitoring systems will allow obtaining the whole data set, which can be easily analyzed in dynamics in the implementation of the RTS development strategy.

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