The experience of the Accounts Chamber of the

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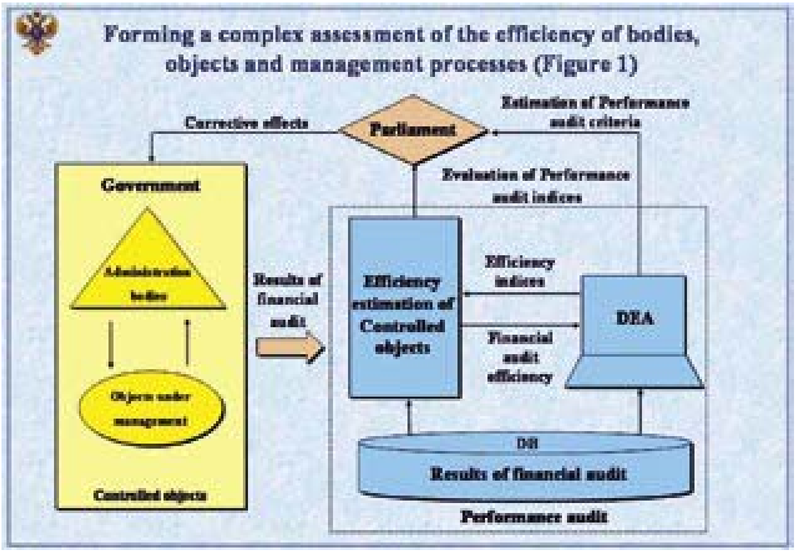
Introduction

Our country is in the process of re-orientating the whole budget system towards achieving maximum economic and social efficiency. As a result, the Accounts Chamber is faced with new, more complicated problems as compared to financial audit. Efficiency or performance audit is becoming the top priority, not so much at the stage of assessing the results of activities, but rather the stage of forming state development programmes for activities or regions.

Therefore, the development and application of software for non-financial audit is one of the priority tasks for the IT department of the Accounts Chamber.

The Accounts Chamber has long used CAATs to improve the quality of our audit and in turn the operational quality of the controlled objects (CO) themselves. However until recently, we could not create adequate analytical tools for evaluating efficiency. The reason for this failure lay in the extreme complexity of functioning processes of economic systems taking place in a multi-dimensional parameter space, with these parameters being heterogeneous in their nature and interconnected in complicated relationships.

When evaluating the efficiency of controlled objects as an economic relations system, we have to make a complex assessment of the efficiency of bodies, objects and management processes as a single cybernetic system (Figure 1).



Data Envelopment Analysis (DEA) methodology has been used by the Accounts Chamber of the Russian Federation to make a socio-economic diagnosis of several regions of Russia. This methodology is the outcome of interdisciplinary research conducted in the last two decades in the field of economics, system analysis and operations research. It also uses the fundamental provisions of mathematical economics, production theory and Pareto principles of optimality. American scientists A. Charnes and W. Cooper are the founders of this approach [1, 2].

Currently, over 1,000 works related to these subjects have been published and approved in dozens of companies, banks etc in many regions and countries of the world. Two large international conferences were held in 2004 – in Toronto in June (NAPW2004) and in England in September (DEA2004).

The essence of the DEA approach is to study the production objects with multiple input and output parameters and to analyze their activities. In terms of mathematics, use of the DEA can be described as solving and analyzing a large family of optimization problems.

The advantage of this approach is the possibility of system correlation of heterogeneous factors affecting management decision-making, with consequent improvement in the evaluation of its performance.

In Russia, this line of investigation has been successfully developed by a research group under the guidance of V. E. Krivonozhko, Doctor of physical and mathematical sciences.

Russian Federation in the use of DEA approach

and special software for non-financial audits

Russian specialists have obtained a number of important results providing for a broad approach to the analysis of complex economic and social systems. They have created novel algorithms for visualizing a multi-dimensional economic space by generating 2D and 3D sections. They have also created a computer system – «EffiVision» (Efficiency Vision) with interesting performance capabilities. It implements a new class of software models, novel in their approach and directed towards modern economic analysis [3-5].

A brief description of the DEA approach

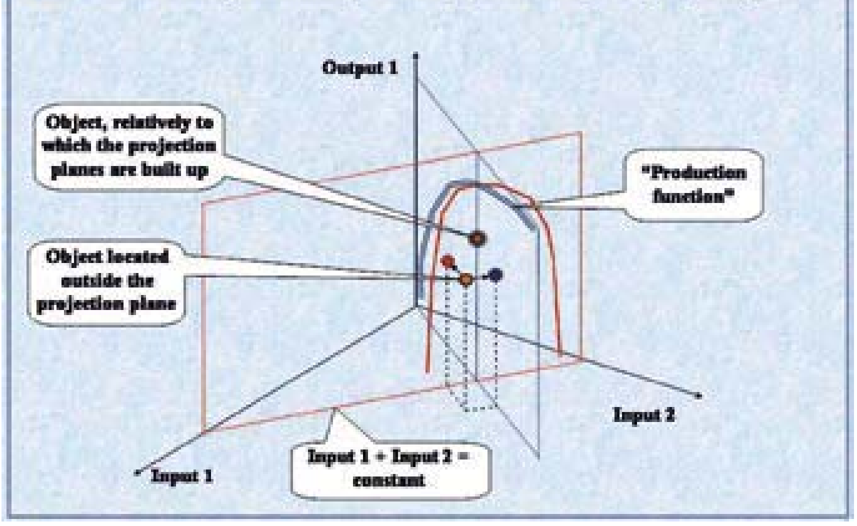
The DEA methodology and «EffiVision» software package enable us, after quantifying measures of efficiency, to visualize the performance dynamics and trends of the controlled objects.

At the same time, the controlled objects *per se* are considered to be a set of Production Objects (PO) processing their inputs (resources) into outputs, constituting, on the whole, the vectors of the input (the results of financial audit) and output (performance indices) parameters (Figure 1).

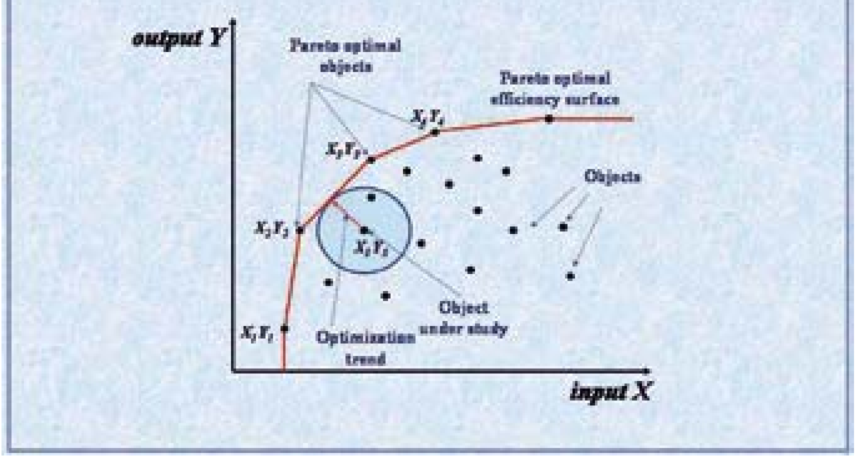
The actual economic objects function in a multi-dimensional economic space. There is only one way of visualizing and studying this multi-dimensional space, and to do that it is essential to generate various sections of a production possibility set and through various objects.

Figure 2 shows two sections of the set of production possibility in a 3D space. The «EffiVision» software can build any sections in a multi-dimensional economic space. In particular, the sections built may be generalizations of such well known economic functions as the production function, isocost, isoquant, etc.

Figure 3 shows the section of a production function in a model with one input index and one output index.



Sections of production possibility set in 3D space (Figure 2)



Analysis of companies' efficiency in a model with one input and one output index (Figure 3)

The production possibility set of controlled objects shown on Figure 3 is very informative, as it gives us an idea of the comparative efficiency of objects. This efficiency, i.e. the terms “better” or “worse”, for the transformation of inputs into outputs, $X \longrightarrow Y$, in the given functioning environment, is determined by the position of the point characterizing the controlled object under consideration with coordinates (X,Y) as opposed to the boundary of this set:

- if the point is located at the efficient boundary, e.g. the points (X_1,Y_1), (X_2,Y_2), (X_3,Y_3), (X_4,Y_4) in the Figure, the object works with a 100% efficiency;
- if the point is located within the set, e.g., the point (X_5,Y_5) in Figure 3, its distance from the efficient boundary will measure the efficiency score – the larger the distance is, the worse the efficiency of the object with coordinates (X_5,Y_5) will be.

The DEA approach allows us:

- to determine the quantitative measure of the object efficiency, i.e. the distance from the efficient boundary;
- to determine the reference set for each inefficient object, i.e. the efficient objects whose structure is the closest to it (objects (X_2,Y_2) and (X_3,Y_3) for the object (X_5,Y_5) in the Figure);
- to find the optimal directions of efficiency improvement.
- to determine the stability zones of an object, i.e. the areas of parameters (X,Y), where the regarded object does not change its status (either efficient or not). In Figure 3, the stability zone for object 5 will be the sphere with the centre at point (X_5,Y_5) tangent to the efficiency boundary;
- to monitor the dynamics and reveal the trends in the object development.

Finally, the DEA approach allows us to design the optimal development strategies with better substantiation, both for structure units and for the Controlled Objects as a whole.

In the scientific literature on DEA, the boundary set is often called the frontier. It turns out that the frontier coincides with the set of weakly Pareto-efficient points of the production possibility set, see, for example, [3]. According to the determination, a production object is weakly Pareto-efficient if it is not possible to improve all inputs and outputs simultaneously, see [4].

The use of the DEA approach for the purposes of the Accounts Chamber of the Russian Federation

The Accounts Chamber has used the DEA approach to analyze the budget functioning efficiency of the Russian regions.

DEA model. This model studies the level of revenues collected subject to the level of population income, commodity circulation, industry, agriculture and transport.

Inputs: the volume of the industrial output plus the volume of the agricultural production plus the volume of the construction work in the region, all in million rubles *per capita*; the retail turnover plus the services to the population plus the wholesale turnover, all in million rubles *per capita*; the income of the population per capita; the transport turnover of goods in the region *per capita*.

Outputs: revenue collected in the region, in rubles (1000s) *per capita*.

The production volumes of key industries as well as the monetary income of the population have been chosen as the primary factors affecting the tax potential of the regions. The latter index has been used, for it is a substantial tax-forming factor in the above-mentioned regions.

The resulting index was the gross income collected in the regions. All indices were used *per capita*, since these regions differ greatly in their size. The research covered 2000-2003.

We used data from the Federal Service of State Statistics and the Federal Tax Service accumulated in the databases of the Accounts Chamber.

The statistical bases for modelling are data on Russian southern regions plus data on the Southern District as a region, in total 11 regions, each over a period of four years, the same region for different years being considered as a separate production unit. The model density is increased by this method as it allows us to use considerably more production units in constructing the frontier. In addition the data on the regions across time enable us to construct a development trajectory of each region in a multi-dimensional social and economic space.

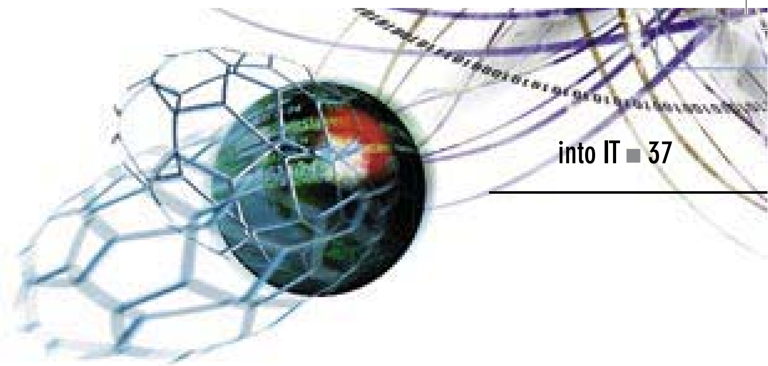
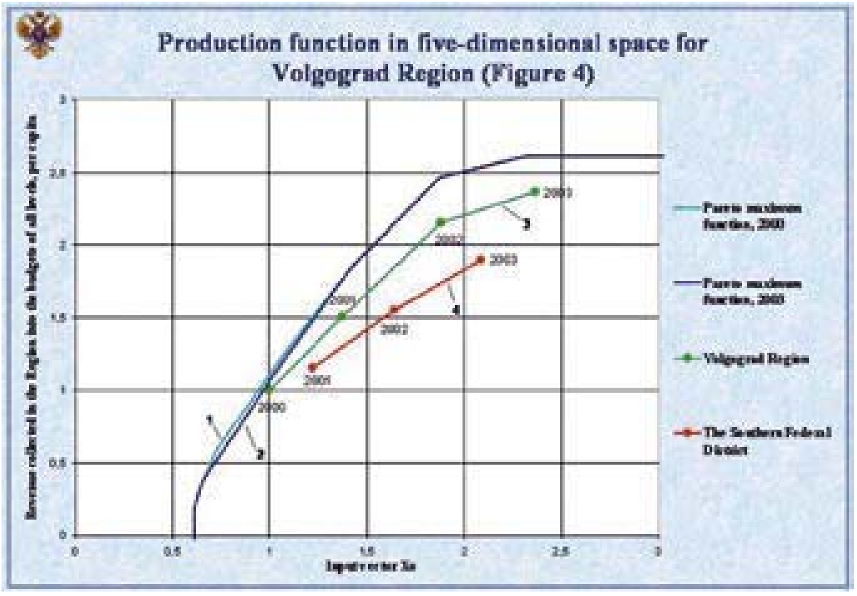


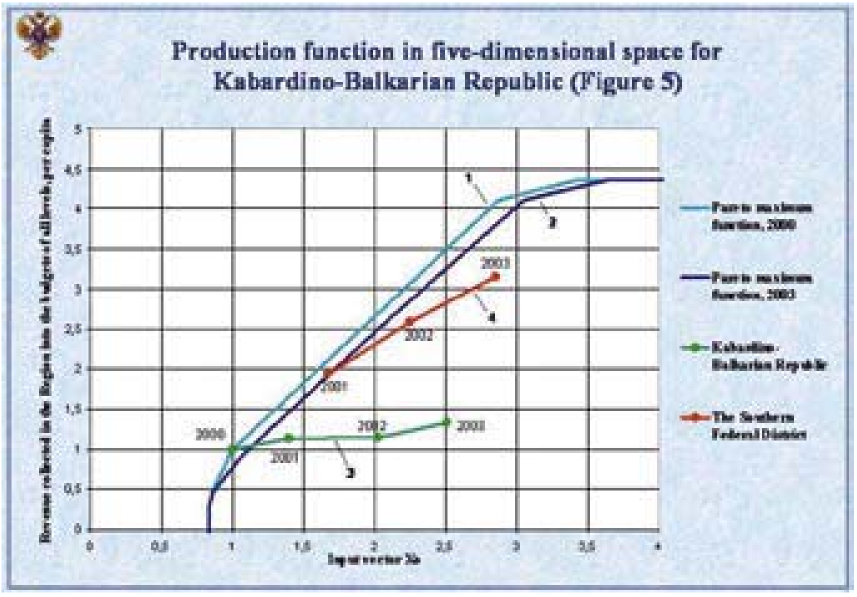
Figure 4 shows an intersection of the frontier in five-dimensional space with the two-dimensional plane for the Volgograd Region for 2000 with respect to the DEA model. In the figure, the horizontal line is determined by input vector *X0* of the Volgograd Region for 2000, and the vertical line corresponds to output. The scale is such that point $(X_0, Y_0)=(1,1)$ corresponds to the Volgograd Region for 2000. Line 1 is a trace of the frontier on the two-dimensional plane. Line 2 is an intersection of the frontier with the two-dimensional plane that goes through the Volgograd Region for 2003. Dots on line 3 are projections of points, associated with the Volgograd Region for the years 2000, 2001, 2002 and 2003, onto the two-dimensional plane. Line 4 is determined by dots that are projections of points associated with the Southern Federal District for the years 2001, 2002 and 2003. Lines 3-4 are trajectories of development of the above-mentioned regions.

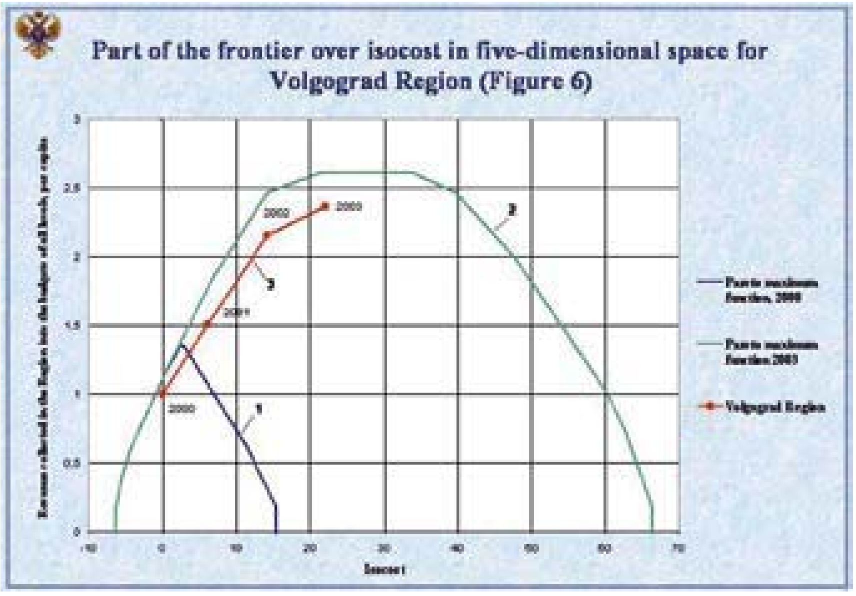
Naturally, in the course of our investigation we constructed cross-sections through every production object (region). But in order to compare dynamic behaviour of different regions we projected several regional trajectories onto the same two-dimensional plane.

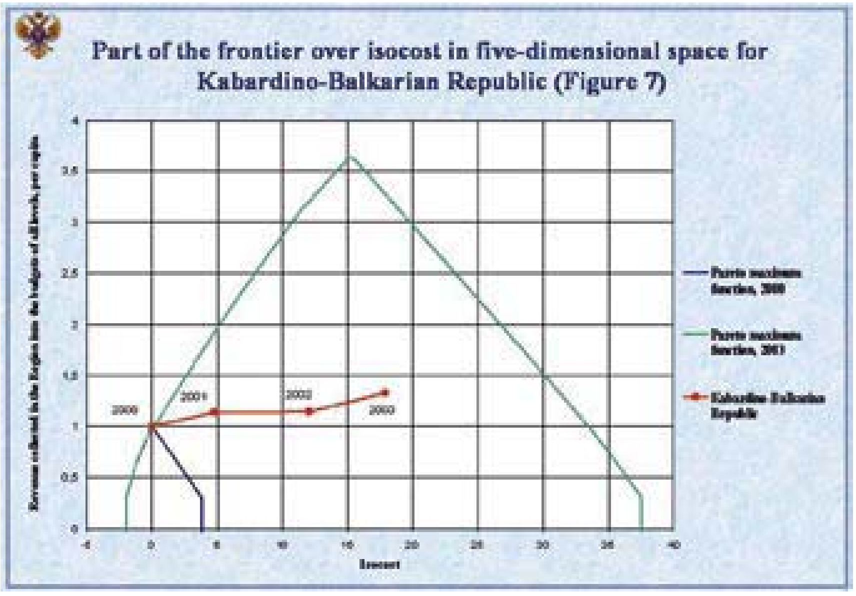
In a similar way we compared trajectories of development in accordance with the DEA model for the Kabardino-Balkarian Republic.

Figure 5 represents an intersection of the frontier in five-dimensional space with a two-dimensional plane for the Kabardino-Balkarian Republic. Lines 1 and 2 are traces of the frontier on the two-dimensional planes going through this regions for 2000 and 2001 respectively. Dots on line 3 are projections of points, associated with the Kabardino-Balkarian Republic for the years 2000, 2001, 2002 and 2003 onto the two-dimensional plane. Lines 3 and 4 are trajectories of development of this republic and the Southern Federal District, respectively.

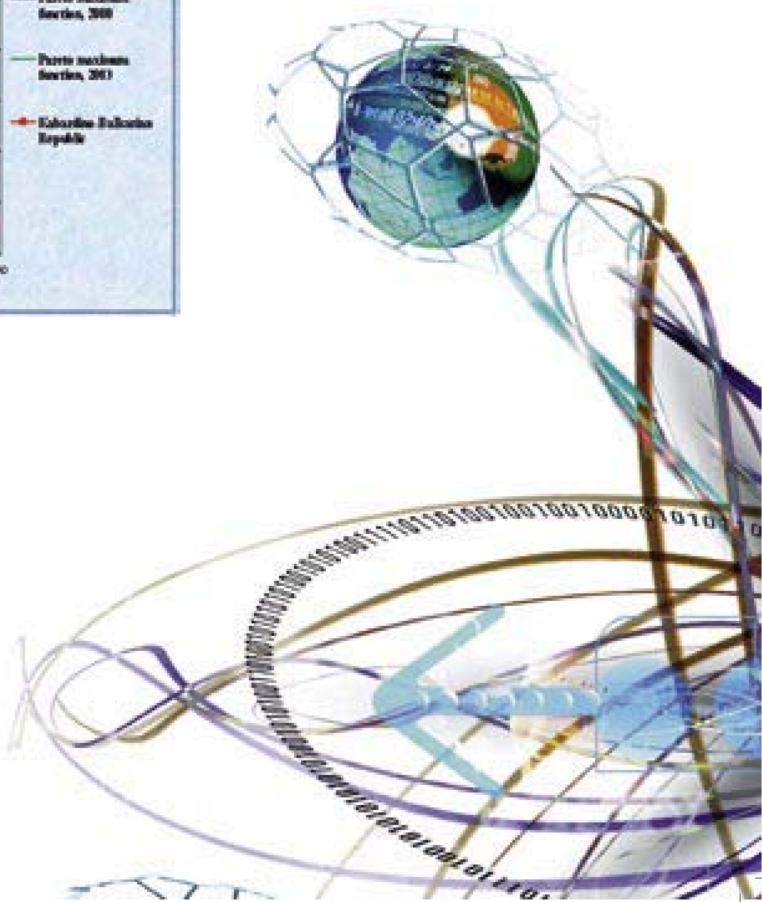








In Figure 6, the horizontal line is an isocost (a line where the sum of inputs is constant) and the vertical axis corresponds to the output in the DEA model. Lines 1 and 2 are intersections of the frontier with two-dimensional planes that go through the isocosts and the Volgograd Region for 2000 and 2003, respectively. Isocosts for construction are chosen in parallel in order to compare these two sections of the frontier explicitly. The scale of the isocosts is such that point (0,1) corresponds to the Volgograd Region for 2000. Line 3 is a projection of the trajectory of the Volgograd Region development onto the two-dimensional plane. The positive direction of the horizontal line corresponds to the increase of population income and the decrease of the sum of other inputs. In a similar way, we constructed the trajectory of development of the Kabardino-Balkarian Republic in the multidimensional space, Figure 7.



The Pareto efficiency surface in this study reflected the actual obtainable level of the revenues collected in this group of regions with the existing development indices of the key industries and the level of the monetary income of the population.

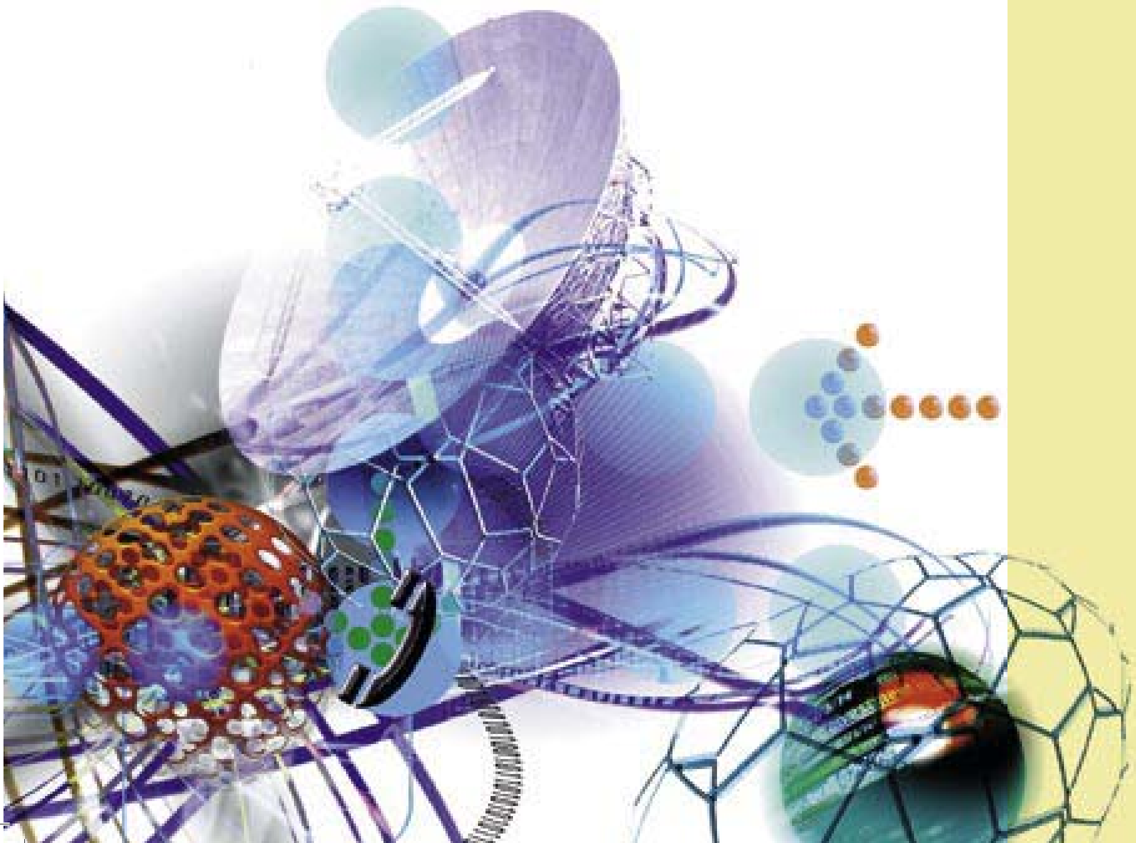
The Volgograd Region has shown a significant growth of the main development parameters during the period, as well the growth of the efficiency of the use of tax potential, as compared to the other regions of the group in question. Kabardino-Balkaria, on the contrary, along with the factual stagnation of the main production factors, has decreased the efficiency of the use of tax potential almost by one third.

The growth of revenues collected in the South Federal District is quite obvious. At the same time, in contrast to the Volgograd Region where we can see a high efficiency level retention (proximity to the Pareto efficiency surface) and an essential growth of fiscal revenues, the Kabardino-Balkarian Republic is characterized by a low increase in budget system revenues, with a drop in efficiency (remoteness from the Pareto efficiency surface).

To summarise we now have new tools which enable us to obtain quantitative assessments of the efficiency parameters, to visualize the outcome and to facilitate the elaboration of standards for assessing efficiency of each branch of industry.

The results of this research have been submitted to the President of the Russian Federation as part of analytical documents characterizing the social and economic condition of the subjects of the Southern Federal District.

Success with DEA depends on certain critical decisions, including choosing the right objects of analysis and input parameters as well as correctly interpreting the results. However, our experience proves that proper statistics can help to solve the problem of identification of the sections of efficiency functions, including the proposals on efficiency audit standards aimed at certain types of control.



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