NATIONAL RESEARCH UNIVERSITY
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PARAMETRIC AND NON-PARAMETRIC COST EFFICIENCY BENCHMARKING OF WATER UTILITIES IN RUSSIA

BASIC RESEARCH PROGRAM

WORKING PAPERS

SERIES: MANAGEMENT
WP BRP 42/MAN/2015

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PARAMETRIC AND NON-PARAMETRIC COST EFFICIENCY BENCHMARKING OF WATER UTILITIES IN RUSSIA

The activities of the water companies in Russia are regulated in order to overcome market failures caused by regional monopolization, information asymmetries and the need to find a balance between the interests of consumers and company objectives for its normal functioning and development. In the Russian Federation, the regulator uses the outdated and inefficient cost method, which deprives the company an incentive to reduce their own costs. However, Russian regulator is in active discussion about the transition to modern long-term management regulation practices in order to increase companies' efficiency, which in the framework of the regulation defines the future of the company's profits.

Russian regulator should take more active steps to encourage regulated companies to increase efficiency and productivity. Solution is to move to using benchmarking, which allows to identify sources of companies' inefficiency to assess the validity of the established tariffs. This study presents the first attempt to implement benchmarking methods used by the world's leading regulators to determine the cost efficiency of companies and improve their potential.

The authors tested a parametric (COLS) and non-parametric (DEA) methods to assess the performance of companies with different technical and economic characteristics more accurately. The study makes a number of recommendations for the specification of the model, assessing its sensitivity to the changes in samples.

The authors concluded that the model based on COLS is of high quality and resistance to changing of sample while assessing the technical efficiency. However, a similar statement for DEA models is unfair, since the inclusion in the analysis of either too large or too small companies does not lead to plausible results. On the other hand, DEA allowed to assess not only the technical efficiency of companies but also the allocative one.

In general, the authors have shown that the potential for increasing the efficiency of Russian water supply companies is large enough, and the regulator is necessary to accelerate the transition to incentive regulation in order to increase efficiency in the sector.

JEL Classification: L95, D42, C60

Keywords: Benchmarking; Efficiency; Incentive regulation, Water Utilities, DEA, COLS.

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1. Introduction

In the absence of competition, insurmountable barriers to entry and price inelasticity of demand determine the nature of natural monopolies. In turn, the lack of competition, information asymmetry in the market, operating costs and investment inefficiency, poor quality of services, all mentioned determine the feasibility of state regulation of prices for products and services of natural monopolies. Regulation of natural monopolies is an attempt to reduce the negative impact of excessive market power on their own performance and the social welfare [10]. In other words, the main objective of regulation is to maximize social welfare and limit the rent received by monopolies due to market imperfections.

In the Russian regulatory practice the problem of establishing tariffs for natural monopoly entities has become particularly acute in recent years. The appropriateness of the "freezing" of tariffs for services of natural monopolies and the impact of such policies on the development strategy of both business and infrastructure organizations themselves are turned heated debates [11,16,17]. Too high tariffs increase the costs of goods and services for companies. Inflated prices placed a heavy burden on the population allowing natural monopolies not to care about efficiency.

In this situation, it is advisable to consider the transition from traditional methods to more modern regulatory approach designed to attract investment in the sector and improve the efficiency of companies that in the medium term will reduce the tariff burden on consumers of natural monopolies. Currently Russia predominantly uses the so called “cost” methods of regulation, based on the justification of the tariff depending on the amount of the costs of the regulated company. With this regulation, companies are not interested to invest in improving their own effectiveness as cost reduction would cause the reduction in the tariff set for the company. However, currently in Russia there is a gradual transition from such method to the incentive method that is based on the long-term parameters of tariff regulation. As part of the incentive regulation, the level of regulated costs defines corporate profits and the volume of attracted investments.

The world's leading regulators experience shows that as part of incentive regulation it is expedient to use benchmarking methods to determine a fair tariff in accordance with the efficiency of regulated costs. A tariff, established in the light of cost efficiency, stimulates increased companies’ efficiency and allow them to attract the necessary investment for the development, which will undoubtedly affect the subsequent tariffs reduction for consumers.

The present study was carried out in the framework of the HSE Basic Research Program devoted to benchmarking of cost efficiency of Russian water supply companies. This sector is currently experiencing significant difficulties with increased operational efficiency, primarily related to the low volume of investments due to high and sometimes unreasonable costs of companies. In turn, this affects the depreciation of assets and paces of its renovation, losses and accidents in pipelines, etc. The purpose of this study is to determine the cost efficiency of water companies and the potential to improve it, which is feasible to realize in the framework of incentive regulation.

It is worth noting that the present work is the first attempt to use the experience of the world's leading regulators in the area of benchmarking in order to improve the water companies regulatory practices in Russia.

The article is structured in the following way. The first chapter is devoted to theoretical assumptions in regulation of natural monopolies, it describes the main problems leading to the need for regulation of the sector. The second chapter presents the object of our study - the cost efficiency of natural monopolies, some basic definitions and types of cost efficiency, as well as an overview of the latest academic and applied research in the field of methodological approaches. The third chapter presents the analyzed sample and specification of the models we used. The fourth chapter reflects the results of different models of benchmarking and efficiency evaluation and its potential for the industry as a whole and for individual companies. In conclusion, the main findings and recommendations are presented.

2. Theoretical basis of the activities of water companies regulation

It is considered that if there is only one supplier, the market is showing monopoly characteristics. From the consumer benefits point of view the monopoly is undesirable. Monopolist faces a downward demand curve and may limit the output establishing higher prices. The result - a negative economic effect: limited output and higher prices [1].

However, due to technological specifics of natural monopolies, the demand is met by a limited number of companies. Construction costs of water supply systems are too high, that does not allow other companies to enter the market easily. That is why the activity of water utilities is seen as natural monopolies. In this case, the cost of supplies carried out by the one company may be less than by a few companies. Natural monopoly exists when the cost function in the industry is such that no other combination of two or more firms cannot produce products cheaper than one company [15]. An alternative definition was given by Posner, who believes that a natural monopoly is determined not by the number of sellers in the market, but by the relationship between demand and supply technologies [15].

In the efficiency analysis of the water companies it is important to highlight the main problems associated with their performance: high prices, inefficiency costs, inefficient investment and poor quality of service. Sources that reduce economic efficiency or inefficiency may be different.

Price signals can be distorted because of the prices set above marginal cost. The degree to which a firm can raise the price depends on the price elasticity of demand. For essential commodities, which include water, it's pretty low. Thus, the manufacturer can increase its revenues at the expense of consumers. This can lead to a decline in welfare and economic efficiency.

Another factor contributing to inefficiencies is the problem of high production costs. Monopolies often cannot be successful in minimizing production costs. Deprived of competition, they often demonstrate misallocation of resources, which some theorists call factor X - inefficiency average costs (e.g., Leibenstein [12]). In the context of weak regulation, the monopolist can recover all its inefficient spending and has no incentive to reduce their costs. Compensate for the inefficiency due to consumers, the monopolist reduces social welfare.

Investments in the absence or lack of regulation may be redundant and ineffective, and with excessive regulation may not be sufficient to meet future needs. Along with the static inefficiency natural monopoly also shows a tendency to dynamic welfare loss. According to [13], dynamic inefficiency can lead to distortion and delay adaptation to the changing economic environment, as well as a lower willingness to technical progress. In this regard, the regulator must monitor the activities of regulated companies to the largest possible period of time.

Quality of service of water utilities can be characterized by the reliability of supply, number and duration of outages and other indicators. Generally, monopoly always has quality problem [9]. But this problem is particularly important in the political level, due to it is associated with the welfare of the population. Monopolies need simple profit maximization, and the problem of the quality looks by monopoly in terms of the marginal consumer willingness to pay for quality. On the contrary, from the social policy point of view additional benefits that come to the average consumer are important.

Thus, the problems outlined above determine the importance of regulation of natural monopoly activities, and in particular the activities of water companies, since they limit the impact of monopolist excessive market power on its own efficiency and social welfare.

3. Cost efficiency benchmarking: definitions, approaches and methods

One of the purposes of the application of benchmarking in the framework of regulatory practice is to assess the cost efficiency of regulated entities. Cost efficiency reflects the companies' performance and established tariffs. Cost efficiency of the regulated entity can be divided into two types: technical efficiency and allocative efficiency (price efficiency). Technical efficiency (or production efficiency) is achieved through the implementation of maximum output with minimum use of resources [13]. Allocative efficiency - the ability of the company to find the optimal combination of resources at given prices, ideally equal (or close) to the marginal cost (=). Active social policy can lead to the fact that the firm can demonstrate a high production efficiency ( ) at low allocative efficiency ( ). Economic efficiency ( ) of firm as a whole can be represented as follows [8]:

= · (1)

Limitations and shortcomings of the market as described above, lead to the fact that the prices do not correspond to the marginal cost. That is why regulation is considered as more appropriate approach in pricing. Moreover, the presence of allocative efficiency does not mean that the costs are effective. However, low costs allow to set economically viable and not excessive rates. It should be noted that technical efficiency is considered by many uses as preferred because unlike allocative efficiency, it reflects the ratio of output and resources used to produce it in physical terms without weighing with distorted prices.

In the absence of competition, there are no incentives to reduce costs, but the company can benefit from economies of scale and diversification, so regulators should create an environment where regulated firms seek to minimize costs, optimize the set of resources used, improve the management efficiency and reduce other sources of factor X (inefficiency).

But the problem is that the regulator sets tariffs and calculates the efficiency for a short period (regulation period), and the effect on investment can be expected only in the long run. Firms must be effective, reducing costs, and at the same time be able to carry out maintenance, repairing and expansion their networks. There is room for compromise between allocative efficiency and productivity: in order to be effective in the short term, a firm can become productive without investing in the development of capacity and reducing costs for maintenance work. However, in the long term the behavior of the firm is not able to provide it with efficiency. In addition, the reduction in investment activity is usually negative on the economy as a whole.

In practice, regulators seek to find a balance between technical and allocative efficiency, so that the company would not get super-profits, but receive sufficient revenue in order to ensure the necessary investments in network development.

As part of the benchmarking of costs, it is necessary to determine what costs have to be included in the analysis. According to [14] it is preferable to analyze the total cost for benchmarking the technical and economic performance of companies, since the benchmarking only operating costs completely ignores differences in the quality of capital structure of the company, at the same time some non-operating costs may be the least effective at all. The company, which in the past invested in equipment and technologies that reduce transaction costs would have higher levels of efficiency, regardless of whether such investments are reasonable in terms of efficiency to reduce operating costs. The use of benchmarking operating costs only would have a serious impact on the company, which in the past invested less than the average company in the industry. Such companies will not only have a relatively low cost of capital (and this company will get a smaller return on capital), but they also will have lower performance indicators calculated based on benchmarking operating costs.

Benchmarking total costs, rather than the individual components of costs, such as operating costs, avoids manipulation associated with the replacement of operating costs by capital ones. Such manipulation can be expressed simply in the change in accounting policy of the company and leads to the need for additional data cleaning. But in some cases, the substitution effect of operation costs on capital may have more serious consequences, especially if the company moves away from the optimum technology, changing the ratio of resources.

The use of different methods in the framework of benchmarking allows to quantify the cost efficiency of a company. All methods are based on the construction of a certain frontier in the industry, which includes the most efficient companies. Those companies that are located within the built frontier are assessed along with the degree of their inefficiency, i.e., values of deviations from the frontier. In general, benchmarking methods can be divided into two principal groups [3]: parametric and nonparametric methods.

The most commonly used parametric approaches to benchmarking - Corrected ordinary least squares (COLS) and Stochastic Frontier Analysis (SFA). The difference in these approaches is that in the former case any deviation from the efficient frontier is attributed to the inefficiency of the company, and in the second case, the part of deviation refers to the deviation of inefficiency, and the other part - to white noise. It is worth noting that the second approach has a complex methodological framework, since the efficiency frontier seems random, and the shape of the frontier is determined on the basis of pre-selected function (Cobb-Douglas or translog function). It is not always possible to clearly identify the most suitable function, since there are discussions in the academic environment [7].

COLS, on the contrary, is based on the method of OLS and characterized by its relative simplicity. [3] Within benchmarking method was used to assess the technical performance, because the technical efficiency analysis does not require inclusion of cost explanatory variable in the model, which often leads to a weak force and explanatory specification errors. When evaluating technical efficiency, we consider a model based on a composite variable that is defined by a set of weighted production factors [2].

The most commonly used nonparametric approach - Data envelopment analysis (DEA) [4]. This method is based on linear programming, and the efficiency frontier is a piecewise linear function. Unlike COLS and SFA, it is not required to choose the form of the efficiency frontier, because the frontier is based on the most remote points in the direction of the company performance. This approach allows us to take into account the effect of including the economies of scale, when the frontier is not strictly a line or close to it. Moreover, based on DEA it is possible to calculate both technical and allocative efficiency. However, using the method of DEA it is necessary to limit the number of possible input parameters: the more input parameters, the more firm tends to efficiency frontier.

4. Benchmarking data and methodology

4.1. Data

In our study, we used mostly data on key indicators of water companies for the period 2011-2013, published as part of the mandatory disclosure requirements on the part of the regulator FST. Data includes indicators of 29 large private and public companies running their business in cities with a population of over 250 thousand people and presented in all federal districts of Russia.

Benchmarking the cost efficiency companies requires the formation of large amounts of data, reflecting both technological and economic aspects of the company. Our data characterizes both economic and allocative efficiency of companies: total cost, various cost items, the amount of water pumped, purified and transferred to water users, the number of pumping stations, piping length, etc.

For the purpose of comparability of costs at different times, all cost parameters in the sample were given in 2013 in accordance with the rate of inflation based on the Producer Price Index (PPI), the values of which are assembled in a regional context.

After analyzing the sample, we concluded that the data are distributed according to a lognormal distribution. If for the original sample hypothesis of normality in the Kolmogorov-Smirnov test is rejected at a significance level of 95%, for the logarithm of the sample, the same test showed statistical significance p = 0,2 on the same level of confidence. Descriptive statistics of logarithmic sample are presented in Table 1.

Tab.1. Descriptive statistics of the analyzed sample (logarithmic)

	№	Min	Max	Mean	St.dev.
Total cost, m rub.	49	12,40	14,78	13,53	0,59
Electricity cost, m rub.	49	11,17	13,44	12,12	0,60
Electricity consumption	49	3,03	5,13	4,20	0,59
Labor cost, m rub.	49	9,73	12,65	11,42	0,66
Labor, pers.	49	4,47	7,54	6,10	0,67
Capital cost, m rub.	49	8,67	12,88	10,64	1,04
Pipeline length, km	49	5,62	7,88	6,84	0,51
Pumping stations, units	49	1,10	5,48	3,53	0,96
Water lifted, thousand of cubic m	49	10,05	12,46	11,23	0,62
Water delivered, thousand of cubic m	49	9,50	12,12	10,84	0,63

For the specification models of benchmarking, we selected factors having the highest correlation with the total cost of production: Electricity cost (= 0,74), Electricity consumption (= 0,83), Labor cost (= 0,46), Labor (= 0,48), Capital cost (= 0,79), Pipeline length (= 0,43).

4.2. Methodology

4.2.1. COLS approach

COLS is a most commonly used frontier method that is based on the technique of regression and allows to assess the efficiency of firms from 0 to 1 (1 for the efficiency of the company, which forms the efficiency frontier). Using this method allows to quantify the technical cost efficiency of water companies in Russia.

As the dependent variable we have choose the total costs of water supply companies, as an explanatory - a component variable reflecting the technological aspects of the company. Similarly practices used by the British regulator Ofgem [2], in a composite variable, we selected those options of companies that reflect their technological condition, and have a close relationship with the company's costs. The composite variable can be represented as follows:

$$= \cdot \cdot \qquad (2)$$

Where – composite variable, – electricity consumption, – average number of production staff, – pipelines length, , , – weight parameters in a composite variable, and they must comply with the following principle:

$$+ + = 1 \qquad (3)$$

There are two approaches to the estimation of the parameters of the weights in the composite variable: the first one more often appears in the academic literature and is based on regression analysis [3]; the second is used by most of the world regulators and based on linear programming [2]. In our study, we have addressed the second approach, as already established methods in the global regulatory practices. Calculated on the basis of this approach, the weights reflect the results obtained from the use of DEA model with constant return to scale for medium firms using data on the cost of production as an input variable, and the consumption of electric energy, as well as the length of the pipelines and the number of production personnel as output variables. Moreover, were calculated as the average weight, the volume weighted average and median weights. The latter has the highest correlation with the company's costs and therefore was included in the subsequent analysis.

Assessing the value of a variable component for each of the companies, the following regression equation is considered:

$$\ln(\ ) = + \cdot \ln(\ ) + \qquad (4)$$

where is the total cost of production, is calculated composite variable, α,β are estimated regression parameters, and ε is the normally distributed random variable. The above regression equation is first evaluated by the method of least squares (OLS) and then regression line was transferred in parallel to the lower right corner on the value corresponding to the most efficient company.

4.2.2. DEA approach

To calculate the performance of costs we used DEA methods - nonparametric method of efficiency calculation. The most effective firms are located on the frontier forms an efficiency shell, inside of which less efficient firms are located. Performance indicators of firms take values from 0 to 1, where firms forming the frontier are assigned the value 1. DEA models can be specified as a model with constant return to scale (CRS) or variable return to scale (VRS), input-oriented or output-oriented. Output-oriented models maximize output for a given level of resources. In turn, input-oriented ones minimizes amount of used factors to produce a given level of output.

In Data envelopment analysis, we used the standard DEA model with constant and variable return to scale, described by Faere, Grosskopf and Lovell [6]. We applied input-oriented model as we believe that the level of output for water companies in Russia is given exogenously. We used two types of models used depending on the output variable. In both models, the input variable was the total cost of production. We calculated the performance indicators, using a composite variable as an output parameter in the first model based on DEA for better comparability of performance results obtained using DEA and COLS. In the second DEA model, to assess exactly allocative efficiency, there are output parameters that are not only in natural expression, but also in the price expression.

Calculations were made using the non-commercial version of the computer program DEAP Version 2.1, developed by Coelli [5]. Performance indicators in the framework of the use of DEA in general evaluated as part of solving the following optimization problem:

$$\min_{,} \theta \tag{5}$$

subject to

$$-y + Y \cdot \lambda \geq 0, \tag{6}$$

$$\theta \cdot x - X \cdot \lambda \geq 0, \tag{7}$$

$$\lambda \geq 0, \tag{8}$$

where θ is the scalar embodying efficiency scores, λ is vector of constants of size ? 1, Y and X are matrices of size ? and ? respectively, and y и x are output and input vectors-columns for the *i*-th company respectively. In models with the variable return to scale the problem statement includes the restriction on convexity $\sum \lambda = 1$, which provides a comparison of firms of comparable size.

5. Benchmarking results

5.1. COLS results

As part of the COLS method examines the relationship between total costs of companies and a composite variable that reflects the weighted consumption of production factors such as electricity, labor and capital. Thus, here we consider just the technical efficiency of companies. Assessing the performance of companies (such as the degree of deviation from the efficiency frontier), we also evaluated the model sensitivity to sample which exclude the best and the worst efficient company. Results for constructing models based on COLS shown in Tables 2 and 3 as well as Figure 1.

Tab. 2. Regression equation characteristics

Sample	Coefficient	Value	St.dev.	t-stat.	p-value	.	F	F-stat.
Full sample	a	6.757	0.648	10.433	.000	0.694	110.051	0.000
	b	1.043	0.099	10.491	.000			
	Average efficiency of companies (with standard deviation)					57% (22%)		
Without the best and worth companies	a	6.670	0,587	11,365	0,000	0.748	137.280	0.000
	b	1.056	0,090	11,717	0,000			
	Average efficiency of companies (with standard deviation)					55% (24%)		

The results demonstrate a high explanatory power of the model. Free term takes a positive value that has its logical interpretation, as we consider total, not just operating costs: with the suspension of activities companies experience losses in terms of fixed costs.

The results of implementing COLS indicated that the average efficiency in the industry is pretty low. The potential to improve cost efficiency for the industry is 43% for the original sample and 45% for more conservative second sample.

Comparison of the average values of efficiency of the industry as a whole, calculated by the model COLS on the original sample and the sample without the most and least efficient companies using analysis of variance indicates a weak sensitivity of the results to the average efficiency of the samples.

Table 3 shows the results of Evaluation rankings of their technical performance and sensitivity to the analysis sample. The quality of the model is confirmed by the fact that the ranking of companies in both samples has not changed.

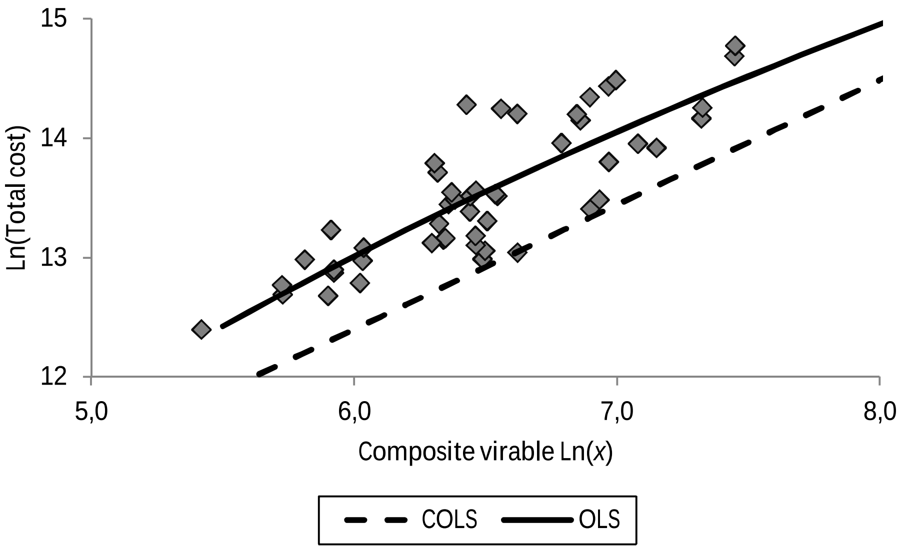

Fig. 1. COLS model based on composite variable.

Tab. 3. Results of efficiency ranking and sensitivity analysis of the COLS model.

Position	City	Year	Efficiency	City	Year	Efficiency
	Full sample			Without the best and worth companies		
			Leaders			
1	Belgorod	2011	100%	*Eliminated*		
2	Kemerovo	2012	95%	Kemerovo	2012	100%
3	Belgorod	2012	94%	Belgorod	2012	99%
4	Kemerovo	2011	92%	Kemerovo	2011	97%
5	Vladimir	2011	90%	Vladimir	2011	94%
			Outsiders			
45	Novosibirsk	2012	27%	Novosibirsk	2012	18%
46	Stavropol	2011	25%	Stavropol	2011	15%
47	Khabarovsk	2011	19%	Khabarovsk	2011	9%

48	Khabarovsk	2012	12%	Khabarovsk	2012	0%
49	Omsk	2012	0%		*Eliminated*	

5.2. DEA results

As part of the cost efficiency benchmarking of water companies we considered four DEA models: DEA based on a composite variable based on CRS and VRS (technical efficiency), and DEA on the basis of three parameters correlated in volume and value terms, also taking into account the CRS and VRS (allocative efficiency).

In the analysis on the basis of a composite variable we are faced with problems of model specification: when the considering sample of companies is fairly heterogeneous in size of companies, and in the number of input parameters, taking into account the variable returns to scale, inefficient companies that have a significant deviation from the general trend (anomalies) come closer to the efficiency frontier. This is clearly shown in Table 4.

Tab. 4. Results of DEA benchmarking model based on composite variable.

Observations	Scale	Mean efficiency (with standard deviation):	Companies that define the frontier
49	CRS	57.0% (17.6%)	Belgorod (2011)
	VRS	72.2% (18.6%)	Belgorod (2011), Kemerovo (2012), Perm (2012), Rostov-on-Don (2011,2012), Ufa (2011)
47	CRS	57.6% (17.7%)	Belgorod (2011)
	VRS	71.4% (18.0%)	Belgorod (2011), Kemerovo (2012), Perm (2012), Togliatti (2011), Ufa (2011,2012)

The table shows that in the analysis of technical efficiency with the premise of constant returns to scale, the results are almost identical: the same company is in top of list and the estimated average efficiency of the sector is virtually identical. Nevertheless, taking into account the variable scale of activities of the companies, the efficiency frontier become close to two observations of Rostov-on-Don, which demonstrates one of the worst positions in the ranking according to the results of previous analyzes. Such anomalies arise due to the fact that these observations are significantly vary in their performance indicators. Excluding these observations from the sample, we got quite a logical result: leader companies demonstrate virtually the same average efficiency as in the previous analyses.

It is worth noting that the inclusion of VRS DEA models demonstrate increased average efficiency of companies in the industry, due to widely enveloped efficiency frontier (shell).

Consideration of models DEA CRS and VRS on the basis of three factors of production allowed us to estimate allocative efficiency companies. The results are presented in Table 5.

Tab. 5. Results of DEA benchmarking model based on three parameters.

Observations	Scale	Mean efficiency (with standard deviation):	Companies that define the frontier
49	CRS	60.4% (17.7%)	Belgorod (2011)
	VRS	69.6% (18.4%)	Belgorod (2011), Belgorod (2011), Perm (2012), Rostov-on-Don (2011), Saratov (2012), Cheboksary (2013)
46	CRS	61.1% (18.0%)	Belgorod (2011)
	VRS	68.2% (17.9%)	Belgorod (2011), Perm (2012), Saratov (2012), Cheboksary (2013)

In this case, when considering the CRS model efficient frontier identifies all companies at the same order as in the previous analysis. Nevertheless, the difference in methodological approaches affects the assessment of the average performance of companies in the industry: assessment is higher than those in the DEA model with composite variable by about 3%, and the COLS model by 4%. DEA VRS model demonstrates once again the problem of inclusion too heterogeneous in size companies in the sample. Excluding anomalies in the sample, we have more or less the expected results: better performance demonstrate virtually the same leaders, as the results of previous analyses.

In general, we can conclude that the DEA models of benchmarking of technical efficiency and allocative efficiency determine almost the same leaders in the industry. It should be noted that these methods give relatively higher estimate of the average performance of companies, rather than model-based method COLS. In turn, models DEA showed higher sensitivity to the sample, because the incorporation of either too large or too small companies have led to the fetched results.

6. Key findings and recommendations

As part of the benchmarking of water companies in Russia we evaluated the cost efficiency, as well as the potential to improve it of individual companies and industry as a whole, implementing modern methods of analysis used by the world's regulators.

Estimates of the average effectiveness of companies and potentials to increase it, obtained on the basis of various methods of benchmarking, are presented in Figure 2. It demonstrates that depending on the approach used, performance evaluation, as well as the potential of its improvement, changes over a considerable range. We believe that it is not clear to conclude what kind of evaluation is more representative because the difference in methodological approaches, as well as the diversity of the sample reflected in the results.

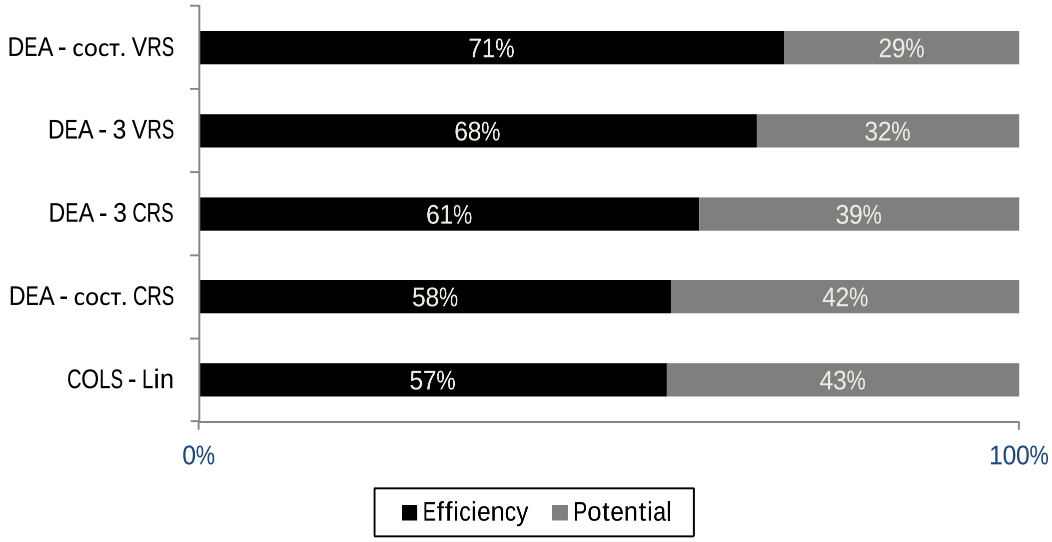

Fig. 2. Cost-effectiveness of water companies in Russia based on DEA and COLS

Indeed, parametric and non-parametric analysis methods yield similar, but still demonstrate different results for both companies and the industry. At the same time, the analysis showed some restrictions on the use of a particular approach. COLS model proved to be highly resistant to the sample. However, this model is characterized by lower estimates of the effectiveness of both the industry as a whole and companies. This is mainly due to the fact that the shape of the efficiency frontier based COLS cannot account for the companies' variable scale of return.

Application of DEA methods solved this problem, because they allow to construct piecewise-linear form of the efficiency frontier. However, the model DEA VRS based on a composite variable and on a set of three parameters demonstrated their instability to the sample:

those companies that have significant deviation from the general trend indicators (anomalies) formed the efficiency frontier, which led to misinterpretation of results.

In general, we can conclude that the benchmarking models of technical efficiency (based on a composite variable) and allocative efficiency (based on three parameters, expressed in volume and value terms) rank companies almost the same, except for some changes in the tails. This indicates that in the Russian practice it is possible to introduce regulation and monitoring of the financial aspect, as the distortion of factor prices was not as significant.

In the end, we came to the conclusion that under the incentive regulation Russian regulator can apply a combined approach, i.e. jointly used as model COLS and models DEA in order to monitor the cost efficiency of companies. The first approach is more robust, allows to include in the analysis the large number of companies with different parameter deviations from the average for the industry, and the second allows to take into account the effect of the variable scale of return of companies. The latter is especially plays an important role at the initial stage of incentive regulation because it is important to attract the companies to be involved in benchmarking regulation, while DEA models provide a more favorable assessment for companies.

We should note that in our study we were faced with the problem of the quality of statistical data. Despite the requirement by the regulator to disclose data on economic activity, many water supply organizations either do not publish them at all, or provide incomplete set of data. For example, the water utility of the city of Moscow, the largest water utility in Russia, does not publish data on the number of production personnel and payroll, which had not been included in the analysis. In this regard, we could not include in the analysis any other major companies, because they do not have the proper size analogue.

Improving standards and tougher disclosure requirements could significantly improve the quality of this analysis. So, all we collected data were analyzed in a single sample. However, with a significant increase in the number of the analyzed companies, the cost efficiency of clusters could be considered, since company size and geography of presence, as the climate and the specificity of regional social policy, significantly affect the performance of water supply companies.

However, despite the above-mentioned problems, we believe that our analysis is the first successful attempt to assess the possibility of applying the methods of benchmarking within the incentive regulation of activity of water utilities in Russia.

References

1. Averch, H., & Johnson, L. L., Behavior of the Firm Under Regulatory Constraint. American Economic Review, № 52(5), 1962, p. 1052.
2. Background to work on assessing efficiency for the 2005 distribution price control review // Report by Cambridge Economics Policy Associates, CEPA. 2003. 124 p.
3. Berg S.V. Water Utility Benchmarking. Measurement, Methodologies, and Performance Incentives / IWA Publishing. – N.Y., 2010. – 180 p.
4. Berg S.V., Lin C., Consistency in performance rankings: the Peru water sector. Applied Economics, №40, 2007. pp. 793-805.
5. Coelli, T., A Guide to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program, CEPA Working Paper 96/08, University of New England, Armidale, 1996b.
6. Faere, R., Grosskopf, S., and Lovell, C.A.K., Production Frontiers, Cambridge University Press, 1994.
7. Filippini M., Orea L. Applications of the stochastic frontier approach in Energy Economics. Economics and Business Letters. № 3(1). 2014. pp. 35-42.
8. Green, W.H. The Econometric Approach to Efficiency Analysis, The Measurement of Productive Efficiency^ Techniques and Applications, Oxford University Press, NY, 1993, pp. 68-119.
9. Laffont, J.-J., & Tirole, J., A Theory of Incentives in Procurement and Regulation, vol. 1. Cambridge: MIT Press, 1 ed., 1993.
10. Martin, S., Industrial Organization: A European Perspective. Oxford: Oxford University Press, 1 ed., 2001.
11. Moody's: Russia's 2014 tariff freeze 'unlikely' to result in rating actions." Russia & CIS Business and Financial Newswire 13 Nov. 2013. General OneFile. Web.
12. Murillo-Zamarano, L.R., Economic Efficiency and Frontier Techniques, Journal of Economic Surveys, №18(1), 2004, pp. 33-77.
13. Networks of the future - an exploratory study. Tech. rep., Netbeheer Nederland, 2011
14. NIW Comparative Efficiency: An Econometric Analysis Using Panel Data. A Report for NIAUR. Report by Nera. 2009. 43 p.
15. Posner, R., Natural Monopoly and Its Regulation. №3(21), 1969, pp. 548–643.
16. Putin: monopolies must fulfill investment programs despite tariff freeze." Russia & CIS Business and Financial Newswire 2 Oct. 2013. General OneFile. Web.
17. Russian govt might freeze natural monopoly tariffs in 2014 - paper." Russia & CIS Energy Newswire 6 Sept. 2013. General OneFile. Web.

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