Performance effectiveness of Russian energy companies based on EVA and DEA

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Abstract. Calculating both EVA and DEA indices is an effective way to comprehensive performance estimation. Russian market is full of differences between largest companies which influence their operation results. Some of them have more refinement facilities, other differ in export share or capital structure. There are plenty factors which we determined at the first stage of this research to compare those companies. Though, not all of them can really explain effectiveness changes such as EVA fluctuations or it's decreasing trough 2014-2017 years at Russian market. This is possible with using a method suggested in this research.

1 Introduction

Over the past decade and a half, there has been a significant increase in the resource-reserves orientation of the development of the Russian economy, based on revenues from the extraction and export of hydrocarbons. Until 2014, revenues from the oil and gas sector in the structure of federal budget revenues increased to 50% and taking into account other general economic taxes of the industry, this figure increased to almost 65%. In the structure of the balance of payments, reflecting foreign economic operations, foreign exchange earnings from hydrocarbon exports rose to 70%.

The bulk of sovereign funds, including gold and foreign exchange earnings, the National Wealth Fund and the Reserve Fund, were formed at the expense of revenues from oil and gas industry.

Revenues from oil and gas determined the basic parameters of the fiscal policy in terms of the expenditure and revenue parts of the federal budget and the basic parameters of taxation with the redistribution of a larger tax burden from the economy to the oil and gas complex of Russia. In addition, the dynamics of oil and gas revenues had a strong influence on monetary regulation in terms of inflation, the exchange rate, as well as a number of other indicators.

Over the past eight years, oil production in Russia has steadily increased (Fig. 1). During this period, the total oil production in the country increased by 42% or almost 8% from the level of 2017. Annual growth rates increased by 1.3% in 2011–2012. By 2014, this figure dropped to 0.7%, but already in 2016 it increased more than four times – to 2.5%.

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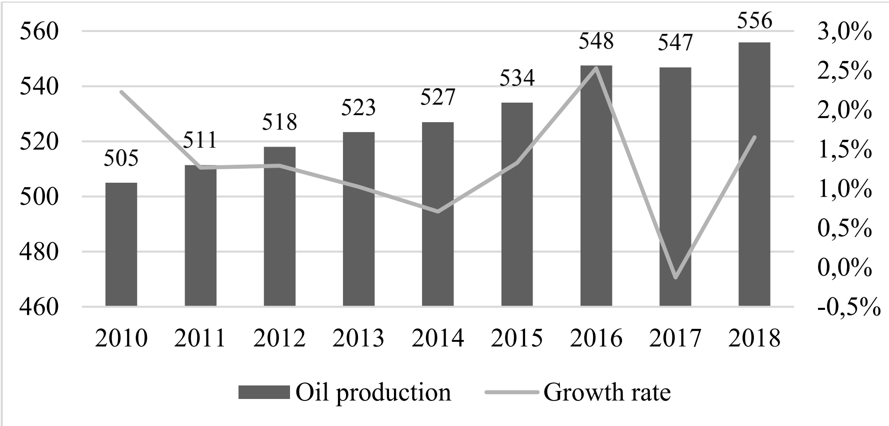

Fig. 1. Oil production and its growth dynamics in Russia.

In 2017, oil production in Russia remained at the level of the previous year and amounted to 546.8 million tons. A slight decrease in production (by 0.1%, or 0.7 million tons) can be attributed to a smaller number of days in 2017 relative to a leap year 2016 In connection with the extension of the OPEC + agreement on the limitation of oil production until the end of 2018, this year the Ministry of Energy expects production to remain at the level of 547 million tons.

Gas production in Russia in 2010–2013 had an unstable dynamic (Fig. 2). However, against the background of a reduction in fuel consumption in Europe, gas production in Russia has gradually decreased. The first positive shift in gas production in Russia occurred in 2016. The fall in oil and gas prices led to a return of interest on cheap hydrocarbons in Europe. Affected by the reduction of own production of gaseous fuels [1].

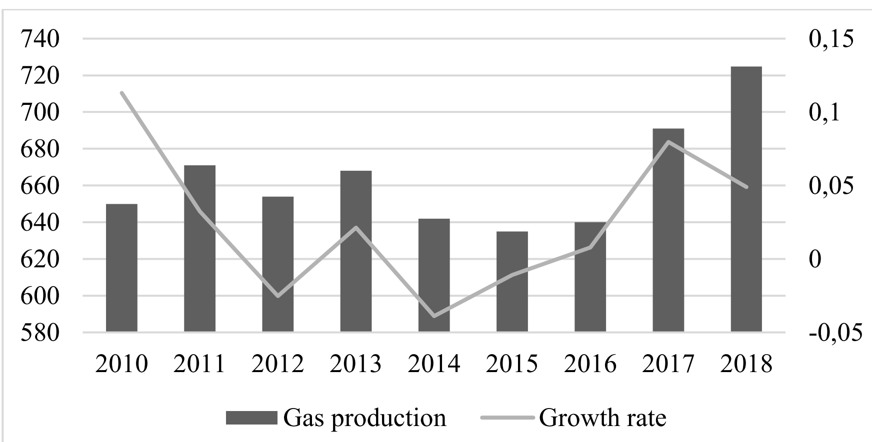

Fig. 2. Gas production and its growth dynamics in Russia.

In addition, the climatic conditions and the cold winter allowed to increase the demand for Russian gas. These effects significantly increased in 2017, when there was a record increase in gas production in Russia by more than 50 billion cubic meters, which substantially blocked the effect of falling gas production, which was observed in recent years.

2 Methods and data

2.1 Comparative analysis of theoretical and practical approaches in measuring economic performance of companies

There are many different approaches to determine economic efficiency of a company. The most famous approaches are traditional financial models, which was invented in the beginning of the 20th century were largely improved. These models is assessment of performance of a company based on calculations of a variety of internal performance indices. The most famous one related to increasing profits while reducing costs. The data used for calculation is reports of the companies through period of time (financial report) and the results of the forecasted periods depends on previous performance results [2].

An alternative to the traditional financial model is the numerous cost models for determining the efficiency of a company, in which the increase in the economic performance of its activities is related an increase in its value [3-5]. James Tobin, one of the first authors of the model, who in 1966 proposed the "theory of choice of portfolio investments".

This model creation associated with a new concept appearance called "value thinking", which means efforts of managerial staff aimed to maximize value of a particular company based on cash flows (CF) using wide range of input factors or resources (unlike traditional models focused on internal processes of an enterprise).

Some of the foreign economist invented different more efficient approach which related to allocation of costs inputs based on estimation of a cost indicators as a discounted cash flow of an enterprise. This particular method suits to estimate the effectiveness of a company comparing to other approaches. It takes into account all the possible factors of both external and internal environment of a company, because they can affect the outcomes of operating activity [6-8].

The development of value models took place in parallel with the improving plan and managerial systems, increasing competition and complexity of the challenges for owners and managers of enterprise and the evolution of information technologies. The first stage of these models evolution began with invention of factor analysis models such as (DuPont model), return on assets (ROA), return on investment (ROI), profit before taxes, earnings per share or EPS indicator, earnings before interests, taxes and depreciation (EBITDA), return on assets (RONA), Edwards-Bell-Olson model and others [9].

Their main drawback is the conduct of calculations based on data from past periods and an insufficient focus on meeting the interests of the company's shareholders. Appeared in the mid-80s last century approaches of market value added (MVA), equity value added (SVA), economic value added (EVA), cash flow return on investment (CFROI), cash value added (CVA), option pricing (OPM) and some others are designed to eliminate these and a number of other problems.

To date, the most common concept in the framework of value thinking is the concept of economic value added (EVA), developed by D. Stern and B. Stewart in which efficiency growth is understood as the excess of the profitability of capital used over its cost. The indicator gained wide popularity among US and European firms: AT & T, Quarker Oats, Briggs & Stratton, Coca-Cola, etc. Currently Russian enterprises and companies are just beginning to use this tool in strategic management.

The main advantage of the model is the ability to take into account not only what the company earned, but also the opportunity cost of capital investments. Among other advantages of the model different studies [10-12] mentioned relationship of the indicator with value-based management theory which turns it to an effective tool for value management. Also, adjustments to the original balance sheet indicators aimed at reflecting the actual directions of using the raised capital and eliminating the effect of imperfect accounting standards.

The first drawback of the indicator is the stability in time of the CARM key parameter - the beta coefficient. R. Levi analyzed the changes of the beta coefficient and resulted that for any enterprise its beta coefficient is not constant through a period of time. So, it cannot serve as an accurate estimation of future risk. The second drawback is the problem of the applicability of the CAPM model for small companies, i.e. focuses on the size problem. In general, the CAPM model does not include account all the possible factors affecting profitability and does not allow to make its analysis. CAPM is a one-factor model which is the main shortcoming of this method.

2.2 Methodical approach in measuring economic performance

As mentioned above, EVA the excess of the profitability of capital used over its cost. Any investment made creates value for its investors only if its expected return is larger than the cost of capital. This main idea of the economic effectiveness of investments for EVA is that a company or its branch creates value for owners only in case when operating income is bigger than the value of invested capital.

The formula for calculating EVA is:

$$EVA = NOPAT - WACC * CE, \tag{1}$$

where EVA = economic value added, NOPAT = Net Operating Profit After Tax, WACC = Weight average cost of capital, CE = capital invested.

NOPAT (Net Operating Profit After Tax) is a net operating profit after taxes, the optimal indicator for evaluating the performance of managers. NOPAT is also used to analyze company performance. Based on NOPAT, it is possible to make a choice between companies for alternatives to purchase. The formula for calculating NOPAT is:

$$NOPAT = EBIT - taxes\ expense, \tag{2}$$

where EBIT = earnings before interest and taxes.

EBIT is intermediate, between gross and net profit. The reducing of interest and taxes make it possible to abstract from the capital structure of the company (share of borrowed capital) and tax rates and allows to compare different companies for this index weighted by invested capital.

$$EBIT = EBT + interest\ expense, \tag{3}$$

where EBT = earnings before taxes.

Invested capital is the total amount of money raised by a company by issuing securities to equity shareholders and debt to bondholders. Here it’s formula:

$$CE = Long\ term\ debt + E, \tag{4}$$

where CE = capital invested, E = stockholder’s equity.

Weighted Average Cost of Capital, WACC is an indicator that allows an enterprise to evaluate the effectiveness of its financial investments.

WACC characterizes the cost of capital in the same way that the bank interest rate is the cost of raising a loan. Only in contrast to the bank rate, the weighted average cost of capital does not imply even payments but requires that the investor's total present income be the same as would ensure a uniform payment of interest at a rate equal to the WACC. That is, the weighted average cost of capital describes the minimum acceptable rate of return on investments. WACC formula is:

$$WACC = \frac{E}{V} \times Re + \frac{D}{V} \times Rd \times (1 - T), \quad (5)$$

where V = total liabilities (equity and debt), D = short term and long term debt, E/V = percentage of financing that is equity, D/V = percentage of financing that is debt, Tc = corporate tax rate, Re = cost of equity, Rd = cost of debt.

A common approach to assessing the level of premiums for equity risk, used in practice by the main investment banks and auditors, is the Capital Asset Pricing Model.

The essence of the CAPM model is as follows: assuming the existence of a highly liquid effective market for financial assets, it can be concluded that the magnitude of the required return on funds invested in an asset is determined not so much by the specific risk inherent in a particular asset, but by the overall level of risk characteristic of the stock market.

$$(CAPM)\ Re = Rrf + \beta \times (Rm - Rrf), \quad (6)$$

where Re = Expected return on a security, Rrf = Risk-free rate, β = Beta of the security, Rm = Expected return of the market.

Beta in the CAPM formula how close to the market does an asset behave. The most common way to calculate beta is:

$$\beta = \frac{Cov(m,a)}{\sigma_m^2}, \quad (7)$$

where Cov(m,a) = covariance of market and asset returns, σ_m^2 = dispersion of market return.

Though, it could be calculated through regression modeling, using market and asset return correlation.

Value spread formula shows how many percent of the created economic value accounts for one rouble of investment. It's formula:

$$VS = \frac{EVA}{CE} = ROIC - WACC, \quad (8)$$

where VS = value spread, ROIC = Return on capital.

Dividing NOPAT on CE we get the ROIC formula shows an operational return on attracted investments and is inherently close to the concept of return on investment (ROI). ROIC formula is:

$$ROIC = \frac{NOPAT}{CE}, \quad (9)$$

These are all the formulas we need to calculate economic value added. The exact procedure will be described in the following part of research.

2.3 DEA and its indices

There are two major types of models for measuring efficiency: parametric and non-parametric. The most widespread models for parametric estimation are Stochastic Frontier Approach (SFA), Distribution Free Approach (DFA) and Thick Frontier Approach (TFA). All of these are aimed to estimate economic efficiency. In the parametric economic sense efficiency means to choose particular structure of allocation (inputs and outputs) in order to maximize profits while minimizing costs. The major non-parametric methods are Data Envelopment Analyses (DEA) and the Free Disposal Hull (FDH). The purpose of these models is to estimate technological efficiency. In essence, technological efficiency means maximization of outputs at fixed level of inputs (output oriented model) or minimization of inputs at fixed level of outputs (input oriented model).

A parametric model captures all its information about the data within its parameters. It's all you need to predict future data value from the current state of the model is just its parameters. In case of linear regression, you need two parameters will enable you to predict a new value.

Unlike parametric models non parametric models can capture more subtle aspects of the data. It allows more information to pass from the current set of data that is attached to the model at the current state, to be able to predict any future data. The parameters are usually said to be infinite in dimensions and so can express the characteristics in the data much better than parametric models. It has more degrees of freedom and is more flexible. A Gaussian mixture model for example has more flexibility to express the data in form of multiple gaussian distributions. Having observed more data will help you make an even better prediction about the future data.

Those of works, presented for Russian oil and gas industry research are really poor in terms of mathematical models application. Actually, no one applied DEA model to measure Russian oil and gas industry effectiveness for wide range of major companies. Especially, there is no combination of EVA and DEA models in works about Russian market. Researchers usually use only one method to measure effectiveness and avoid panel data usage. There are some works with combining EVA and DEA approaches [Oberholzer, 2009], but there is no comparison of results obtained measuring efficiency in two different ways. So in this paper we use both EVA and DEA approaches.

DEA model as mentioned before is a non-parametric linear programming method which helps with measuring efficiency of its units, called decision making units or DMUs. Production process in this case looks like combination of different inputs and outputs. The economic essence of this model tells that if one company can produce certain level of output using particular amount of resources, so another firm of the same scale should be able to do the same. These models construct efficient frontiers where the resources used in the most efficient way and compare companies in relation to this frontier. All the companies out of frontier considered as inefficient units.

For DMU_j the i_{th} input is presented in the way of x_{ij} (i = 1, 2, … m) and the r_{th} output is presented as y_{ij} (r = 1, 2, … s). The optimization model looks in the following way:

$$Maximize\ \theta = \frac{\sum_{r=1}^{s} u_r y_{rn}}{\sum_{i=1}^{m} v_i x_{in}} \tag{10}$$

$$DMU_j = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1 \tag{11}$$

(j = 1, 2, …n), $u_1, u_2, \dots u_s \geq 0$ and $v_1, v_2, \dots v_s \geq 0$

The advantages of DEA model are:

- The model can handle multiple inputs and outputs;
- The model was proven to be efficient in finding correlation that couldn't notice other efficiency estimation methods;
- For this model we don't need to specify in some specific mathematical way a form for the production function;
- The model can handle any input-output estimations;
- Based on result of the model inefficiency can be quantified and analyzed for any given DMUs.

- The shortcomings of DEA are:
- Increasing the number of inputs and outputs we get more efficient firms on the frontier;
- We can't use a lot of inputs and outputs when we lack of subjects of the research (inputs + outputs number should be around 2-3 times bigger than number of subjects DMUs);
- Results of the model will be sensitive to factors selection of inputs and outputs.

2.4 Factors selection and panel data analysis

For modelling of DEA effectiveness strong correlation for inputs and outputs preferred. So, in order to choose appropriate factors for the model regression analysis was applied to explain EVA (more precisely VS) values over time.

Based on literature analysis the following factors was selected:

1. capital share;
2. debt share;
3. profit margin;
4. investment capital margin;
5. asset turnover;
6. tax burden ratio;
7. debt burden ratio;
8. financial leverage;
9. revenue to assets;
10. OPEX to revenue;
11. CAPEX to revenue;
12. export share;
13. refinement share.

For these panel data models and estimators were applied to find significant ones.

Data sample consists of 7 periods (2012-2018) and 9 companies. Then, cross sectional dimension is companies, time series dimension – years. We assume correlation within a period for companies, but not assume correlation between companies.

There are 3 basic types of panel data models: pooled model, the fixed effect model and the random effects model.

Pooled model

The pooled model specifies constant coefficients, the usual assumptions for cross-sectional analysis.

$$y_{it} = \alpha + x'_{it}\beta + u_{it} \tag{12}$$

Fixed effect model

This model assumes that alfa i's and regressors are correlated. So, we have a fixed effect for each I's company. This is an effect we can't explain by regressors. Just for some reason these companies are different.

$$y_{it} = \alpha_i + x'_{it}\beta + u_{it} \tag{13}$$

Random effect model

This model assumes that individual effect alfa i's distributed independently of regressors. So, we just include this constant in the error.

$$y_{it} = x'_{it}\beta + (\alpha_i i + e_{it}) \tag{14}$$

There are several types of estimators for specified panel data models. There are three major ones for each model listed above.

Polled OLS estimator

Basically, this indicator is used seldom for panel data. So, for the purpose of research we will use either within, between or first-difference estimators instead.

We need to decide which kind of model we have first and then choose an appropriate estimator. So, to decide which kind of model we have, we can use two different tests: Breusch-Pegan Lagrange Multiplier test (OLS versus random) or Hausman test (random vs fixed).

2.5 Economical model specification

A general flow of methodical approach can be specified by several consistent steps:

1. Data collection and preparation for EVA calculation (9 companies from 2012 to 2018);
2. CAPM, WACC and EVA calculation for company and industry in general;
3. Collecting, selecting and preparing factors which explain economic performance;
4. Choosing non-correlated set of factors;
5. Running 3 panel data estimators;
6. Choosing the best model using Hausman and Breusch-Pagan LM tests;
7. Selecting important factors in explaining economic performance using results of the estimator;
8. Preparing these factors for DEA modeling;
9. Running DEA model to get effectiveness benchmarking indices for each company and each particular year, calculating average indices through the period;
10. Demonstrating results of EVA and DEA using charts and diagrams.

Table 1. Stock quote indexes of the major OGI companies.

Index	Company
SNGS	Surgutneftgas
SIBN	Gazpromneft
LKOH	Lukoil
ROSN	Rosneft
BANE	Bashneft
SLAV	Slavneft
RNFT	Russneft
GAZP	Gazpromneft
NVTK	NOVATEK
RNHS	TNK BP

Based on the market returns of the assets of the represented companies, a beta was calculated for the CAPM formula. A simple linear regression was used to search for the beta. The yield ratio was used as a beta. The regression formula is following:

$$Ra_i = \beta \times Rm_i + C \tag{15}$$

where Ra_i = return of a stock in i's year, β = beta coefficient, Rm_i = return of the market in i's year.

In order to see how a stock return could correlate with the market return the Fig. 3 was created.

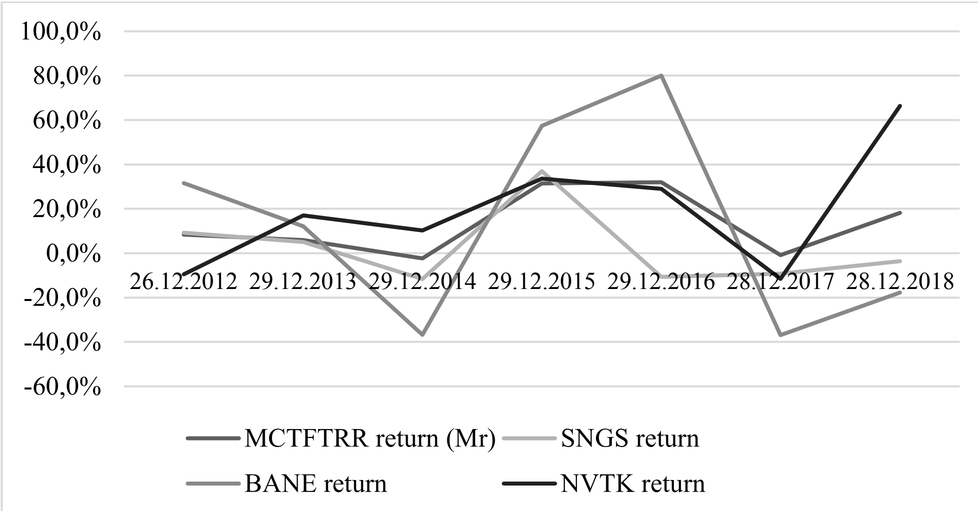

Fig. 3. Beta indicators and assets return.

On this chart you can see the dynamics of stock returns with different beta relative to market yield (black). Now we have all we need: bonds return, tax rate, average market return, betas of companies: SNGS (beta = 0.559), BANE (beta = 2.701), NVTK (beta = 1.147).

EVA calculation IFRS financial statements were used to assess economic value. The following lines of IFRS were used: gross revenue, net income before tax rate, interest expenses, equity and debt.

Based on this data NOPAT and investment capital were calculated using formulas (2), (3) and (4).

For the calculation of WACC, it was necessary to use the cost of attracting borrowed capital. For this indicator, refinancing rates of the central bank of Russia from 2012 to 2018 were used as the closest approximation to the average cost of attracting borrowed capital in the market.

Then, based on CAPM model results, refinancing rates and liabilities proportions and formula (5) WACC for the considered period was calculated. Finally, we would got EVA (1) and Value Spread index (8).

The meaning of using the VS index is that there is no possibility to compare companies with each other on the basis of an indicator expressed in value. To do this, we need to abstract from the size of companies, the value of their investment capital and consider relative indicators. For these purposes, the VS indicator was used that shows how many roubles of value are accounted for each rouble of investment. Or else this is the difference between the profitability of investment capital and the value of its attraction according to the formula (8).

Industry indexes calculation.

For comparison of companies with industry average values, sectoral indices were calculated based on average industry indicators. Indicators of financial statements were added to one large company, relative to which WACC was applied and indicators averaged across the industry were calculated.

Panel data analysis and factors selection

The second step in the approach is picking significant economic performance factors to construct DEA model. First of all, based on literature analysis of papers a list of potential

factors which influence economic value was described. Some of the factors were rejected based on lack of data or linear correlation. Then, data for listed factors was found and all of the parameters were standardized, basically, using revenue or capital as denominator. This way we can compare companies despite its various scale.
Panel data analysis was conducted using StataMP 15 software. Firstly, all of the factors were structured in xlist (independent variables) and value spread (EVA divided by investment capital). Secondly, correlation matrix among all of the factors were constructed using Pearson correlation and its significance level. This data helped to select non-correlated factors to run three types of estimators: pooled OLS, fixed effect and random effect estimator. To determine the right model among these, two types of tests conducted: Hausman test (fixed vs random effect model) and Breusch-Pagan LM test (random model vs pooled OLS model). Using P-value in regard of H0 hypothesis in this tests one specific model were chosen. For this estimator significance levels and coefficients were assessed to get the most significant factors which explain economic value. These particular factors were selected to run benchmarking DEA model.

DEA modeling
DEA model indices were estimated using specific public software Win4Deap2. The first thing was necessary to do for selected significant factors' set was adjusting data for running DEA model. DEA model can't handle negative values, so profit margin for companies were increased by a constant in order to avoid negative values as recommended for such models. Then all the panel data were uploaded to Win4Deap and split by inputs factors and outputs factors. Input oriented BBC model was constructed for each seven periods. DEA indices (technical, pure and scale efficiencies) were selected from the results for each particular year. Then average indices for each company were calculated through the period. Using year by year data benchmarking frontiers were exposed using graphs in the next chapter.

3 Modelling of economic performance for Russian oil and gas industry

3.1 EVA calculation

What is important that we apply two different models to estimate efficiency. EVA is capable to measure the excess of the profitability of capital used over its cost in money and DEA can create optimal efficient frontier of different resource (inputs) usage. That is how we can get two different estimators and comparative results could be different.

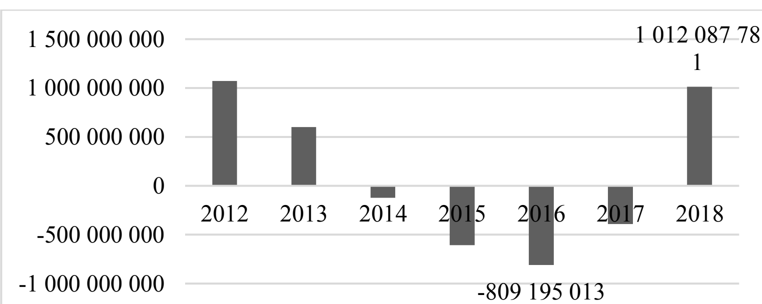

Fig. 4. Industry EVA.

In Fig. 4 you can see how industry EVA changed through the period. It's easy to notice, that companies in general generated negative EVA from 2014 to 2017 years, which were related to crisis in Russian economy, sanction restrictions, problems with attracting capital. Industry's Value spread, obviously, was negative too (Fig.5). At 2016 it was -2.5% which means that for each rouble of investment capital a company lost 0.025 roubles of its EVA.

In Fig. 11 changes of each company considered according to industry. All of the company's fluctuations centred to industry values, so the Industry line is horizontal axis exactly. We can mention some firms which performed better than industry such as Lukoil, Surgutneftegas, NOVATEK. Lukoil for example has a lot of refinement facilities which provides to be more sustainable to market fluctuations. Surgutneftegas is a vastly closed company which have a small share of equity relative to liabilities. Russneft had negative equity in 2014 and 2015 years which means that liabilities were greater than assets in general.

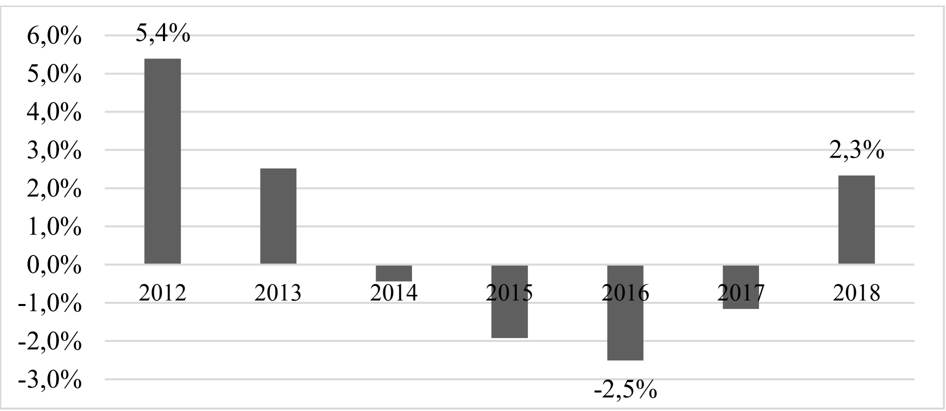

Fig. 5. Industry value spread.

3.2 Key effectiveness factors identification

Special attention was paid to conducting profound research in factors specification. Most of the literature while applying EVA only uses literature review to determine key factors for the model. I think that is not enough for this purpose and apply correlation and panel data analysis in order to choose right factors for DEA model.

The first list of factors contained 34 potential factors. Plenty of them were refused due lack of data or inappropriate form to model application. Some of them were adjusted to DEA specifications. For instance, Revenue was divided by total assets and Profit divided by Revenue. It's necessary to eliminate scale effect of different firms on the Russian market.

The list of factors potentially explaining EVA indicator:

1. Capital share (capital divided by assets);
2. Debt share (debt divided by assets);
3. Profit margin (profit divided by revenue);
4. Investment capital margin (investment capital divided by revenue);
5. Asset turnover (revenue divided by assets);
6. Tax burden ratio (net profit divided by earnings before taxes);
7. Debt burden ratio (earnings before taxes divided by earnings before interests and taxes);
8. Financial leverage (assets divided by equity);

9. Revenue to assets (revenue divided by assets);
10. OPEX to revenue (OPEX divided by revenue);
11. CAPEX to revenue (CAPEX divided by revenue);
12. Export share (export revenue divided by revenue);
13. Refinement share (refinement revenue divided by revenue).

In order to construct panel data model correlation analysis was conducted. Pearson's correlation matrix was used to choose not correlated factors. Coefficients marked with * has significant Pearson correlation (Fig. 6). Though, some of them were considered further due to either moderate significance level or low correlation level (below 0.5 for DEA modeling).

	Capita~e	Profit~n	Taxbur~o	Financ~e	OPEXto~e	Export~e	Refine~e
Capitalshare	1.0000						
Profitmargin	0.4207*	1.0000					
	0.0006						
Taxburdenr~o	-0.0569	0.2577*	1.0000				
	0.6577	0.0414					
Financiall~e	0.0715	0.0949	-0.2422	1.0000			
	0.5776	0.4594	0.0558				
OPEXtoreve~e	0.2322	0.4434*	0.1979	-0.1643	1.0000		
	0.0670	0.0003	0.1201	0.1982			
Exportshare	0.4652*	0.2198	-0.0109	0.0372	-0.3341*	1.0000	
	0.0001	0.0835	0.9325	0.7720	0.0074		
Refinement~e	0.2013	0.0997	0.1069	0.0281	-0.1633	0.3057*	1.0000
	0.1137	0.4369	0.4042	0.8269	0.2009	0.0148	

Fig. 6. Correlation matrix between chosen parameters.

Based on correlation analysis the following factors were selected:
1. Capital share;
2. Profit margin;
3. Tax burden ratio;
4. Financial leverage;
5. OPEX to revenue;
6. Export share;
7. Refinement share.

For these factors panel data estimators of OLS, fixed and random effects were calculated.

Source	SS	df	MS			
				Number of obs	=	63
				F(7, 55)	=	12.10
Model	.291060803	7	.041580115	Prob > F	=	0.0000
Residual	.188926369	55	.003435025	R-squared	=	0.6064
				Adj R-squared	=	0.5563
Total	.479987172	62	.007741729	Root MSE	=	.05861

VS	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Capitalshare	.014046	.0428374	0.33	0.744	-.0718021	.099894
Profitmargin	.3139427	.0476679	6.59	0.000	.218414	.4094714
Taxburdenratio	-.0296197	.0414347	-0.71	0.478	-.1126568	.0534174
Financialleverage	.0049133	.0024659	1.99	0.051	-.0000283	.009855
OPEXtorevenue	-.0608912	.0323278	-1.88	0.065	-.1256776	.0038952
Exportshare	-.0608978	.06923	-0.88	0.383	-.1996377	.0778421
Refinementshare	.0924699	.0316658	2.92	0.005	.0290102	.1559296
_cons	.0220663	.0532083	0.41	0.680	-.0845656	.1286982

Fig. 7. Pooled OLS estimator.

For Pooled OLS estimator (Fig. 7) significant factors appeared to be profit margin (0.314), financial leverage (0.005) and refinement share (0.09). Though, Pooled OLS is seldom for application to panel data.

Fixed effect estimator (Fig. 8) showed profit margin (0.367), financial leverage (0.05) and OPEX to revenue (-0.17) as significant factors. Overall R square is not such strong, though.

```
Fixed-effects (within) regression               Number of obs     =         63
Group variable: id                              Number of groups  =          9

R-sq:                                           Obs per group:
     within  = 0.7399                                         min =          7
     between = 0.1017                                         avg =        7.0
     overall = 0.2780                                         max =          7

                                                F(7,47)           =      19.10
corr(u_i, Xb)  = -0.6582                        Prob > F          =     0.0000
```

VS	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Capitalshare	-.0506124	.0542397	-0.93	0.356	-.1597285	.0585038
Profitmargin	.3667287	.0389981	9.40	0.000	.2882747	.4451827
Taxburdenratio	-.0547268	.0281211	-1.95	0.058	-.1112992	.0018456
Financialleverage	.0055357	.0017681	3.13	0.003	.0019787	.0090926
OPEXtorevenue	-.1798987	.0439238	-4.10	0.000	-.268262	-.0915353
Exportshare	.3266649	.1800678	1.81	0.076	-.0355847	.6889146
Refinementshare	-.0523484	.1782504	-0.29	0.770	-.4109419	.3062451
_cons	-.0461788	.1178298	-0.39	0.697	-.2832218	.1908642
sigma_u	.09327742					
sigma_e	.03869132					
rho	.8532003	(fraction of variance due to u_i)				

```
F test that all u_i=0: F(8, 47) = 9.90                       Prob > F = 0.0000
```

Fig. 8. Results of fixed effect estimator.

```
Random-effects GLS regression                   Number of obs     =         63
Group variable: id                              Number of groups  =          9

R-sq:                                           Obs per group:
     within  = 0.7353                                         min =          7
     between = 0.1631                                         avg =        7.0
     overall = 0.3693                                         max =          7

                                                Wald chi2(7)      =     139.85
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =     0.0000
theta          = .8642398
```

VS	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Profitmargin	.3603896	.0369432	9.76	0.000	.2879823	.4327969
Taxburdenratio	-.0524301	.0271885	-1.93	0.054	-.1057187	.0008585
Capitalshare	-.0352299	.0497343	-0.71	0.479	-.1327074	.0622475
Financialleverage	.0052258	.0016838	3.10	0.002	.0019255	.008526
OPEXtorevenue	-.1697128	.0380828	-4.46	0.000	-.2443538	-.0950719
Exportshare	.1766587	.146277	1.21	0.227	-.1100389	.4633564
Refinementshare	.0003413	.1094523	0.00	0.998	-.2141813	.2148639
_cons	.0082529	.0975339	0.08	0.933	-.18291	.1994159
sigma_u	.10672166					
sigma_e	.03869132					
rho	.88383075	(fraction of variance due to u_i)				

Fig. 9. Results of random effect estimator.

The last model was random effect model (Fig. 9). This estimator showed significance of profit margin (0.36), financial leverage (0.05) and OPEX to revenue (-0.169). So, in order to determine which estimator is appropriate one among those three Hausman and Breusch-Pagan LM tests was made.

For Hausman test the difference between estimators of fixed effect and random effect model was calculated (tab. 4). The results showed that P-value is 0.8965 which means we reject H0 hypothesis about systematic difference in coefficients and we should use random effects model.

Table 4. Hausman test results.

Hausman test coefficient value	2.82
P-value	0.8965

Breusch-Pagan LM test P value is 0.000 what means that we should use random effect model instead of Pooled OLS estimator (Fig. 10).

```
Breusch and Pagan Lagrangian multiplier test for random effects

        VS[id,t] = Xb + u[id] + e[id,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                      VS |   .0077417       .0879871
                       e |    .001497       .0386913
                       u |   .0113895       .1067217

        Test:   Var(u) = 0
                             chibar2(01) =    29.92
                          Prob > chibar2 =   0.0000
```

Fig. 10. Breusch-Pagan LM test results.

So, the random effects estimator showed that we have four key factors. Some of them appeared to be not significant regarding P value (Export share). Nevertheless, their coefficients are high enough to contribute effectiveness, so we chose them also. Running the model using only these four parameters approved the significance of the model. Alike previous model, tests for the right estimator pointed to random effect model.

1. Profit margin (P value = 0.000, Coeff = 0.36);
2. Tax burden ratio (P value = 0.054, Coeff = -0.524);
3. Financial leverage (P value = 0.002, Coeff = 0.052);
4. Export share (P value = 0.227, Coeff = 0.176).

3.3 DEA indices calculation

As mentioned before, to demonstrate model four factors were chosen. The following example of DEA calculation will use profit margin as an output and tax burden ratio, financial leverage and export share as inputs. For DEA indices calculation WinDeap2 software were used.

Several iterations of DEA were conducted for each particular year. Multi-stage input oriented variable return to scale model was used. The result of frontiers estimation you can see at graphs below.

In Fig. 11 you can see average of the estimated parameters of DEA model: technical efficiency and pure efficiency. Scale efficiency has no economic interpretation while we are using profit margin as an output: the greater scale is the better one by definition. Russneft, Gazprom and NOVATEK were the most efficient in terms of chosen factors and its allocation (pure efficiency). This basically means that they choose the best combination of its inputs to produce profit margin. Russneft and NOVATEK in this list had relatively low export shares which could possibly explain it's performance during crisis period. Gazprom has fewer tax burden ratio comparing to other companies and it's export share is not such large also.

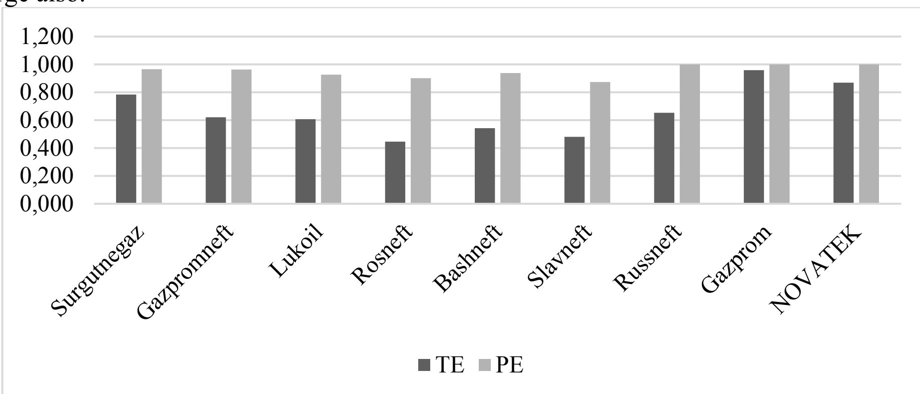

Fig. 11. Average efficiency of DMUs through 2012-2018.

Nevertheless, Russneft has quite low values of technical efficiency comparing to leaders of allocation effectiveness. The worst performing companies in terms of either pure or technical efficiency are Rosneft and Slavneft. These two companies generated the worst profit margin using listed resources. While export share and tax burden were moderate comparing to other companies, it couldn't help to become relatively profitable. Mistakes can not be only allocational one, but processes shortcomings. For instance, export share could be optimal for this particular context, but to whom we export and for what prices is not the best decision.

Now let's take a look by efficiency dynamics. In Figure 12 you can see technical efficiency estimation. So, the best values are equal to one. The most of the companies have efficiency decrease by 2014 and slight growing of technical effectiveness till 2018. That can represent how do companies adjust to market fluctuations and trying to restructure their processes in order to increase effectiveness. Meanwhile, other companies have relative decrease in effectiveness through the period, such as Russneft and Rosneft's last year dropdown. Russneft has a really volatile capital structure (two years of negative equity for instance) and high values of financial leverage. Surgutneftegas has a significant profit margin drop at 2016 which caused large ineffectiveness while inputs values didn't change so much. Lukoil and Slavneft were inefficient comparing to other companies. Lukoil through the period had large export share. Slavneft historically had low relative profit margins. Unlike mentioned companies, Gazprom and NOVATEK are efficient in relative comparison to other. It means that their production of profit margin is not effective and there could be some problems in creating outputs using inputs.

Pure effectiveness or allocative effectiveness doesn't change in such a sharp way as technical performance does (Fig. 13). Nevertheless, there are dramatic decrease for some companies in 2013 and 2014 years. What is interesting is that those companies (Slavneft, Lukoil, Bashneft) have relatively high share of export in revenue which could cause some problems of selling products through these years. Meanwhile, the top performing companies had lower export shares as the most important factor due panel data estimators.

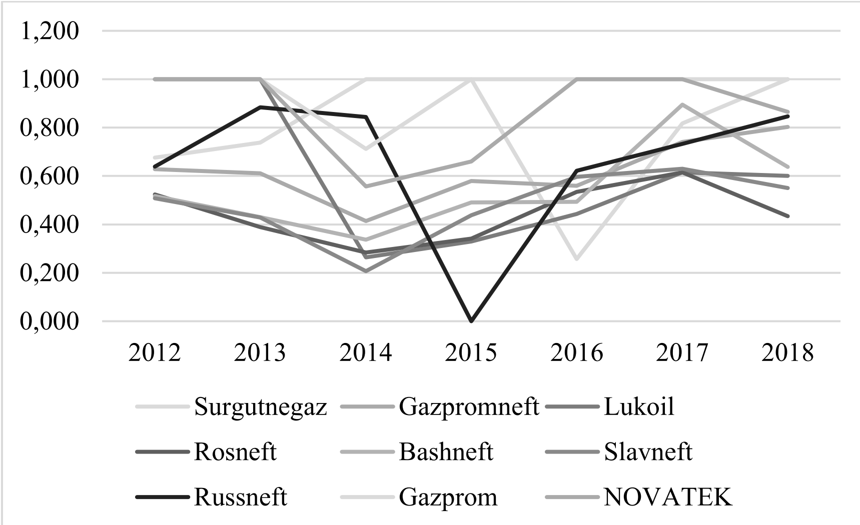

Fig. 12. Technical efficiency of DMUs.

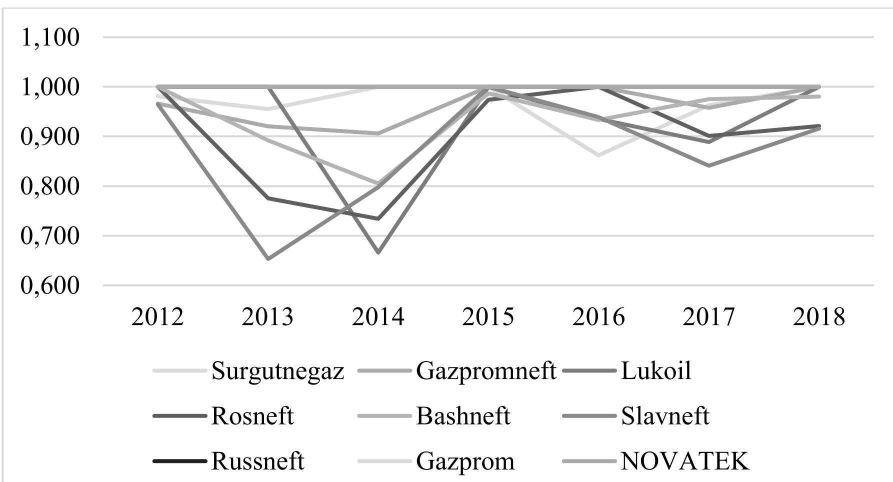

Fig. 13. Pure efficiency of DMUs.

Finally, 9 listed companies have quite different results, considering this particular set of parameters (profit margins for output and financial leverage, export share, tax burden for outputs). Used models such as EVA and DEA do provide different results, but there is no point to compare them. These models serve as complements to each other. EVA serves to find and estimate significant factors which influence effectiveness, DEA indices used to choose particular set of factors and benchmark companies based on this set. EVA and Value Spread are the more general indicators, which helped to estimate economical effectiveness through the period. Technical efficiency and pure efficiency of DEA served to benchmark companies regarding to particular set of effectiveness factors.

4 Conclusion

Calculating both EVA and DEA indices is an effective way to comprehensive performance estimation. Russian market is full of differences between largest companies which influence their operation results. Some of them have more refinement facilities, other differ in export share or capital structure. There are plenty factors which we determined at the first stage of this research in order to compare those companies. Though, not all of them can really explain effectiveness changes such as EVA fluctuations or it's decreasing trough 2014-2017 years at Russian market. This is possible with using a method suggested in this research.

Basically, the factors chosen for DEA calculation just a one of plenty possible combinations. Presented method is aimed to assess companies using different parameters. An important thing to keep in mind is the proper panel data estimators modelling which discards correlated factors and collide the rest in a proper way. Some of the cost structure can be analysed further, such as OPEX share in revenue or refinement share. This model has wide range of applications and consideration of different key effectiveness factors in order to conduct benchmarking analysis.

Methodical novelty represented in several aspects. For purposes of this research a comprehensive benchmarking method for a particular set of factors was suggested. This one based on economic value added and data envelopment analysis models. A unique set of factors for DEA effectiveness calculation was specified. Initial data for each company through the time period was adapted for specifics of models used and oil and gas industry. The benchmarking method developed within this research helps to analyze entire market through a specified time period.

Using suggested methodical approach, a wide range of practical results was accumulated. Economic value added and value spreads were calculated for each particular company and industry as a combination of these companies. Average technical and pure efficiency were estimated for listed companies based on using profit margin as an output and export share, financial leverage and tax burden as inputs. Changes of technical and pure efficiencies were estimated in particular. Significant effectiveness factors were determined using panel data estimators and specified tests. These are export share, financial leverage, tax burden, OPEX, refinement share and other in condition of a particular set chosen. Additionally, some important supportive estimates were calculated while modelling EVA and DEA, such as CAPM, WACC factors indices for benchmarking.

Finally, a comparative analysis of 9 largest companies of Russian oil and gas industry was conducted. Further researches can expand the introduced methodical approach, apply this to wider range of companies or even for another industry. Another key factors can be observed for benchmarking companies' performance.

The reported study was funded by RFBR according to the research project № 20-010-00699, basic research project lab. 349 №AAAA-A19-119110590034-6.

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