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THE EFFICIENCY OF RUSSIAN HIGHER EDUCATION INSTITUTIONS AND ITS DETERMINANTS

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In Russia, resources available for higher education institutions (HEIs) have been reduced while the expectations of their results have grown. This raises questions about the efficiency of Russian HEIs and the factors influencing it. In this paper, estimations of the efficiency of Russian HEIs for the 2012/13-2014/15 academic years and its determinants are presented. Ratios of weighted outputs and weighted inputs constructed with data envelopment analysis (DEA) are used as the HEIs efficiency measure. Total financial resources of HEIs are used as the input and measures of education and research results are used as the outputs. For the analysis of changes in efficiency the Malmquist index is used. The relation between efficiency scores and the characteristics of HEIs are investigated using a Tobit regression. This research is based on data about 120 public HEIs collected from various sources. The results show that the potential for an increase in the efficiency still remains. An outward shift of the efficiency frontier, i.e. a technological improvement, was found. According to estimations, most institutions operate at decreasing returns to scale and reducing their size will increase their efficiency. However, the substantial growth of the number of HEIs with increasing returns to scale implies that the policy of resource consolidation could be a reasonable response to current challenges. A positive relationship between HEIs efficiency and the diversification of fields of study was revealed.

JEL Classification: I21, I22, I23.

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Introduction

In 2012, public policies to stimulate the performance growth of higher education institutions (HEIs) in Russia were modernized. Annual monitoring of HEIs become a significant innovation. The monitoring implies the evaluation of HEIs based on a list of the performance indicators. This list characterises various aspects of functioning of HEIs, such as the entrance exam score of enrolled students, graduate employment, scientific results, international activity, financial sustainability and academic staff salaries. HEIs with performance indicator values that do not meet monitoring requirements face penalty measures which are selected on the basis of a closer assessment by public authorities. Among possible punishments are the obligation to establish a development programme, a temporary ban on student enrolment until the problems are eliminated, forced mergers with other HEIs or liquidation. Methods of resource allocation between HEIs were also modernised. Historically, a significant amount of funding for HEIs depended on the number of places which authorities guarantee to finance for every HEI. Annually the total number of these places for first year enrolment is approved by the authorities for each major and then the allocation procedure between HEIs proceeds. HEIs receive financing during the whole period of study for students enrolled. After the regulatory update, financing per student was fixed for fields of study and it is equal for HEIs except for a selected group called the leading universities. The allocation procedure was tied up with the values of the performance indicators. Consequently, the volume of public funding HEIs receive for educational activity is determined by their results. Monitoring and allocation procedures both imply the evaluation of HEIs relative to each other and, as a result, oblige HEIs to improve as others show progress. The functioning of these mechanisms should lead to a continuous increase in the results achieved by HEIs; however, this process is restricted by the amount of resources available to HEIs and the efficiency of how the resources are employed.

Together with policy changes, the higher education system faces a reduction in available resources. As a result of the decline in youth population, the number of students has decreased. As a consequence, public funding for the enrolment of legally guaranteed numbers of students as a share of population and resource inflow from the enrolment of fee-paying students has decreased too. Further, macroeconomic problems have led to a contraction of the government budget and opportunities for the support of HEIs have been reduced. This leads to the question - to what extent can the performance increase of HEIs be provided by the inefficiency reduction?

Generally, efficiency can be described as the ratio of output and input. For educational organisations, it is not suitable to measure output by profit. HEIs produce multiple outputs from multiple inputs, which makes it difficult to apply traditional statistical parametric methods. Several existing approaches account for the specificity of the higher education sector in efficiency estimation. Data envelopment analysis (DEA) is one of the most popular of these methods.

Another important question is what the possible drivers of the efficiency growth of HEIs are. Changes in size of HEIs can be regarded as one of them and require special consideration. In the last decade of higher education policy in Russia, mergers have become an actively used instrument. In the mid-2000s, a programme was launched to merge a number of HEIs into federal universities, which should become higher education leaders in macro-districts (federal districts). Further, in 2015, another programme of mergers, aimed at the creation of flagship universities which are to become drivers for the social and economic development of regions, was started. Mergers applied to the worst performing institutions, according to the monitoring. Despite wide use of mergers, to what extent an increase of size is the reason for the efficiency increase of HEIs in Russia remains unexplored. There are two basic reasons for the possible positive effects of HEIs size growth. The positive scale effect considers that each additional input consumed gives more output than previously, and the positive scope effect means better results with increased output diversification. There is also interest in other factors that are interrelated with efficiency of HEIs. Such factors can characterise different aspects of HEI functioning and the environment in which they operate. To determine scale effects special returns-to-scale tests can be adopted. To find the relationship between efficiency and scope and other possible determinants a regression model can be used where efficiency scores of HEIs are the dependent variable.

With increased claims of growth in results of HEIs and tougher financial constraints, it is of current interest to estimate the remaining stock of expenditure inefficiency of HEIs in Russia. For this purpose, efficiency scores for HEIs using DEA were estimated for 2012-2014. Sources of the efficiency growth were also investigated.

Several papers have been devoted to the efficiency of higher education in Russia. Abankina et al. (2013; 2016) estimated efficiency scores, with different "education" and "research" models describing educational and scientific efficiency separately. Zinkovsky et al. (2016) used the same models as Abankina et al. (2013) and showed that variance between institutions declined; they also identified differences of changes in the relative efficiency scores for groups of merged institutions. One paper (Leshukov et al., 2016) devoted to the efficiency of higher education at the regional level, where a positive correlation between regional-level efficiency scores and indicator of regional competition between HEIs was found. In all previous publications, DEA was used.

This paper addresses the following innovations in research of the efficiency of HEIs in Russia. In contrast to previous papers, the differences in the cost of producing outputs relating to different fields of study are taken into account. For this purpose, outputs are separated into two groups, named "science" and "social science". Then, it is considered that the same resources can be spent on educational and research outputs, i.e. outputs related to both are included in one model simultaneously. Changes of the HEIs efficiency during the period covered is estimated with the Malmquist index approach for the first time. This is the first research devoted to Russian HEIs where sources of the efficiency growth are investigated.

Methodology

Efficiency estimation

In this research, efficiency scores for institutions were estimated using DEA (Charnes, Cooper, and Rhodes, 1978). In DEA, the efficiency of each unit is measured as the distance to the "envelope" for the data sample; scores are calculated as the ratio of weighted outputs to weighted inputs, and weights are calculated to reflect the unit at its most efficient relative to all others in the dataset (Johnes, 2006).

Two methods of efficiency estimation in higher education research are widely used, namely data envelopment analysis (DEA) and stochastic frontier analysis (SFA). These approaches are mathematically different and both have their own inherent advantages and limitations. SFA requires assumptions about the functional form of the production function, and the distribution forms of inefficiency and noise. It makes possible statistical inferences about the quality of estimations, but any misspecifications lead to estimation errors. In contrast, DEA is less demanding with regard to assumptions but does not provide estimates of the statistical measures of results. Another key difference in the approaches is that SFA allows measurement errors while DEA assumes that data are free of inaccuracy. When DEA is implemented, efficiency scores for one or more institutions in the sample are necessarily equal to the unit, however these institutions may not function on production frontiers, i.e. they can be inefficient. Moreover, with an increasing number of inputs and outputs, the quantity of institutions with a maximum efficiency score estimated using DEA may also increase. One of the features of DEA is that it provides some additional useful information such as benchmarks for every unit, which can be valuable in developing recommendations (Thanassoulis et al., 2009).

Two orientation types of DEA exist. In the input-oriented model, it is assumed that outputs are fixed and that units minimize the level of inputs. In the output-oriented model, inputs are fixed and units maximize the level of outputs (Agasisti and Pérez-Esparrells, 2010). Due to the legislative fixing of educational production costs, output-oriented model is more suitable in this research.

It is also necessary to choose between constant returns to scale (CRS) and variable returns to scale (VRS) when DEA is used. The CRS model assumes that efficiency is not related to the scale of operations (Avkiran, 2001). While the VRS model assumes that an increase in input does not necessary lead to a proportional increase in output. The main estimation results presented below were obtained using VRS. To examine the correct returns to scale assumption for institutions in the sample, other models have also been used.

The output-oriented DEA model with VRS assumption is the following linear programming problem which is for each unit is solved (Banker, Chames and Cooper, 1984; Johnes, 2006):

$$Maximize\ \phi_k + \varepsilon \sum_{r=1}^{s} s_r + \ \varepsilon \sum_{i=1}^{m} s_i$$

$$subject\ to\ \phi_k y_{rk} - \sum_{j=1}^{n} \lambda_j y_{rj} + s_r = 0, r = 1, \dots, s,$$

$$x_{ik} - \sum_{r=1}^{n} \lambda_j\, x_{ij} - s_i = 0, i = 1, \dots, m,$$

$$\sum_{j=1}^{n} \lambda_j = 1,$$

$$\lambda_j, s_r, s_i \ \geq 0\ \forall j = 1, \dots, n; r = 1, \dots, s; i = 1, \dots, m,$$

where s are outputs and m are inputs, y_{rk} is the amount of output r used by unit k, x_{ik} is the amount of input i used by each unit k, s_i and s_r are the output and input slacks respectively. Efficiency of unit k is measured by $1/\phi_k$; unit k is efficiency if the efficiency score is equal to 1 and slacks are equal to zero.

Returns to scale

Correct returns to scale were identified for each institution. Wrong assumptions about returns to scale can lead to misleading results. Moreover, knowledge about the correct returns to scale can be valuable in further policy recommendations. Three main methodologies for returns to scale determination have been developed by Färe and Grosskopf (1985), Banker (1984), Banker, Charnes and Cooper (1984), and Banker and Thrall (1992). Banker et al. (1996) showed that these methods are equivalent. In this research, returns to scale for each university were investigated using the methodology developed by Färe and Grosskopf (1985) which is based on a comparison of the ratios of efficiency scores derived with models using different returns to scale assumptions. In the first stage, ratios between efficiency scores with assumptions of CRS and VRS are calculated:

$$S_{1i} = \frac{\theta_i^{CRS}}{\theta_i^{VRS}} \leq 1$$

where θ_i^{CRS} and θ_i^{VRS} are efficiency scores under CRS and VRS returns to scale assumptions respectively, and i is the unit number. If S_{1i} is equal 1 then the technology for i is characterised by CRS, and by VRS otherwise.

At the same time, VRS can be decreasing or increasing. Decreasing returns to scale (DRS) means that an increase in input leads to a less than proportional increase in output, while a increasing returns to scale (IRS) means that an increase in input leads to more than a proportional increase in output. To test which is correct, a second type of ratio between efficiency scores is calculated:

$$S_{2i} = \frac{\theta_i^{NIRS}}{\theta_i^{VRS}} \leq 1$$

where θ_i^{CRS} and θ_i^{NIRS} are efficiency scores under CRS and non-increasing returns to scale (NIRS) assumptions respectively, and i is the unit number. The model with NIRS suggests that units can operate under DRS and CRS (mathematical expressions for the models can be found in Färe and Grosskopf (1985)). If $S_{2i} = 1$ then technology for i is characterised by DRS, and by IRS otherwise.

Dynamics

Changes in efficiency between periods can be the result of both an individual change of the efficiency relative to the best performing units and a production frontier shift. Consequently, a comparison of DEA efficiency scores for the units between periods is insufficient for inferences regarding an improvement or decline in efficiency. The Malmquist index is an approach used to investigate efficiency time changes considering production frontier shifts and is commonly employed together with DEA. The Malmquist index for unit i can be written as:

$$M_i = \frac{D_i^t(x_t, y_t)}{D_i^q(x_q, y_q)} \left(\frac{D_i^q(x_t, y_t)}{D_i^t(x_t, y_t)} \cdot \frac{D_i^q(x_q, y_q)}{D_i^t(x_q, y_q)} \right)^{\frac{1}{2}}$$

where $D_i^q(x_t, y_t)$ is the actual output in period t relative to the maximum output that could be achieved by the unit with the technology of period q operating at (x_t, y_t), $D_i^q(x_q, y_q)$ is the actual output in period q relative to maximum that could be achieved by the unit with the technology of period q operating at (x_q, y_q), $D_i^t(x_t, y_t)$ is the actual output in period t relative to the maximum that could be achieved with the technology of period t operating at (x_q, y_q), and $D_i^t(x_q, y_q)$ is the actual output in period q relative to the maximum that could be achieved for the unit with the technology of period t operating at (x_q, y_q). The first component of the equation is the ratio of the efficiency at period t and at q, and the second is the technology frontier shift between the periods.

Efficiency model

HEIs provide three types of output that are related to education, science and "the third mission". There is no consensus about appropriate quantitative measures of the last and it not covered by this research.

The basic measure of education output is the number of students. In this paper students were divided into two groups, namely students of "science" and "social-science" programmes. This takes into account the difference in the cost of teaching different students and the financing provided. One of the accepted indicators of quality in higher education research is entrance exam score (Roschin and Rudakov, 2015). Enrolees in Russia are required to pass the unified state exams (USE). On a par with the required exams in certain disciplines, students also choose additional subjects required by selected program of study in institution. The measurement scales for the examinations are different despite the uniform minimal and maximal score (0 and 100, respectively). An "excellent" grade can be given by a different score for different exams. The division of students and examination results into two groups helps overcome this due to an increase in the homogeneity of the exams taken inside selected groups. However, the grade scales for subjects change slightly from year to year. Changes in results can be as a consequence of grade inflation or changes in the quality of secondary school teaching and enrolee preparation efforts. To overcome these problems, average "science" and "social-science" USE scores for HEIs are divided by the sample averages for each year.

To measure the research output, two types of indicators are commonly used, namely the amount of research financing and the number of academic publications. Finance as an indicator is a less appropriate output measure as it can regarded as an input. In this research, publication activity is used to measure research output. Despite the inclusion of publications in international academic journals as indicators of performance of institutions by government and accounting for it in the distribution of financial resources, Russian HEIs still show uniformly poor results in the production of such publications. At the same time, institutions are relatively productive in the number of publications in Russian academic journals. However, the latter are different in terms of quality and accept publications more readily. In 2015, with the participation of the Higher School of Economics, Thomson Reuters and the Russian Academy of Sciences, a list of "quality" Russian academic journals was selected to compile the Russian Science Citation Index (RSCI). In this research, publications in journals included in the RSCI are regarded as quality-adjusted scientific results. As educational output, they also were divided into "science" and "social science" groups.

As for input measures, institutions use labour, finance and equipment. An aggregate financial indicator, which includes expenditure on labour and equipment, is used as a single input. A model with a disaggregated input was estimated for robustness checks.

The specification of the "main" efficiency model is presented in Table 1.

Table 1 Specification of the "main" model (Model 1)

Variable	**Definition**
Input	
TOTAL_INCOME	Total income
Outputs	
STUD_SCN_USE	Number of FTE students enrolled in science courses adjusted by entrance exam score of students of these courses
STUD_SSCN_USE	Number of FTE students enrolled in social science courses adjusted by entrance exam score of students of these courses
STUD_POSTGRAD	Number of postgraduate students
PUB_SCN_RSCI	Number of publications in science journals indexed in RSCI
PUB_SSCN_RSCI	Number of publications in social science journals indexed in RSCI

Determinants of efficiency

To estimate the relationship between efficiency scores and different variables describing institutional and external characteristics, a Tobit regression was used.

Robustness check

DEA results are sensitive to the input and outputs variables used. For capital-intensive "science" teaching and research production the amount of equipment is more important than for "social-science" activity. This can be crucial for results if the different importance of input is ignored. Here, main findings with disaggregated input are presented.

Data

Data from a number of sources were used. The main source is a publically available government database of the results of HEI monitoring. Data concerning the USE results were collected from HEI websites during regular Admission Quality Monitoring conducted by the Higher School of Economics. Publication information was obtained from the Scientific Electronic Library (eLIBRARY). The regional statistics used are published by the Russian Federal State Statistics Service.

The sample covers public HEIs, data about which are available for every year covered by this research, and those that do not have branches in Russia and other countries. A number of HEIs were excluded due to data errors. In total, the number of HEIs included in the sample is 120. Descriptive statistics can be found in appendix.

Financial and publication data refers to the calendar year, i.e. from January to December, and other indicators are available for academic years. In this research, data for the year 20XX corresponds to the 20XX/20YY academic year. The number of students and staff are expressed in full-time equivalents (FTE). Financial data and GDP are deflated by the consumer price index.

Results

Efficiency estimation

The efficiency score estimation results are presented in Table 2. The mean values of the efficiency scores for Russia are lower compared to the results obtained for other countries. For the DEA scores estimated with the output-oriented model, inefficient HEIs can increase their output by (1-DEA score)×100% to reach the technology frontier without any increase in input. Regarding the 2014/15 academic year, HEIs could produce 23% more output with the amount of input used.

The results show a decrease of the variation in performance between HEIs. Between 2012/13 and 2014/15, the minimal efficiency scores increase from 0.241 to 0.279. At the same time, the number of efficient units decreased from 32 to 24. The latter partly explains the decrease in the mean of the efficiency scores.

These results show only the change of homogeneity between HEIs during the period. Conclusions about change in performance cannot be made because the results of the DEA are relative scores and performance for each unit is compared with the best performing unit in a particular year. The estimation of change in performance is also presented in this paper below.

Table 2 Results of efficiency scores estimation

Year	Mean	Minimum	Maximum	Standard Deviation	Number of efficient units
2012/13	0.791	0.241	1.000	0.204	32
2013/14	0.780	0.272	1.000	0.201	28
2014/15	0.770	0.279	1.000	0.196	24

Returns to scale test results

The estimated numbers of HEIs operating with DRS, CRS or IRS are presented in Table 3. For the 2014/15 academic year, most institutions (55.0%) operate with DRS, i.e. reducing the scale of operations should be considered; 35.8% of institutions operate with IRS and their activity can be expanded; 9.2% face CRS. Between 2012 and 2014, the number of institutions with DRS decreased, and at the same time, the number of institutions with IRS grew.

Table 3 Number (and % of sample) of institutions operating with decreasing, constant or increasing returns to scale

	Decreasing	Decreasing, %	Constant	Constant, %	Increasing	Increasing, %
2012/13	88	73.3	11	9.2	21	17.5
2013/14	71	59.2	9	7.5	40	33.3
2014/15	66	55.0	11	9.2	43	35.8

Using the procedure described by Simar and Wilson (2002), an additional returns to scale test was conducted. This strongly indicates that HEIs in the sample operate with VRS.

The Malmquist index and its components

Annual changes in total factor productivity (TFP) measured with the Malmquist index are presented in Table 4. The change in TFP has two components: changes in technical efficiency and the technology frontier. Between 2012 and 2014, the average TFP of institutions improved by 4.6%. This growth is primarily the result of an average technology frontier shift by 5.0%; average technical efficiency increased by 0.6%.

Table 4 Averages of annual changes in Malmquist Indexes and its components

	From 2012/13 to 2013/14	From 2013/14 to 2014/15	Whole period
Malmquist index	1.012	1.037	1.046
Efficiency change	1.000	1.007	1.006
Technology change	1.014	1.033	1.050

Determinants of the efficiency

In the second stage, the relationship between the efficiency score and the number of variables was examined using the Tobit model.

The primary goal of the estimation is to examine whether there is a relationship between efficiency and the scope of education and its possible direction. While diversification can be related to economy of scope, which implies that interdisciplinarity may lead to a decrease in the production costs of HEI outputs (Agasisti and Johnes, 2010), a concentration on competitive advantages can also be beneficial for HEIs (Wolszczak Wolszczak-Derlacz and Parteka, 2011; Teixeira et al., 2013). Followng Teixeira et al. (2012), the index of diversification calculated as:

$$DIVERSIFICATION_{it} = \frac{1}{\sum_j \left(\frac{x_{ijt}}{X_{it}}\right)^2}$$

where x_{ijt} is the number of FTE students enrolled in jth major (one of 28 according to OKSO codes) in ith institution during period t, and

X_{it} is the total number of FTE students in ith institution during period t.

As Leshukov et al. (2016) pointed out, competition and efficiency in higher education are interrelated. To take into account the relationship between the efficiency of individual institutions and the level of competition, the Herfindahl-Hirshman index for regions where institutions are situated as a competition measure was included in model. The Herfindahl-Hirschman index HHI_{it} calculated as:

$$HHI_{it} = \sum_{j} \left(\frac{r_{ijt}}{R_{jt}} \right)^2$$

where r_{ijt} is the number of FTE students in jth institution situated in the same region as ith institution during period t, and R_{jt} is the total number of students in institutions operating in the same region as ith institution during period t.

The source of finance is also regarded as a possible factor affecting efficiency. Allocation of publically financed places for students between institutions in Russia is based on the previous performance of the institutions in education and research[3]. More successful institutions, in terms of the allocation criteria, receive more finance for student enrolment, and the least well-performing institutions receive a significantly less public funding. Moreover, students with lower entrance exam scores have a lower chance of publically funded study. As a result, it can be considered that a lower share of public finance in the total income is related to lower efficiency as estimated with the presented model.

It is necessary to take into account the quality of academic staff at institutions, which is measured as the share of academic staff with postgraduate degrees.

The location of institutions can also be a substantial factor affecting the efficiency of institutions. In more economically developed regions there can be a higher demand for education and the scientific results of institutions. It is also possible, however, that institutions push poorer regions, and in this case, the relationship will be reversed (Agasisti and Wolszczak-Derlacz, 2014). To control for the relationship between different economic conditions, the gross-regional product per capita of regions where the institutions are situated was included in the model. To account for the fact that the wealth of a region can be related to resource rent or production development, the share of the mining industry was also included in the model. To examine the determinants of efficiency, the following model was employed:

$$DEA_{it} = \alpha + \beta_1 DIVERSIFICATION_i + \beta_2 ACADEMIC\_STAFF\_POSTGRAD_{it} + \beta_3 PRIVATE\_SHARE_i + \beta_4 HHI_{it} + \beta_5 GDPPC_{it} + \beta_6 RESOURCE_i + \beta_7 DUMMY\_2013 + \beta_8 DUMMY\_2014 + \varepsilon_{it} ,$$

where DEA_{it} is the efficiency score estimated at the first step,

$DIVERSIFICATION_i$ is the index of institution student body diversification (for the 2014/15 academic year),

$ACADEMIC\_STAFF\_POSTGRAD_{it}$ is the share of academic staff with a postgraduate degree equivalent to PhD degree ("kandidat nauk" or "doktor nauk"),

$PRIVATE\_SHARE_i$ is the share of financing from non-public sources (for the 2014/15 academic year),

HHI_{it} is the regional higher education institution market concentration index (monopolisation measure), for regions where the ith institution is situated, measured as the Herfindahl-Hirschman index,

$GDPPC_{it}$ is the gross regional product per capita of region where the ith institution is situated,

$RESOURCE_i$ is the share of mining in gross regional product of the region where the ith institution is situated (for 2014),

[3] Decree of the Ministry of Education and Science 01.04.2015 N 340

$DUMMY\_2013$ and $DUMMY\_2014$ are time dummies for the 2013/14 and 2014 academic years respectivly,

i is the institution index, t is the period index.

The results of the model estimation are presented in Table 5. There is a positive significant relationship between the efficiency scores, the diversification of the institution and the share of academic staff with a PhD-degree equivalent. A negative significant relation is observed with monopolisation and the share of mining in the gross regional product.

Table 5 Estimation results of truncated regression to identify determinants of efficiency

Variable	**Coefficient**		**Z-score**
CONSTANT	0.601	**	(7.241)
DIVERSIFICATION	0.006	**	(3.028)
ACADEMIC_STAFF_POSTGRAD	0.004	**	(3.449)
PRIVATE_SHARE	0.0002		(0.232)
HHI	-0.320	**	(-5.296)
GDPPC	-0.038		(-0.859)
RESOURCE	-0.005	**	(-4.944)

Log-likelihood: 132.4
p-value < 0.01
** significant at 0.01, * significant at 0.05

Robustness check

The specification of the model with disaggregated input is presented in Table 6. Yearly expenditure on fixed assets are used as a proxy for capital.

Table 6 Specification of model with disaggregated input (Model 2)

Variable	**Definition**
Input	
ACADEMIC_STAFF	Number of FTE academic staff
COST_ADMIN	General and administrative expenditure
COST_EQUIPMENT	Expenditure on fixed assets
Outputs	
STUD_SCN_USE	Number of FTE students enrolled in science courses adjusted by entrance exam score of this students
STUD_SSCN_USE	Number of FTE students enrolled in social science courses adjusted by entrance exam score of this students
STUD_POSTGRAD	Number of postgraduate students
PUB_SCN_RSCI	Number of publications in science journals indexed in RSCI
PUB_SSCN_RSCI	Number of publications in social science journals indexed in RSCI

The mean of efficiency scores estimated with Model 2 is higher than the result obtained using Model 1 by 3% (

Table 7). However, this result can be partly explained by the positive relation between the DEA efficiency scores and the number of inputs and outputs.

Table 7 Results of efficiency scores estimation for alternative model (Model 2)

Year	Mean	Minimum	Maximum	Standard Deviation	Number of efficient units
2014/15	0.795	0.394	1	0.177	34

Conclusion

The higher education system in Russia is experiencing two opposing processes. With a decrease in the amount of resources available, the implementation of measures aiming to increase the results of HEIs continues. This research investigates what unutilised internal resources the higher education system has to improve results, to estimate to what extent policy changes directed at increasing the performance of institutions have been successful, and to find the determinants of the efficiency of HEIs. The study provided estimates based on a sample of 120 institutions for the 2012/13, 2013/14, 2014/15 academic years. Data envelopment analysis was implemented to calculate efficiency, while the Malmquist index was used for the estimation of efficiency dynamics and their components. In addition, the relationship between efficiency and potential determinants was estimated using a Tobit regression.

The results indicate that HEIs have internal resources for improving results. For the 2014 /15 academic year, institutions could increase their output on average by 23% without increasing input. This value is less then results in Abankina et al. (2013) for 2010 where average inefficiency of institutions varies between 26%-34%. Thus, further measures for efficiency growth stimulation are reasonable.

It can be supposed, that the monitoring of HEIs and the modernization of the public finance allocation procedure between HEIs that took place at the beginning of the study period had a positive impact on the efficiency of HEIs and can be regarded as valuable tools in future. This can be confirmed by the 5% productivity growth during the covered period. Unfortunately, the comparison of efficiency changes before and after reforms was impossible due to data restrictions. But there are also grounds to consider that policy mechanisms need improvement. The productivity growth observed is a result of a frontier shift, not individual efficiency growth. In other words, typical HEIs were not coming near to the best-practicing HEIs and additional policy is required for less efficient HEIs to catch up with the most efficient. The period is also characterized by a decrease in the variation of HEIs efficiency, with a decrease in the number of lagging and best-performing universities. The increase of homogeneity of the efficiency scores is also confirmed by findings of Zinkovsky et al. (2016). This result can be also considered a consequence of public intervention.

Besides the policy mechanisms mentioned, other measures can be regarded as ways of the higher education system. Changing of size of HEIs will increase their efficiency as a non-optimality of sizes of HEIs was found. Most institutions (55%) operate with decreasing returns to scale, and the utilisation of one additional unit of input gives less output than the before. For these HEIs reducing production is recommended. At the same time, 36% of institutions should expand their activity as they operate with increasing returns to scale. Only 9% of institutions face constant returns to scale. Such heterogeneity and the dominance of institutions with decreasing returns to scale indicate that the mergers of institutions as policy instruments should be used with caution. Meanwhile, possible measures of resource redistribution should take into account past trends in returns to scale changes. The substantial growth of the share of HEIs with increasing returns to scale and the fall of share of HEIs with decreasing returns to scale during the covered period was found. This can be regarded as a result of the decline in the number of students due to the demographic situation. Such a trend supports the policy to consolidate resources in response to current challenges.

It was also found that specializing in fields of study does not provide additional gains. Conversely, a positive relationship between efficiency and diversification was found. It raises question of the reasonableness of Russian HEIs with industrial specializations.

Overcoming the gap found between HEIs should not be accompanied with further financing restrictions for the higher education system. Inefficiency scores presented in the paper show lagging of HEIs from best-performing HEIs. In other words, further steps are needed to overcome the inefficiency between HEIs. But being fully efficient, the Russian higher education system will still not produce results comparable with results of more productive higher education systems of other countries. To catch up other countries significant additional financing is needed. Expenditure per student in Russia is equal 60% of expenditure per student in OECD countries (OECD, 2016). Efficiency growth will release additional resources but will not close the gap.

In the further research, the results should be examined for different groups of HEIs due to substantial heterogeneity in the Russian higher education system. The relationship between efficiency and other factors not covered by this research need to be investigated. Due to restrictions of DEA the implementation of alternative methods for robustness analysis is important.

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Appendix

	2012				2013				2014			
	Mean	**Min**	**Max**	**Std. Dev**	**Mean**	**Min**	**Max**	**Std. Dev**	**Mean**	**Min**	**Max**	**Std. Dev**
USE_SCN	1.0	0.0	1.6	0.2	1.0	0.0	1.6	0.3	1.0	0.0	1.6	0.2
USE_SSCN	1.0	0.0	1.5	0.3	1.0	0.0	1.4	0.3	1.0	0.0	1.5	0.3
STUD_SCN	2128.3	0.0	7510.6	1608.7	2131.6	0.0	7629.4	1629.5	2117.9	0.0	7531.9	1632.1
STUD_SSCN	1881.3	0.0	7265.0	1606.6	1780.3	0.0	6664.4	1532.5	1683.3	0.0	5726.3	1458.2
STUD_POSTGRAD	170.8	10.0	612.2	117.3	153.7	10.0	609.8	108.2	139.8	4.0	654.8	104.6
PUB_SCN_RSCI	35.5	0.0	432.0	58.8	34.1	0.0	375.0	54.5	36.7	0.0	354.0	57.6
PUB_SSCN_RSCI	6.1	0.0	108.0	13.2	6.0	0.0	113.0	12.8	6.0	0.0	113.0	13.5
TOTAL_INCOME	726652.8	89040.8	3442076.1	521941.5	710204.8	89599.3	4197270.2	539753.7	682145.1	84713.2	4490244.7	552302.0
ACADEMIC_STAFF									335.6	13.1	992.4	175.7
COST_EQUIPMENT									99539.2	1856.7	1476917.1	180336.7
COST_ADMIN									263237.1	22323.6	1545035.7	213958.9
DIVERSIFICATION	6.4	1.0	20.8	4.3	6.4	1.0	20.8	4.3	6.4	1.0	20.8	4.3
ACADEMIC_STAFF_POSTGRAD	66.8	32.1	89.0	10.5	71.3	52.0	91.3	6.7	73.4	52.4	94.1	7.6
GDPPC	351383.7	77877.2	1719109.2	347864.4	352202.5	86295.8	1615557.8	331803.4	343370.7	88160.7	1532663.4	319187.9
HHI	0.2	0.0	1.0	0.2	0.2	0.0	1.0	0.2	0.2	0.0	1.0	0.2
RESOURCE	8.0	0.0	67.9	15.6	8.0	0.0	67.9	15.6	8.0	0.0	67.9	15.6
PRIVATE_SHARE	33.0	5.6	81.4	14.3	33.0	5.6	81.4	14.3	33.0	5.6	81.4	14.3

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