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Measuring Efficiencies of Turkish Public Universities with Non-Parametric Efficiency Estimation Method

Türkiye'de Kamu Üniversitelerinin Etkinliğinin Parametrik Olmayan Yöntem ile Ölçülmesi

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Abstract: The purpose of this paper is to estimate technical and cost efficiencies of public universities in Turkey between 2005 and 2010 by the means of non-parametric technique named as Data Envelopment Analysis (DEA). In doing so, overall efficiencies of HEIs are computed on the basis of certain production and cost models motivated by different sets of input/output. The results of those models, firstly, have shown that majority of public HEIs in Turkey are performing at unsatisfactory levels although some of them are doing fairly well. Besides after employing bootstrapping procedures, results indicated that efficiency scores are significantly diverging between best and worst performing institutions. Secondly, even though there is not any systemic improvement during this five-year time span, overall efficiencies of public HEIs in Turkey had gone up at the course of 2008-2009 and 2009-2010 academic years. Thirdly, the share of full-time academic staff in the whole faculty and having a medical school are found as the determinants of inefficiencies among HEIs regarding to the estimates of Tobit regression analysis. Consequently, even though those findings might have methodological limitations concerning the DEA, results of the study are recommended to be used as the departure points both for academic and policy-making interests.

Keywords: Data envelopment analysis, technical and cost efficiency, public higher education, Tobit regression, Turkey

ÖZ: Bu makale, Türkiye'deki kamu üniversitelerinin teknik ve maliyet etkinliklerini parametrik olmayan bir yöntem olan Veri Zarflama Analizi (VZA) ile hesaplamaya çalışmaktadır. Bu çerçevede, örneklem kümesine alınan üniversitelerin kaynak etkinliği skorları, farklı girdi-çıktı modellerine sahip üretim ve maliyet fonksiyonları kullanılarak ölçülmüştür. Bu modeller referans alınarak ulaşılan sonuçlar, ilk olarak Türkiye'deki kamu üniversitelerinin etkinliğinin bazı istisnalar dışında iyi olmadığını gözler önüne serdi. Buna ilaveten, bir takım özyükleme (*bootstrapping*) prosedürleri neticesinde, iyi performans sahibi üniversiteler ile kötü performans gösteren üniversitelerin birbirlerinden tamamıyla farklılaştığı ortaya çıktı. İkinci olarak, ele alınan beş yıllık akademik yıl zarfında (2005-2010) düzenli her hangi bir etkinlik iyileşmesi olmamasına rağmen 2008-2009 akademik yılı itibariyle az da olsa bir düzelme olduğu tespit edilmiştir. Üçüncü olarak ise, Tobit regresyonu ile yapılan analizlerde tam-zamanlı akademik personel oranı ve tıp fakültesine sahip olmanın etkinlik performansını etkilediği saptanmıştır. Sonuç olarak, bu bulgular belli metodolojik sorunları içerisinde barındırsa da, bundan sonraki akademik çalışmalar ve politika yapım kararları için önemli bulguları barındırmaktadır.

Anahtar Sözcükler: Veri zarflama analizi, teknik ve maliyet etkinliği, kamu yükseköğretimi, Tobit regresyonu, Türkiye

1. INTRODUCTION

Estimating technical and cost efficiencies of higher education institutions (HEIs) has become a central area of research in the literature of efficiency analysis particularly at the course of the last two decades. Unlike other for-profit entities that have been under scrutiny in terms of efficiency performance by researchers such as banking and airlines companies, not-for-profit

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motive among HEIs run either public or non-profit entrepreneurs has attracted attentions of researchers to test the fundamental arguments around incentive-efficiency dichotomy claiming that lack of profit motivation among non-profit and public organizations would lead them to operate less efficient then their for-profit counterparts (Ben-Ner, 2002). Eventually, a remarkable number of papers –whose results are discussed in the following section-, have accumulated on the efficiencies of HEIs that were applied to various country cases including UK, Sweden, Canada, Australia, China and Greece (Katharakia and Katharakis, 2010; Daghbashyan, 2011).

So as to investigate efficiencies of HEIs, two mainstream methodologies were developed: Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA). In this paper efficiencies of public HEIs in Turkey are estimated by employing non-parametric DEA technique. This paper aims to address certain questions that have vital importance for the various aspects of public HEIs in Turkey regarding their efficiency performances. In other words, the analysis of this research sheds light on the extent to which public HEIs are using their resources in an efficient manner both individually and the sector as a whole within the framework of the non-parametric efficiency estimation technique. Those questions are:

1. What are the overall technical and cost efficiency levels of public HEIs in Turkey concerning different input/output specifications and production/cost frontier?
2. How efficiency scores are behaving when bootstrapping procedures are taken?
3. To what extent efficiency scores are changing throughout 5-year time span?
4. What are the determinants of inefficiencies among public HEIs? Do environmental factors matter for universities concerning efficiency performances?

The organisation of the paper is as follows: Section 2 reviews the literature building upon non-parametric efficiency researches on HEIs; Section 3 discusses the methodology. The following section –section 4- illustrates the dataset and variables that are used for this analysis and also puts forward models comprising different input/output sets. Section 5 summarises the mean efficiency values for selected DEA models and examines them as well as conducts robustness tests for the models in the light of spearman rank correlation values. Section 6 illuminates the potential driving forces behind inefficiencies by employing two-stage DEA method through which efficiency values are estimated in the first stage and Tobit regression model is carried out to reveal the association between certain environmental variables and efficiency scores in the second. Section 7 concludes.

2. REVIEW OF LITERATURE

The pioneering works on this particular area of research may be enumerated as follows: Johnes and Johnes (1993), Coelli (1996) and Madden, Savage, and Kemp (1997). The first one applies a basic DEA model to the 36 UK university economics departments for the 1989 academic year. The second paper deals with 36 Australian universities using a Variable Returns to Scale (VRS) model through which both technical and scale efficiencies of universities were computed. And the third paper investigates 24 Australian university economics departments between 1987 and 1991. All these three papers form the fundamentals of the literature in higher education efficiency analysis and encouraged further researches, even though they put forward inadequate insights on the efficiencies of HEIs in broad-spectrum. Moreover, the main concern of these aforementioned papers is to address the reliability of DEA to become an appropriate performance indicator for HEIs as clearly put forward by Johnes and Johnes (1993): "We conclude that DEA has a positive contribution to make in the development of meaningful indicators of university performance". Accordingly, subsequent researches on the efficiency analysis of HEIs have been built upon the theoretical as well as methodological framework put forward by Johnes and Johnes (1993), Coelli (1996) and Madden, Savage, and Kemp (1997).

After the first stream of papers, the most comprehensive work which still preserves its significance in the literature –due to its inquiry on the determinants of inefficiency- is Macmillan and Datta's piece (1998) written on 45 Canadian universities for the 1992-1993 academic year. They estimated efficiencies of universities concerning different input/output sets to check the robustness of efficiency values and ended up with the fact that overall efficiency among Canadian universities is nearly 94% which would be "upwardly biased due to modest number of observations" as the authors argue. In addition to the efficiency estimates, they conducted two-stage DEA analysis to reveal the determinants of inefficiency in Canadian higher education sector. Abbott and Doucouliagos's work (2003) covers 36 Australian universities for the academic year of 1995. They find that Australian universities are operating very close to the technically efficient frontier for the different mixture of input and output measurement sets. However, efficiency results suggest, "There is still room for improvement in several universities".

Casu and Thanassoulis (2006) focus on UK universities' central administrative services (CAS) based on 1999/2000 academic year. Their initial findings claim that 17 institutions out of 108 are found cost-efficient. Besides UK universities have mean inefficiency scores of 27% on providing CAS. In relation to the scale efficiency estimations, the result corresponds to the fact that although universities have different sizes, there is not an indication of scale inefficiency 'with the exception of a few institutions'. Another significant analysis coming out of this particular paper is that new universities are paired with new universities whilst old universities are paired with the old ones as far as the peer analysis is concerned.

Johnes (2006) extended her previous works with updated data and more comprehensive analysis including robustness checks for the efficiency results. She applied DEA with bootstrapping methods to the universities in England for the academic year 2000-2001. As a consequence of bootstrapping procedures –which is the distinctive attribute of this paper as it is the first research develops bootstrapping method- that are followed up to construct 95% confidence intervals for efficiency scores of the universities, pointed out that there is a significant difference between best- and worst-performing English universities. Hence, "while DEA cannot reliably be used to discriminate between the middle-performing HEIs in terms of their level of efficiency, it can discriminate between the worst- and best performing HEIs".

In recent years, DEA is commonly and widely applied to measure efficiency performance of the HEIs for different datasets with more enhanced methodological papers. Flegg et al. (2004) computed efficiency values of 45 British universities with multi-period DEA through which the influence of public funding and student/staff ratios on the variations in efficiencies among the chosen universities is figured out. Worthington and Lee (2008) focuses on inter-temporal analysis of efficiency scores among 35 Australian universities by way of employing Malmquist index. The results of the paper "indicate that annual productivity growth averaged 3.3% across all universities, with a range from -1.8% to 13.0%, and was largely attributable to technological progress". Ying Chu Ng and Sung-Ko Li (2009) apply DEA to the Chinese universities, Maria Katharakia and George Katharakis (2010) opt for 20 Greek public universities for assessing their efficiencies.

The history of efficiency analysis on Turkish HEIs goes back to very recent years; first paper appeared in the first half of the last decade. In the related paper, Kutlar (2004) measured technical efficiencies of the faculties in Cumhuriyet University –which is one of the public HEIs in Turkey- and came up with the conclusion that whereas Faculties of Medicine, Administrative Sciences, Education and Engineering have higher efficiency values, Theology, Fine Arts faculties confront relatively lower efficiency scores. Following Kutlar's paper (2004), Baysal et al. (2005) calculated efficiency performances of 50 public HEIs relying on 2004 statistics and set forth an individual budget projection for universities in 2005. According to this research, overall technical efficiency among these 50 universities is almost 92%, whilst the worst performing university is 62% efficient.

Babacan et al. (2007) extended Kutlar's earlier work (2004) so as to compare the efficiency performance of Cumhuriyet University (CU) with the rest of the public universities. Throughout five years, CU had performed relatively less inefficient then its counterparts, although it exploits increasing returns to scale both in input and output oriented technologies. Ozden's paper (2008) is the first research that applies DEA onto the Turkish non-profit universities. To the paper's analysis, non-profit universities have differing efficiency values ranging from 52% to 100%. Moreover, the overall efficiency of non-profit universities in Turkey is calculated as 92%. In addition to the technical efficiency analysis of public universities carried out in previous papers, Kutlar and Babacan's work (2008) gauged the scale efficiencies of them to check whether there are any gains from economies of scale. The findings reveal the fact that the number of technically efficient universities had decreased considerably from 33 to 17 in five years. On the other hand, the number of universities experiencing 'increasing returns to scale' (IRS) had risen from 8 to 17 during the same period.

3. NON-PARAMETRIC EFFICIENCY ESTIMATION

So as to illustrate basic DEA model mathematically, let's assume that each decision-making unit [DMUs] use *m* inputs for the production of *n* outputs in a given technology level. X_{ij} denotes the amount of input *i* *(i=1,2…m)* produced by j^{th} DMU *(j=1,2…k)*, whereas Y_{sj} represents the quantity of output s *(s=1,2…n)* produced by j^{th} DMU *(j=1,2…k)*. The variables u_r *(r=1,2…n)* and w_i *(i=1,2…m)* are weights of each output and input respectively. The efficiency of DMU_0 can be written as:

$$max = \frac{\sum_{r=1}^{n} u_r Y_{r0}}{\sum_{i=1}^{m} w_i X_{i0}} \tag{1}$$

subject to:

$$\frac{\sum_{r=1}^{n} u_r Y_{rj}}{\sum_{i=1}^{m} w_i X_{ij}} \leq 1 \quad (j=1,2\ldots k) \tag{2}$$

$$u_r \text{ and } w_i \geq 0 \quad (r=1,2\ldots n) \text{ and } (i=1,2\ldots m) \tag{3}$$

This optimisation model above aims to specify best-fitted values for *u* and *w* that maximise efficiency level of the observed firm subject to all efficiency scores are less than or equal to 1. To avoid infinite solutions (Coelli et al., 2005:163) and obtain a linear programming model, Charnes-Cooper transformation can be used as following:

$$max = \sum_{r=1}^{n} \mu_r Y_{r0} \tag{4}$$

subject to:

$$\sum_{i=1}^{m} w_i X_{i0} = 1, \tag{5}$$

$$\sum_{r=1}^{n} \mu_r Y_{rj} - \sum_{i=1}^{m} w_i X_{ij} \leq 0, \tag{6}$$

$$\mu_r \text{ and } w_i \geq 0 \quad (r=1,2\ldots n) \text{ and } (i=1,2\ldots m) \tag{7}$$

Via using duality property of linear programming, equivalent form of this envelopment system with variable-return to scale (VRS) is illustrated as:

$$\min \Theta \tag{8}$$

subject to:

$$\sum_{j=1}^{k} \lambda_j X_{ij} \leq \Theta X_{i0} \qquad (i=1,2\ldots m) \tag{9}$$

$$\sum_{j=1}^{k} \lambda_j Y_{rj} \geq Y_{r0} \qquad (r=1,2\ldots n) \tag{10}$$

$$\sum_{j=1}^{k} \lambda_j = 1, \qquad (j=1,2\ldots k) \tag{11}$$

where Θ is a scalar and λ is a k x1 vector of constants. The solution of this linear system ends up with finding Θs corresponding to the efficiency level of each DMU. Therefore Θ should be less than or equal to 1 as well as the firm with Θ=1 is technically efficient that means operating on the frontier concerning Farell's (1957) proposition.

In addition to the Farell's (1957) proposition, Koopman's (1951) stipulates lack of "coordinate-wise improvements" to reach the best-practising frontier. Therefore, there is a precise need to integrate slack variables into the linear programming model through which efficiency scores are gauged concerning the slack usage of any input. The model becomes as follows:

$$\min \Theta_0 - \varepsilon \left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{n} s_r^+\right) \tag{12}$$

subject to:

$$\sum_{j=1}^{k} \lambda_j X_{ij} + s_i^- = \Theta X_{i0} \qquad (i=1,2\ldots m) \tag{13}$$

$$\sum_{j=1}^{k} \lambda_j Y_{rj} + s_r^+ = Y_{r0} \qquad (r=1,2\ldots n) \tag{14}$$

$$s_r^+, s_i^-, \lambda_j \geq 0 \qquad (j=1,2\ldots k) \tag{15}$$

s_r^+ and s_i^- are constrained to become non-negative and transformed inequalities into equations. s_r^+ means that $Y_{r0} \leq \sum \lambda_j Y_{rj}$ must be satisfied by every single solution, whereas s_i^- denotes that $\sum \lambda_j X_{ij} \leq X_{i0}$ must be sustained for each input used by DMU_0.

As a result of all these linear programming iterations, efficiency level of the observed DMU - DMU_0 in this case- is equal to 100% if and only if:

i. $\Theta_0 = 1$

ii. s_r^+ and $s_i^- = 0$ for all *(i=1,2,……,m) and (r=1,2,…..,n)*

4. DATA AND MODELS

In this section, dataset for the DEA is described concerning the input and output measures as well as the environmental factors that would influence the efficiency performances of the given HEIs in Turkey. Secondly, different DEA models are developed to improve the robustness of the results on the basis of VRS production/cost frontier framework.

4. 1 Output Measures

The ideal output bundle of universities needs to be consisting of various fields of activity including teaching, research, community service and cooperation with business sector due to the fact that services offered by HEIs are not appealing merely to the students and academia. However, lack of sufficient data on related activities does not allow researchers to map out HEIs fully, thus efficiency estimation may not be performed properly. Within this scenario, efficiencies of universities that are good at providing community services as well as developing effectual relations with business sector would culminate in downwardly biased values.

While being aware of these weaknesses and limitations, certain output variables that are currently measurable are used in this paper. For HEIs in Turkey, the following variables are taken into the analysis:

i) Number of Full-time Undergraduate Students (UG): This refers to total number of registered undergraduate students within one academic year.
ii) Number of Full-time Postgraduate Students (PG): This corresponds to total number of registered master’s and doctoral students within one academic year.
iii) Number of Indexed Publications per Academic Staff (PUB): It denotes total number of publications appeared in SCI, SSCI and AHCI indexes per the number of academic staff
iv) Total Amount of Research Grants (RES): This measures total amount of funding that is given by The Scientific and Technological Research Council of Turkey (TÜBİTAK) to the HEIs on project-based applications.

4. 2 Input Measures

Universities produce those outputs by employing certain set of inputs. In the literature of efficiency analysis of HEIs, for input variables, expenditures of universities that are divided into different factors such as labour, material, capital, library and total expenditures are used by researchers (Maria Katharakia and George Katharakis, 2010). In this paper, similar variables are situated into the DEA model as shown below:

i) Number of Academic Staff (FAC): It is the total number of faculty including full and part-time staff.
ii) Labour Expenditures (LAB): It represents total amount of expenditures allocated to the salary payments of academic and non-academic staff.
iii) Capital Expenditures (CAP): This represents the remaining amount of expenditures in the total expenditures when labour related as well as goods and services expenditures are subtracted.
iv) Goods and Services Expenditures (G&S): This measures the amount of money allocated to purchase certain goods and services needed to keep up daily operations.
v) Total Expenditures (TOTEXP): This accounts for the total amount of expenditures within a specific year.

4. 3 Environmental Factors

In addition to the measures for outputs and inputs, environmental variables constituting individual characteristics of HEIs that would have an impact on either cost function or inefficiency scores are put forward in this section. Thanks to the two-stage DEA estimation methodology, to what extent these university-based factors are exerting influence upon inefficiencies of HEIs are illuminated.

The environmental variables that are used throughout the two-stage DEA are as follows:

i) Age of the university (AGE): Number of years since the establishment of the university regarding to the procedures of Ministry of Education.
ii) Size of the university (SIZE): The number of total students comprising both undergraduate and postgraduate students will be used as a proxy.
iii) Load per academic staff (LOAD): It is the ratio of full time student to all academic staff.
iv) % of full-time staff (FTS): It is the ratio of full-time academic staff to all academic staff.
v) % of professors among academic staff (PROF): It is the ratio of professors to all academic staff.
vi) % of foreign students (FORGN): It is the share of students with foreign background.
vii) Dummy variable for having medical school (MED).

4. 4 Data Description

This research covers 53 public universities existing in Turkish Higher Education between 2005 and 2010 including five full academic years, corresponding to 265 observations. The data for inputs and outputs as well as university-based characteristics were collected from the website of The Council of Higher Education [YÖK], archives of Measurement, Selection and Placement Centre [ÖSYM] and the annual reports of Ministry of Education of Turkey. Moreover, the Scientific and Technological Research Council of Turkey [TÜBİTAK] releases report on the amount of research funds granted to the universities annually.

The sample of this research includes a variety of HEIs concerning their size, amount of expenditures and geography that are distinctly embodied in the relatively wide ranges for related variables. The variation among the given HEIs is summarised under the rubrics of institutional features as well as the staff and student characteristics. Table-1 summarises the dataset for the all variables whose explanations are indicated above.

Table-1: Descriptive Statistics

Variable	Mean	Std.Dev.	Minimum	Maximum	Obs
Output					
UG	43262.8	148210	623	1.58E+06	265
PG	2222.03	2556.4	76	12909	265
PUB	0.231741	8.03E-02	1.93E-03	0.482192	265
RES*	2856.73	4613.2	7.6	47649.8	265
Input					
FAC	1510.21	1028.16	275	5437	265
LAB*	68121.7	51690.6	3744	297693	265
G&S*	22117.7	17283.4	2627	109375	265
CAP*	25017.5	10661.6	500	83533	265
Financial Output (TOTEXP*)	128236	84787.9	8055	509612	265
University-based Characteristics					
AGE	27.26415	13.78013	12	66	265
SIZE	45484.82	148317.2	1408	1584003	265
LOAD	28.66435	83.9492	1.22863	888.6197	265
PROF	0.115158	0.064291	0.028874	0.378363	265
FTS	0.856985	0.241984	0.071222	1	265
FORGN	0.009205	0.012179	0	0.066902	265
MED	0.679245	0.46765	0	1	265

Note: *Thousands of Turkish Liras (TLs)

4. 5 Model Specification

The different specifications of DEA model are needed to perform robustness checks for the efficiency values assigned to the HEIs. In this paper, each model is consisted of different sets of outputs and inputs departing from the fact that “DEA analysis can be sensitive to the variables included" as well as to reflect the theoretical discussions on the selection of variables (outputs and inputs) in the efficiency analysis of higher education (Macmillan and Datta, 1998).

Developing different models entail two distinct efficiency estimation named as technical and cost efficiency. That is to say, whereas first four models measure technical efficiencies of HEIs with respect to the non-parametric production frontier, last two models compute cost efficiencies of HEIs regarding non-parametric cost frontier. And eventually variable returns to scale (VRS) optimisation method is applied to the each specification. The illustration of these alternative models is shown below:

Table 2. Alternative DEA models

Variable	Model 1	Model 2	Model 3	Model 4	Model 5*	Model 6*
Output						
UG	X	X	X	X	X	X
PG	X	X	X	X	X	X
PUB			X	X		X
RES	X	X	X	X	X	X
Input						
FAC				X		
LAB	X	X	X	X		
G&S		X	X	X		
CAP	X	X	X	X		
Financial Output						
TOTEXP					X	X

Note: *Cost Specification, financial output is treated as the only input

Model 1 and Model 5 are the most parsimonious models. Whereas Model 1 computes technical efficiencies, Model 5 reveals cost efficiencies of universities due to the fact that it uses cost specification model. Model 2 enriches the previous variable set of Model 1 with the inclusion of new input variable –which is goods and services expenditures-; Model 3 extends the specification through adding new output variable (publication per faculty). Model 4 uses all output and input sets available for this research to measure technical efficiencies of universities. And the last model (Model 6) is arranged to gauge cost efficiencies of universities with all existing output measures.

5. INTERPRETATION OF RESULTS

This section consists of four pillars a) efficiency values of public HEIs in Turkey referring not only to the production frontier but also cost frontier (technical and cost efficiencies) b) confidence intervals are developed for measured efficiency values through bootstrapping procedures, c) Total factor productivity indexes are estimated thanks to the Malmquist method for the sector as a whole and finally d) spearman rank correlation values are demonstrated among the specified DEA models.

5. 1 Efficiency Values (Technical and Cost Efficiency)

The summary statistics of technical and cost efficiencies of 53 public universities in Turkey with VRS frontier are shown in Table-3. Whereas the first 4 models are designed to measure technical efficiencies, the last two are measuring the cost efficiencies of universities with different output mixtures. Moreover, each model comprises both input and output orientations so as to detect possible variation coming out of the type of optimisation choice, even though orientation method does not have any impact on the ranking of HEIs in terms of their efficiency performances.

Table 3. Summary statistics for efficiencies

Model/Estimated Efficiencies	Orientation	Mean	St.Dev.	Min	Max
Model 1	Input	0.2769	0.2326	0.0476	1
	Output	0.3303	0.2425	0.0427	1
Model 2	Input	0.3735	0.2267	0.0726	1
	Output	0.3708	0.2487	0.0516	1
Model 3	Input	0.4158	0.24	0.1048	1
	Output	0.6043	0.1924	0.1695	1
Model 4	Input	0.5647	0.2114	0.2267	1
	Output	0.6182	0.1947	0.1755	1
Model 5	Input	0.2525	0.2069	0.0537	1
	Output	0.3114	0.2367	0.0416	1
Model 6	Input	0.3074	0.2367	0.0675	1
	Output	0.5822	0.1928	0.1071	1

In the first two models (Model 1 and 2) where output mixture does not include number of publications per faculty, the overall technical efficiencies of universities are computed as almost 35% ranging from 27% to 37% concerning different orientations (input/output). Even though there are universities that perform higher efficiency scores, nearly two-thirds of them have efficiency scores below than 50% depending on the normality assumption. Furthermore, the dispersion of efficiency scores is quite significant and revealing the fact that worst practising DMUs are dramatically differing from best-practising ones.

Completing output and input matrices via adding new variables leads to an increase in efficiency scores. In the Model 4 in which all output and input variables are utilised, the overall efficiency scores doubled if they are compared with the values in Model 1. When one output variable (number of publication per faculty) is ruled out, average of efficiency values diminished from 56% to 41% in input-orientation and 61% to 60% in output-orientated measurement. Besides, the efficiency of worst-performing university increased by three times in model 3 and five times in model 4.

In the last two models through which total expenditures are used as the sole input variable, cost efficiencies of universities are calculated. For the model 5, the mean cost efficiencies of universities are estimated as 25% and 31% in input and output orientations respectively. In the model 6 where publication per faculty is added to, efficiency scores have shown slightly higher values up to 30%. The difference between worst- and best-practising universities has widened in model 5 and model 6 if they are measured up to model 3 and 4, whilst it has not significantly changed if the comparison is performed with Model 1 and 2.

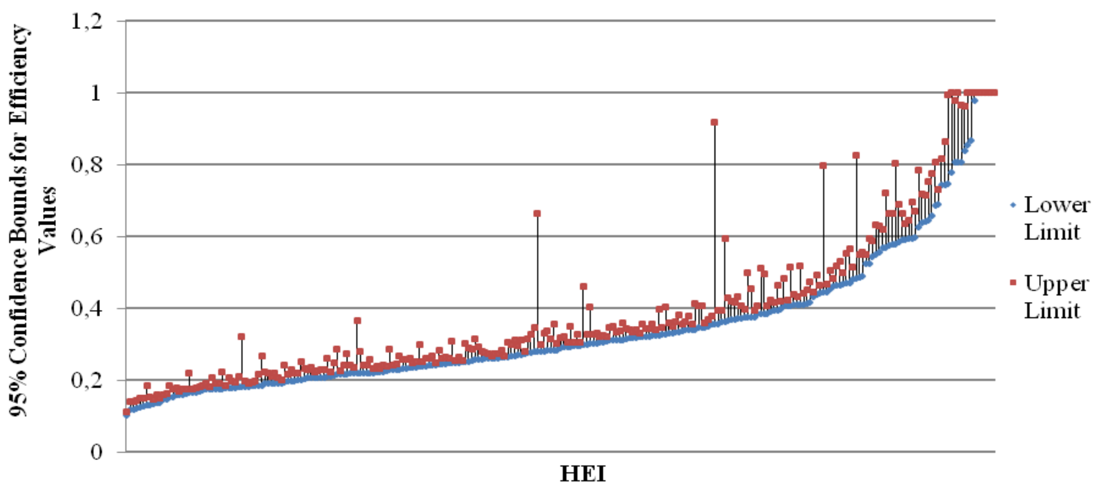
If the findings of VRS-DEA efficiency scores of this research are put side by side the previous literature on public HEIs in Turkey –even though it is considerably limited-, it could be argued that the results of these models are diverging notably from them concerning mean efficiency values and the performance of worst-practising HEIs. For instance, whereas overall technical efficiencies of public HEIs in Baysal et al's paper (2005) are nearly 90%, the mean technical efficiency of public HEIs is 60% in the full model (Model 4). However, Kutlar and Babacan's (2008) paper revealed the fact that there is a downward tendency among public HEIs in Turkey concerning efficiency performances, which is in line with the findings of this paper. Besides, whereas the efficiency values of public HEIs in Turkey are scattered within a pretty narrow-range in the previous literature (Baysal et al, 2005; Kutlar and Babacan, 2008), dispersion of HEIs pertaining to their efficiency values is remarkable in the research, which galvanise a subsequent inquiry on the determinants of this dispersion among the public HEIs in Turkey.

5. 2 Confidence Intervals and Bootstrapping

Non-parametric efficiency measurement techniques have a fundamental shortcoming that is lacking of statistical properties in their estimation procedures. DEA is not immune to this problem that makes its efficiency results less reliable. That is to say, "although DMUs may appear to vary widely in their efficiency (as denoted by the DEA efficiency score), the basic DEA technique provides no indication whether the difference between DMUs is statistically significant" (Johnes, 2006). To overcome this specific obstacle, bootstrapping method that constructs confidence intervals for efficiency values is introduced (Simar and Wilson, 1998) and becomes a widely used method in the DEA literature. Thanks to this method, the distinction between the HEIs concerning efficiency performances is statistically tested.

For this specific analysis, 95% confidence bounds are developed for efficiency values in Model 6 with 10 times replicated sample. The upper and lower limits for the each DMU are shown in Figure-1.

Figure-1: 95% Confidence Intervals of DEA Efficiency Scores



Although confidence bounds are not appropriate to reveal the distinction among the mid-performing universities, they clearly indicate that best-performing universities have significantly higher efficiencies than worst performing ones. As Figure-1 shows, the universities with 40% and lower efficiency scores are dramatically diverging from the universities with 60% and above. Efficiency values of the ones between those thresholds are not significantly different concerning bootstrapping statistical procedures. The apparent variation between best- and worst-performing universities would have indispensable policy-implication through peer analysis of worst performing universities.

5. 3 Malmquist Index (Inter-Temporal Analysis)

The salient advantage of having panel data is the ability to check whether any improvements in efficiency values have taken place at the course of the observed time period. Malmquist Index (or Total Factor Productivity and MI hereafter) is the only method to conduct inter-temporal analysis in DEA literature. Caves et al. (1982) introduced this index in the productivity literature by departing from Shephard's (1970) distance function. Furthermore, it should be noted here that if the value yielded by MI is less than 1, it signifies a decrease in total factor productivity (TFP), whilst the productivity increases if the MI is greater than 1; and accordingly it refers to a lack of change in TFP if the value is exactly equal to 1.

For this research, Malmquist values are computed as shown in Table-4 with respect to the cost efficiency values yielded in Model 6. Besides, time periods are assigned to the transition process between current year and the next one. That is to say, Period 1 refers to the move from 2005-2006 to 2006-2007 academic years. And subsequent periods are determined by the same method.

Table 4. Average malmquist results across HEIs, by period:

Average/Period	Period 1	Period 2	Period 3	Period 4
TFP	1.023	0.669	1.487	1.1156

Period 1 indicates a slight increase in TFP, whereas Period 3 and 4 denote relatively significant improvements. However, Period 2 signals an apparent deterioration in overall TFP among public HEIs in Turkey. Furthermore, even though there is not any systematic improvement in efficiencies among universities, during the last two years they have demonstrated progress in terms of efficiency. Figure-2 clearly reveals this inconsistent improvement through which efficiency performances of universities had witnessed ups and downs, thus motivates researchers to understand the driving forces behind this variation.

5. 4. Spearman Rank Comparison of DEA Models

After examining efficiency results of HEIs regarding to different DEA optimisation procedures, this sub-section is devised to deal with comparison of aforementioned models relying upon Spearman rank correlation. Even though HEIs may get different efficiency scores for diverse models, Spearman rank correlation checks whether this divergence influences the rankings of HEIs concerning their efficiency performances. For this particular analysis, Spearman rank correlation values are calculated to expose the impact of following scenarios:

i) Introducing new input and/or input variables,
ii) Measuring the efficiencies by the means of non-parametric production or cost frontier,

Table-5 is the indication of rank correlations between the models assumed VRS frontier:

Table 5. Spearman rank correlation for VRS models

	M1	**M2**	**M3**	**M4**	**M5**	**M6**
M1	1					
M2	0.896564	1				
M3	0.869533	0.955112	1			
M4	0.850428	0.880198	0.90661	1		
M5	0.964431	0.911273	0.871489	0.853839	1	
M6	0.941888	0.905349	0.903175	0.902046	0.96187	1

Rank correlation coefficients among the models that employed VRS frontier are considerably close to each other in Table-5. It clearly figures out that as the models get nearer to the full model (Model 4), spearman rank correlation attains higher values. Whilst the coefficient is 0.85 between Model 4 and Model 1, it becomes 0.90 when the relationship between Model 4 and Model 3 is concerned. In addition to that, high correlation among the results derived from cost and production frontiers encourages policy-implication aspect of this research to emerge confidently.

6. DETERMINANTS OF INEFFICIENCY

In addition to the estimation of efficiencies, recent literature in efficiency analysis persuades researchers to take step forward and accordingly interrogate potential factors influencing efficiency performances of decision-making units (DMUs). This statement is not different for efficiency analysis of higher education sector through which certain university-based features are put under spotlight. For this paper, so as to illuminate the causes of inefficiencies among public HEIs in Turkey, a set of environmental variables indicated above are employed via building upon previous studies.

As the efficiencies of HEIs driven from DEA procedure take values between 0 and 1, classical regression analysis would not be appropriate to be conducted. Thus, Tobit regression is opted for examining determinants of inefficiency by treating data as i) pooled and ii) panel. Besides, since Tobit regression is designed to censor values lower than 0, inefficiency scores (1-efficiency scores) of HEIs will be taken as the dependent variable in lieu of efficiency scores. Therefore, the variable with (+) sign will indicate a negative relationship with efficiency and vice versa. The Tobit regression model for the inefficiency terms is narrated as:

$$(u_{it}) = Z_0 + Z_1 AGE_{it} + Z_2 SIZE_{it} + Z_3 LOAD_{it} + Z_4 PROF_{it} + Z_5 FTS_{it} + Z_6 FORGN_{it} + Z_7 MED_{it} + \alpha_{it} \tag{16}$$

The next step is deciding which inefficiency values will be preferred as the dependent variable. Previous part on the rank correlation of HEIs was stating that efficiency scores do resemble each other due to the fact that the lowest correlation coefficient among different models was 0.82. Hence, choosing any of the inefficiency scores will not be suffered from 'selection bias' in a dramatic way. And eventually, for this research, inefficiency scores yielded from Model 1 with VRS and CRS are selected as the main components of this Tobit regression analysis. The dependant variable in Model A is the inefficiency scores coming from Model 1 with VRS, whilst Model B takes the values from Model 1 with CRS. Model C prefers the values from Model 1 with VRS, when the most insignificant variable is dropped from the regression model. Table-6 reports the results for pooled data:

Table-6: Tobit regression results for pool data

Variables	Model A	Model B	Model C
AGE	-.39940D-04 (-0.0015011)	-0.00041009 (0.00154432)	
SIZE	-.17144D-05 (.11908D-05)	-.149576D-05 (.12252D-05)	-.17245D-05 (.12171D-05)
LOAD	0.002826 (-0.002132)	0.003159 (0.00219382)	0.00320543 (0.00218055)
PROF	-0.13865 (0.39987)	-0.2731 (0.41148656)	-0.30751 (0.37327346)
FTS	0.09785* (0.05941)	0.12641** (0.0611377)	0.1261902** (0.06113406)
FORGN	2.00763 (1.80883)	2.80765 (1.86065793)	2.743357 (1.83340526)
MED	0.06877* (0.03811)	0.0730076* (0.03921196)	0.073668* (0.03919456)
CON	0.49354*** (0.07239)	0.52245*** (0.07449951)	0.51885*** (0.07229048)
SIGMA (u)	0.02279 (0.0097603)	0.02243458 (0.00997657)	0.02243621 (0.0099773)
LOG-L	11.88612	7.8755	7.855646

Notes: 1. ***, ** and * indicate 1%, 5% and 10% significance levels respectively.

2. Asymptotic standard errors in parentheses.

Table-6 reveals that the influence of AGE, SIZE and LOAD of the HEIs on their efficiency performance is ambiguous which is not in the interior of expectations. That is to say, although these factors would be the major components of production and/or cost function of HEIs, their correlations with inefficiency values are statistically vague. Furthermore, percentage of full-time academic staff among whole faculty (FTS) seems to be the leading variable concerning its correlation with inefficiency. The coefficient of FTS implies that as the share of full-time staff increases, inefficiency increases as well, or alternatively efficiency decreases. Another implication coming out from this table is that having medical school (MED) reduces efficiency by almost 0.07 which may encourage researchers to investigate efficiencies of medical schools as a separate research question. Lastly, the percentage of professors (PROF) and foreign students (FORGN) do not have any link with inefficiency scores of HEIs according to the aforementioned regression results. And Table-7 demonstrates the regression results for panel data with random effects treatment:

Table-7: Tobit regression results for panel data

Variables	Model A	Model B	Model C
AGE	-.39930D-04 (-0.00181718)	-0.00030839 (-0.00177478)	
SIZE	-.16144D-05 (.16329D-05)	-.169582D-05 (.17329D-05)	-.172415D-05 (.16559D-05)
LOAD	0.003026 (-0.00285428)	0.0031588 (-0.00296712)	0.00320723 (-0.00289554)
PROF	-0.13954558 (-0.5214565)	-0.27300681 (-0.52132894)	-0.3076005 (-0.450931990
FTS	0.09774264* (-0.05559317)	0.12638375** (-0.05765066)	0.12618928** (-0.05743758)
FORGN	2.00752574 (-2.40340857)	2.80685771) (-2.61961309)	2.7433569 (-2.49164345)
MED	0.06771132 (-0.04789048)	0.07392279) (-0.05037202)	0.07367102 (-0.0483697)
CON	0.49330*** (-0.06620654)	0.52244*** (-0.06441148)	0.51884*** (-0.06442898)
SIGMA (u)	0.02179933 (-0.02372067)	0.02243458 (-0.02398005)	0.02243621 (-0.02326832)
LOG-L	14.76703	7.875583	10.83485

Notes: 1. ***, ** and * indicate 1%, 5% and 10% significance levels respectively.
Asymptotic standard errors in parentheses.

The Tobit regression results obtained from panel data analysis have not had any apparent impact on the coefficients of variables, excluding dummy variable for medical school (MED). MED became insignificant due to a slight increase in its standard deviation for the all three models. Besides, share of full-time academic staff (FTS) still preserves its significance on efficiency performance of HEIs for the panel data analysis. The rest of the variables including AGE, SIZE, LOAD, PROF, and FORGN are not counted as noteworthy factors pertaining to the results indicated in Table-7 that was the case for pooled data analysis.

7. CONCLUDING REMARKS

This paper examined 53 public HEIs in Turkey between 2005 and 2010 to estimate technical and cost efficiencies of public HEIs in Turkey by employing a non-parametric technique called DEA. In doing so, overall efficiencies of HEIs as well as their individual scores are demonstrated on the basis of certain production and cost models motivated by different sets

of input/output. Besides, statistical properties were incorporated to the deterministic DEA frontier to enhance the robustness of the efficiency results belonging to the universities.
The results of those models, firstly, have shown that public HEIs in Turkey are performing in unsatisfactory levels although some of them are doing fairly well. Besides, as the model gets closer to the full input/output set, both individual and overall efficiency scores are getting relatively higher values. Secondly, even though there is not any systemic increase during this five-year time span, efficiencies of public HEIs in Turkey have increased at the course of last two years. Thirdly, the share of full-time academic staff in the whole faculty and having medical school are found as the determinants of inefficiencies among HEIs regarding Tobit regression analysis.

The rising trend in the costs and demand in the higher education motivated administrative bodies in this sector to be cautious about the appropriate usage of the resources (Erkoc, forthcoming). The findings of this research have evident implications particularly for the authorities in Turkey, which decide on the magnitude of expenditures in universities. The inefficiency results obtained in this paper imply that majority of universities in Turkey have significant challenges and/or weaknesses to allocate resources efficiently within their institutions. Therefore, it would be apt to reconsider the current allocations to the universities in the further budget projections.

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Uzun Özet

Yükseköğretim kurumlarının teknik ve maliyet etkinliklerini ölçmeye yönelik yapılan çalışmalar, etkinlik analizi literatürünün önemli bir bölümünü özellikle son yirmi yıldır teşkil etmeye başladı. Bankacılık ve havayolu sektöründeki kar amaçlı faaliyet gösteren firmaların aksine, devlet ya da vakıflar tarafından idare edilen ve kar amacı taşımayan üniversiteler üzerine yapılan çalışmalar etkinlik-teşvik çerçevesinde yapılan araştırmalar için de ayrı bir önem taşımaktadır. Kar motivasyonunun var olmadığı sektörlerde, etkinliğin düşük olacağı beklentisi bu anlamda yapılacak çalışmaların teorik arka planını oluşturmaktadır (Ben-Ner, 2002). Netice itibariyle, Birleşik Krallık, İsveç, Kanada, Avustralya, Çin ve Yunanistan gibi ülkelerdeki üniversitelerin etkinliği üzerine yapılan araştırmalar ile bu alanda yapılan çalışmaların sayısı her geçen gün artmaktadır (Katharakia and Katharakis, 2010; Daghbashyan, 2011).

Kamu bütçesi tarafından finanse edilen kamu üniversiteleri Türkiye'deki toplam eğitim bütçesinde önemli bir orana sahip. Milli Eğitim Bakanlığı'nın her yıl paylaştığı verilerde de belirtildiği üzere, Bakanlık bahsi geçen üniversitelere dikkate değer oranlarda parasal destekte bulunmaktadır. Verilen bu desteklerin üniversite bütçelerinin ortalama %60'ına tekabül ettiği düşünülmektedir (Erkoc, yakında yayınlanacak). Bu noktada, Türkiye'deki yükseköğretim sektörüne ayrılan bütçenin etkinliğini ölçme girişimi, akademisyenler ve karar vericiler için büyük bir öneme sahip. Bu nedenle, özellikle Türkiye'deki yükseköğretim kurumlarının etkinliğini ölçen çalışmaların değeri her geçen gün artmaktadır.

Yükseköğretim kurumlarının etkinlik performanslarını ölçebilmek için literatürde uzun süredir iki ana metot kullanılmaktadır: Stokastik Sınır Analizi (SSA) ve Veri Zarflama Analizi (VZA). Bu çalışmada, Türkiye'deki kamu üniversitelerinin etkinliği parametrik olmayan VZA tekniği ile hesaplanmıştır. Türkiye'deki yükseköğretimin kaynak kullanım etkinliği için birçok yönden önem arz eden soruların cevabını bulmaya çalışmak bu araştırmanın en temel hedefidir. Diğer bir ifadeyle, bu araştırmada ortaya çıkan analizler Türkiye'deki kamu üniversitelerinin bireysel ve sektörel anlamda kaynaklarını ne ölçüde etkin kullandığını parametrik olmayan VZA yöntemi ile bulmaya çalışmaktadır. Bu sorular şu şekilde sıralanabilir:

1. Türkiye'deki kamu yükseköğretim kurumlarının ortalama teknik ve maliyet etkinlikleri farklı girdi/çıktı modelleri ve üretim/maliyet eğrileri baz alındığında ne seviyededir?
2. Özyükleme (bootstrapping) neticesinde etkinlik skorları ne şekilde değişim göstermiştir?
3. Etkinlik değerleri 2005-2010 yılları arasında nasıl bir değişim geçirmiştir?
4. Kaynakların etkin kullanılmamasının sebepleri nelerdir? Çevresel faktörlerin etkinlik performansı açısından bir etkisi var mıdır?
5. Araştırmanın eksik yönleri nelerdi? Sonuçlar bundan sonraki akademik ve politika yapım araştırmaları için ne derece güvenilir sonuçlar sunmaktadır?

Yukarıdaki bilgiler ışığında bu makale Türkiye'deki 53 kamu üniversitesinin 2005-2010 yılları arası teknik ve maliyet etkinlik analizlerini parametrik olmayan bir yöntem olan Veri Zarflama Analizi (VZA) ile hesaplamaya çalışmaktadır. Bu sayede, bahsi geçen üniversitelerin ortalama maliyetleri farklı girdi-çıktı modelleri ile üretim ve maliyet fonksiyonları kullanılarak ölçülmüştür. Bu modellerde bulunan sonuçlar ilk olarak Türkiye'deki kamu üniversitelerinin önemli bir bölümünün kaynaklarını etkin kullanmadığı tespit edildi. Buna ilaveten, bir takım özyükleme (bootstrapping) prosedürleri neticesinde görüldü ki iyi performans sahibi üniversiteler ile kötü performans gösteren üniversiteler iktisadi etkinlik açısından birbirlerinden tamamıyla ayrışıyorlar. İkinci olarak, 2005-2010 akademik yılları arasında sistemli olarak bir etkinlik iyileşmesi olmamasına rağmen 2008 itibariyle az da olsa bir düzelme olduğu gözlenmiştir. Üçüncü olarak ise, Tobit regresyonu ile yapılan analizlerde tam-zamanlı akademik personel oranı ve tıp fakültesine sahip olmanın etkinlik performansını etkilediği saptanmıştır. Sonuç olarak, bu bulgular belli metodolojik sorunları içerisinde barındırsa da, bundan sonraki akademik çalışmalar ve politika yapım kararları için önemli bulgular barındırmaktadır.

Yükseköğretimde hızla artan maliyetler ve talep, üniversitelerin, kaynaklarını ne ölçüde etkin kullandıkları konusunu daha da dikkate değer bir konu haline getirdi. Bu araştırmanın sonuçları, Türkiye'de kamu üniversitelerine kaynak tahsisinde bulunan kamu kurumları için önemli veriler sunmaktadır. Elde edilen etkinlik skorları gösteriyor ki Türkiye'deki kamu üniversitelerinin büyük bir bölümü kaynaklarını etkin kullanmada kayda değer zorluklar yaşıyor. Bu çerçevede, önümüzdeki yıllar için düşünülen kaynak tahsislerinin daha verimli ve etkin bir düzlemde yapılması için yükseköğretimin finansmanını sağlayan kamu otoritesinin bütçe düzenlemelerinde, etkinlik skorlarını da dikkate alması bir öneri olarak sunulmaktadır.