Education and Science tedmem

Vol 42 (2017) No 191 307-322

Efficiency of State Universities in Turkey During the 2014–2015 Academic Year and Determination of Factors Affecting Efficiency

Semra Türkan [1], Gamze Özel [2]

Abstract

The concepts of efficiency and productivity are of vital importance in a world of limited resources. In this study, the productivity of state universities in Turkey is determined through data envelopment analysis, and the universities are ordered according to efficiency using a super efficiency model. Then, factors affecting efficiency are examined by Tobit and beta regression analysis; the results obtained from the two different methods are analyzed on a comparative basis. In the study, data from the 2014–2015 academic year are utilized to measure the training efficiency of 43 state universities in Turkey. As a result of data envelopment analysis, Gebze Technical University, Anadolu University, Middle East Technical University, İstanbul Technical University, İstanbul University, Marmara University, Hacettepe University, Gazi University, Ankara University, and Ege University are found to be effective universities. Generally, 22% of state universities are found to be effective. In terms of the criteria discussed in this study, Cumhuriyet University has the lowest efficiency value. According to the results of the Tobit and beta regression and h-index, the number of graduated students improves the efficiency value of state universities, while the presence of medical schools decreases the efficiency value.

Keywords

University
Effective
Performance
Data envelopment analysis
Tobit regression
Beta regression

Article Info

Received: 11.01.2016
Accepted: 07.21.2017
Online Published: 08.20.2017

DOI: 10.15390/EB.2017.6980

Introduction

Today, performance measurements are needed for organizations in the education sector, as in all organizations. The performance of universities and their effectiveness are important due to the important position universities occupy. In addition, under the current conditions of globalization and growth, universities should effectively use existing resources to provide quality education at international standards so they can compete. Change is inevitable in universities due to ever-changing academic and technological conditions. Therefore, performance measurement and evaluation play a key role in advancing educational institutions.

According to Akal (2002), performance is a concept that quantitatively or qualitatively describes the results of a planned activity. In other words, performance is the measure of the level of reaching of a specified target. Productivity and effectiveness are the most commonly used measures of performance evaluation (Li & Ye, 1999). In general, efficiency is the relationship between the output produced by a

[1] Hacettepe University, Faculty of Science, Department of Statistics, Turkey, sturkan@hacettepe.edu.tr
[2] Hacettepe University, Faculty of Science, Department of Statistics, Turkey, gamzeozl@hacettepe.edu.tr

production or service and the input used to obtain that output (Prokopenko, 1998). In other words, productivity is the most efficient use of scarce resources or the highest output achieved with the least input (Bektaş, 2007). Effectiveness is a measure of achieving plans and objectives, productivity is a certain output with minimum cost, and efficiency is the ability to do things correctly with an input-output mechanism, in other words, a measure of competitiveness (Yükçü & Atağan, 2009). Effectiveness measurement is an approach to determine the performance level of an organization, to identify problems, and to take necessary measures for improvement (Tarım, 2001).

The political and social dimensions of education distinguish educational services from other goods and services (Özdemir, 1995). Efficiency, effectiveness, and productivity are among the performance indicators of educational institutions. Productivity in education is defined as ensuring optimum output with available resources, and effectiveness is defined as the best possible outcome by utilizing resources in the best possible way (Peker, 1994). Efficiency measurement is important in determining whether universities achieve their strategic aims and objectives in their activities and whether they use resources appropriately and efficiently.

The Turkish Higher Education System and the Higher Education Law in Turkey (Law 2547), issued in 1981, are based on the basic principles of the Anglo-Saxon model (Balyer & Gündüz, 2011). The aim of the Anglo-Saxon higher education system is to play a leading role in the market with continuous training programs in the competition environment in universities. In this model, the effect and effectiveness of educational activities as well as educational activities are important. The examination of this effect is important for the evaluation of the training program (Gürüz, 2001). Efficiency measurement allows managers to make the right decisions at state universities, increase the success rate of universities, and implement the decisions they make (Eşme, 2014).

Data envelopment analysis (DEA) is an efficiency measurement method that investigates the activities of educational institutions and is based on the input-output of decision-making units (Çınar, 2013). For this reason, DEA is mostly used for non-profit organizations in the public sector such as schools, universities, hospitals, and clinics (Depren, 2008). The performances of the educational institutions in Konya were investigated by Baysal and Toklu (2001), the effectiveness of state universities in Portugal has been examined by Afonso and Santos (2005), and the efficiency of the hospitals in Afyon were investigated by Gülsevin and Türkan (2015) with DEA.

The first application of DEA in the field of education was conducted by Charnes, Cooper, and Rhodoes (1978) to measure the activities of schools in the United States. Later, the effectiveness of state universities with DEA were examined by McMillan and Datta (1998) in Canada, by Avkıran (2001) in Australia, by Afonso and Santos (2005) in Portugal, by Kempkes and Pohl (2007) in Germany, by Cuenca (2011) in the Philippines, and by Mikusova (2015) in the Czech Republic. McMillan and Datta (1998) found that the average efficiency value of 45 Canadian state universities in 1992–1993 was 94%. In the study conducted by Avkıran (2001), the average activity value of the 36 state universities in Australia was 95% in 1995. The average efficiency value of 52 state universities in Portugal in 2003 was calculated as 55% by Afonso and Santos (2005). Kempkes and Pohl (2007) concluded that 72 state universities between 1998 and 2003 were more effective than East German universities in the West German universities. Cuenca (2011) determined the average efficiency values of 78 state universities in the Philippines between 2006 and 2009 as 85% for 2006, 84.5% for 2007, 74.2% for 2008, and 77.2% for 2009.

The university history in Turkey, dating back to 1870, is based on Darülfünun, which opened in 1900, in the present sense of university history. This institution was transformed into Istanbul University in 1933, signaling the beginning of university construction in the Republican era. In the 50th year of the Republic, there were 12 universities. Although there were only 19 universities in 1981, after the Law on Higher Education (Law 2547) was issued, the number of universities increased to 73 by 2000, with 54 as state and 19 as foundation. Beginning in 2006, 41 state universities and 35 private universities were established over three years: 15 in March 2006, 17 in May 2007, 9 in May 2009. The number of universities increased to 184 after 2009.

Between 2000 and 2015, Turkey achieved a 125% growth in higher education (Çetinsaya, 2014). The establishment of 41 universities and the increase in student quotas between 2006 and 2009 have influenced this growth. Increasing the number of universities ensured that approximately 5.5 million students have higher education opportunities in Turkey. However, problems due to this situation are inevitable. Between 2000 and 2014, the number of students per teaching staff in a university increased from 16 to 21 (Çetinsaya, 2014). For this reason, it is very important to optimally educate students with limited resources and teaching staff. Hence, in this study DEA is used to obtain the most output by using the least input.

The first applications of DEA for university productivity in Turkey were made by Gülcü, Çoşkun, Yeşilyurt, Çoşkun, and Esener (2004) and Kutlar and Kartal (2004) on the basis of faculty or department. Kutlar and Kartal used DEA to examine faculty performance at Cumhuriyet University in 2004. Bal (2013) has used DEA to evaluate academic efficiency of private universities ranked by URAP. The efficiency of state universities in the 2009–2010 academic year was measured by Özel (2014), and the efficiency of private universities was studied by Özel (2015). In these studies, the university efficiency was measured by DEA. However, there are few studies conducted by regression analysis to determine the factors (variables) affecting the effectiveness of the universities. For this reason, this study uses tobit and beta regression models after DEA.

Tobit regression analysis was first used to find factors affecting the efficiency of schools in Tayland by Liu, Wongcha, and Peng (2012). In Turkey, Erkoç (2016) used Tobit regression to determine the factors affecting the efficiency value of universities. Kempkes and Pohl (2010) determined the efficiency scores of 72 German universities between 1998 and 2003 by using DEA, and then investigated the factors affecting the efficiency score with the Tobit regression model. According to the findings of the study, it was determined that an increase in GNP per capita positively affects higher education activity. Aubyn, Pina, Garcia, and Pais (2009) determined the efficiency scores for the higher education system of 28 countries during the 1998–2005 period, and then revealed the factors affecting the higher education effectiveness with the Tobit regression model. Aubyn et al. (2009) have ordered the institutional characteristics of the higher education system as student selection, financial autonomy, personnel policy, output change, evaluation, and financing rules, and analyzed the impact of these criteria on effectiveness. According to the findings of the study, improving the financing rules and personnel policies positively affects efficiency, while output variability negatively affects efficiency (Bursalıoğlu & Selim, 2015).

The efficiency of the higher education system of European countries was determined by Agasisti (2011) with DEA, and then the factors affecting the efficiency score were determined with the Tobit regression model. According to this study, the gross national product (GNP) per capita, the expenditure per student, the ratio of the students in private universities to students in the public universities, the ratio of higher education public resources to total resources, the average age of education are independent variables, and the efficiency score of each university is a dependent variable. Agasisti (2011) found that the increase in GNP per capita positively affected efficiency, but the increase in the proportion of students in public universities to those in private universities and the increase in the average age of education negatively affected efficiency. Selim and Bursalıoğlu (2015) have examined the factors that determine university efficiency using a panel Tobit model.

There has been no study examining factors affecting the efficiency of educational institutions using beta regression. The first objective of this study is to determine the efficiency of 43 state universities operating in 2014¬–2015 academic year using DEA. Another aim of the study is to determine for the first time what factors influence efficiency values via the beta regression model and to compare the results of the Tobit regression model. In the scope of the study, h-index, the ratio of students to lecturers, the number of graduate students, the presence of medical faculty, the number of faculty, and the age of the university as variables influencing state university performance in Turkey will be investigated.

Method

Data Envelopment Analysis

DEA is a method that measures the performance of decision-making units in relative terms; in other words, it compares organizations and institutions that can produce the same output using entries that are similar to each other. The advantages of DEA are as follows (Sarıca, 2007):

- It is possible to use a large number of input and output variables.
- There is no need for a functional form to associate inputs and outputs except the linear form.
- Decision units can be compared relatively.
- Although the units of measurement of input and output variables are different, there is no need to use various assumptions and transformations to measure them in the same way.

The disadvantages of the DEA are as follows:

- DEA is very sensitive to measurement error.
- DEA may measure the performance of decision units, but cannot give an interpretation based on absolute effectiveness.
- DEA is a nonparametric method and statistical hypothesis tests cannot be applied to the results.
- DEA is a static analysis. In other words, it makes a cross-sectional analysis of decision units in a period.

The basic steps of DEA are summarized in the following subsections.

Selection of Decision-Making Units

The decision-making unit in DEA is the unit that converts input to output. This unit can be a school, hospital, university, enterprise, faculty, or department in a university. The decision-making unit is a subunit of an enterprise.

The first step in DEA is to select the decision-making units. An observation set comprised of decision-making units should be homogeneous in order to be consistent with the DEA results. In other words, decision-making units should get similar output with similar entries. In this study, 43 state universities operating in Turkey for the 2014–2015 academic year were selected as decision-making units. Although there are 98 state universities in Turkey, 55 of them were omitted because of missing observation values in terms of the variables considered in the study. For this reason, a sampling selection method is not used.

Determination of variables of input and output

There are many assumptions about the number of input and output variables that will enter into the evaluation process in DEA. The number of units required to measure efficiency correctly must be least three times the number of inputs and outputs, according to Vassiloglou and Giokas (1990). The number of required units must be at least 20, according to Norman and Stoker (1991). As to a more systematic approach to the number of input variables (u) and the number of output variables (v), the number of decision-making units must be at least "u+v+1" (Boussofiane, Dyson, & Thanassoulis, 1991). However, the most common situation in practice is that the number of decision-making units must be least twice the number of inputs and outputs (Charnes et al., 1978; Norman & Stoker, 1991).

In a production or service process, products and services produced at the end of a certain period are output, and the sources of production used to perform this production are called inputs (Özden, 2008). The input and output variables used in previous studies involving DEA for the measurement of the efficiency of state universities are given in Table 1.

Table 1. Input-output Variables in Previous DEA Studies on the Universities

Author	Input variables	Output variables
Babacan & Kartal (2007)	Number of Prof. Number of Assoc. Number of Assist. Prof. Number of Assist. Instructor General Budget Expenditures Number of Administrative Personnel Expenditures out of Budget	University Revenues Number of Publications in Indexes Number of Graduate Student Graduates Number of Graduate Students Number of Undergraduate Graduates Number of Undergraduate Students
Kutlar & Babacan (2008)	General Budget Expenditures Expenditures Out of Budget Number of Prof. Number of Assoc. Number of Assist. Prof. Number of Assist. Instructor Number of Administrative Personnel	Number of Publications in Indexes University Revenues Number of Undergraduate Students Number of Undergraduate Graduates Number of Graduate Students Number of Graduate Student Graduates
Özden (2008)	Number of the Faculty Members Number of Other Academic Staff Total Expenses	Number of Publications Number of Graduate Students Number of Undergraduate and Graduate Students Other Revenues Education-Teaching Income
Bal (2013)	Number of Faculty Members Number of Other Academic Staff	Ratio of Students to Faculty Sum of the Articles and Citations in Journals Indexed by SCI, SSCI, AHCI
Selim & Bursalıoğlu (2015)	Central Government Budget Allowances University Revenues Project Share (TUBITAK) Project Share (BAB) Number of Total Academician	Number of Graduates per Academician Number of Graduate Students Graduate per Academician Number of Ph.D. Students per Academician Number of Publications Number of Employees
Erkoç (2016)	Number of Academic Staff Labor Expenditures Capital Expenditures Goods and Service Expenses Total Expenditures	Number of Undergraduate Students Number of Graduate Students Number of Publications in Indexes Per Academician Total Research Award Amount
Arık & Seyhan (2016)	Number of Academic Staff Number of Units in the University	Number of Publications Number of Undergraduate Students Number of Graduate Students

Considering previous the previous studies outlined in Table 1, total expenses, number of instructors, and number of lecturers were used as input variables in this study. Academic personnel information from the 2014–2015 academic year was obtained from Higher Education Statistics. The number of supported public and infrastructure projects; number of citations; number of publications in

SCI, SSCI, and AHCI indices; number of total undergraduate students; and number of graduate students were output variables. For the first time, in this study, the number of citations is defined as an output variable in the DEA, since the number of citations is an important output that shows the development of science in universities. H-index, introduced by Hirsch (2005), is an indicator that measures together the effectiveness of citation and publication activities. For example, an h-index of 100 means that a researcher's 100 most-cited papers have been cited at least 100 times (Oruç, 2008).

Hirsch (2005) suggested that the h-index could be a better marker of output than total number of publications or total number of citations. Although h-index was initially proposed for scientists, it has been used for assessment in many research fields, many countries, and at many universities (Al, 2008). The h-index is used as a ranking criterion on the basis of both the faculty member and the university. In this study, h-index values related to universities were used to examine university efficiency.

Determination of DEA models

The next stage of identifying input and output variables of DEA is to select the most suitable DEA model. In this study, an input-oriented Banker, Charnes, Cooper (BCC) model proposed by Banker, Charnes, and Cooper (1984) is utilized. Efficiency values between 0 and 1 were calculated for all decision-making units in DEA. Decision-making units with efficiency values of 1 are effective, and decision-making units with efficiency values lower than 1 are not effective (Çınar, 2013).

It is assumed that inefficient decision-making units in DEA have a similar level of efficiency when they use methods and systems used by efficient decision-making units. A set consisting of efficient decision-making units that effective decision-making units try to emulate is called a reference set (Karacabey, 2001).

There are many developed DEA models in the literature. There is the assumption of constant returns in the CCR model proposed by Charnes et al. (1978); there is the assumption of variable returns to scale in the BCC model proposed by Banker, Charnes, and Cooper. In the CCR model, there is an identical increase in output for each input, but in the BCC model, there is varying output for each input. These models are also examined in two groups for input-oriented and output-oriented DEA models. In the input-oriented DEA model, the goal is to find the optimum combination of inputs to produce the best composition of output. In the output-oriented DEA model, the goal is to achieve maximum output with per amount of input (Charnes et al., 1978). This study uses the output-oriented BCC model under the assumption of variable returns to scale. Therefore, only this model will be explained in the study.

In the BCC model, the amount of input is minimized by holding constant the quantity of output. The structure and interpretation of the output-oriented BCC model is similar to that of the input-oriented model. The primal of the output-oriented model is as follows:

$$\max z_k = \varphi$$

$$\varphi_k y_{rk} - \sum_{j=1}^{n} y_{rj}\lambda_j + s_r^{+} = 0$$

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^{-} = x_{ik}$$

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

$$s_i^{-},\ s_r^{+},\ \lambda_j \geq 0$$

The dual of the model is as follows:

$$\min q_k = \sum_{i=1}^{m} v_i x_{ik} - v_k$$

$$\sum_{r=1}^{s} \mu_r y_{rk} = 1$$

$$\sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} - v_k \leq 0 \quad j=1, 2, \ldots, n$$

$$v_i , \mu > 0 \quad i = 1,2,...,m$$

The efficient line of the BCC model does not have to go through the origin.

Interpretation of DEA results

In the last stage of DEA, the results, along with the input and output of each unit, are analyzed on the basis of the decision-making unit.

Tobit Regression Analysis

The Tobit regression model is a widely used method for regression models with limited dependent variables (Amemiya, 1984). In this model, the model also takes the name of the censored sample because the information of the dependent variable is only for some observations (Fethi, Jackson, & Weyman-Jones, 2000). There are limited dependent variables in Tobit regression (Tobin, 1958). A censored sample is available in the event that the information from the dependent variable is available only for some observations (Fethi et al., 2000).

The discrete model is available in the event that some observations are missing out of a certain range in the regression model, which limits the range of variation observed in the dependent variable. The censored model is available in the event that at least the independent variables are observed (Üçdoğruk, Akın, & Emeç, 2001). Therefore, the Tobit model is called the censored or discrete regression model (Amemiya, 1984; Gujarati, 2004). The Tobit model is as follows:

$$y_i^* = \mathbf{x}_i^T \boldsymbol{\beta} + u_i, \quad i = 1, 2,1,$$

where y_i^* is the latent variable, $\mathbf{x}_i$ is the vector of independent variables, $\boldsymbol{\beta}$ is an unknown parameter vector. Observable y_i values are defined as:

$$y_i = \begin{cases} y_i^* = \mathbf{x}_i^T \boldsymbol{\beta} + u_i, & y_i^* > 0 \\ 0, & y_i^* < 0 \end{cases}$$

The maximum likelihood estimate obtained, assuming the distribution of the error term is normal, is consistent and asymptotically normally distributed (Üçdoğruk et al., 2001; Karlı & Bilgiç, 2007).

Beta Regression Analysis

Regression models are often used to determine the relationship between variables. Linear regression is one of the most common regression models. However, this model is not used when the value of a dependent variable is between 0 and 1 or is a ratio or percentage (Espinheira, Ferrari, & Cribari-Neto, 2008). In this situation, beta regression—an alternative to the linear regression model—is used (Ferrari & Cribari-Neto, 2004).

Beta regression is a generalized form of logistic regression, and it is used when the values of dependent variables are ratios. Assume that y has beta distribution. Accordingly, the probability density function of the beta distribution is written as:

$$f(y;p,q)=\frac{\Gamma(p+q)}{\Gamma(p)\Gamma(q)}y^{p-1}(1-y)^{q-1}, \qquad 0<y<1$$

where p, q > 0 and $\Gamma(.)$ is the gamma function (Ospina, Cribari-Neto, & Vasconcellos, 2006).

Respectively, p and q are converted to location and scale parameters by re-parameterization in beta distribution. $E(y)=p/p+q$ and $V(y)=pq/\left[(p+q)^2(p+q+1)\right]$ and $\mu=E(y)$, $\sigma^2=V(y)$. Hence

$$E(y)=\mu=\frac{p}{p+q}\Rightarrow p=\mu(p+q)$$

where $\phi=p+q$. According to this,

$$p=\mu\phi \quad \text{and} \quad q=\frac{\mu\varphi(1-\mu)}{\mu}=\varphi-\varphi\mu$$

The beta function is written as follows:

$$f(y;\mu,\phi)=\frac{\Gamma(\phi)}{\Gamma(\mu\phi)\Gamma((1-\mu)\phi)}y^{\mu\phi-1}(1-y)^{(1-\mu)\phi-1}, 0<\mu<1 \text{ and } \phi>1$$

When re-parameterization is used, μ can be interpreted as a location parameter and ϕ can be interpreted as a scale parameter (Cribari-Neto & Lima, 2007). Taking the logarithm of the equation, the log likelihood function is obtained as follows:

$$\ln f(\mu,\phi;y)=\ln\Gamma(\phi)-\ln\Gamma(\mu\phi)-\ln\Gamma((1-\mu)\phi)+(\mu\phi-1)\ln(y)$$
$$+((1-\mu\phi)-1)\ln(1-y\ \ )$$

In beta regression, two link functions for location parameter μ and scale parameter ϕ are used to comprise the regression model. When logit link function is used, regression coefficients are interpreted as odds-ratio (Simas, Barreto-Souza, & Rocha, 2010).. The logit link function includes:

$$\ln(\mu/(1-\mu))=\mathbf{X\beta}$$

If the link function is used to find fitted values in beta regression, the sub-location model and the sub-scale model can be written, respectively, as:

$$\mu_i=\frac{\exp(\mathbf{x}_i^T\boldsymbol{\beta})}{1+\exp(\mathbf{x}_i^T\boldsymbol{\beta})},\ \phi_i=\exp(-w_i\delta)$$

Re-parameterized, the log likelihood function for regression coefficients proceeds as follows:

$$\ln f(\beta,\delta;y,X,W)=\ln\Gamma(e^{-W\delta})-\ln\Gamma(\frac{e^{X\beta-W\delta}}{1+e^{X\beta}})-\ln\Gamma(\frac{e^{-W\delta}}{1+e^{X\beta}})+(\frac{e^{X\beta-W\delta}}{1+e^{X\beta}}-1)\ln(y)$$

$$+(\frac{e^{-W\delta}}{1+e^{X\beta}}-1)\ln(1-y)$$

The derivatives of the log likelihood function are taken according to β and δ are equal to zero; the log likelihood estimates of β and δ are obtained as the polygamma function. The gradient vector is obtained by taking the first derivative of the log likelihood function, while the Hessian matrix is obtained by taking second derivatives utilizing these equations (Ferrari & Cribari-Neto, 2004; Espinheira et al., 2008).

Results

In this part, the goal is to determine the efficiency scores of 43 state universities as determined by DEA in the 2014–2015 academic year by the variables: total expenditure; the number of teaching members; the number of teaching assistants; the number of supported public and infrastructure projects; the number of citations; the number of SCI, SSCI, AHCI indexed publications; total number of undergraduate and undergraduate students; and total number of undergraduate students. Efficiency scores of state universities obtained by the output-oriented BCC model and the efficiency rank of state universities obtained by using the super efficiency model are presented in Table 2:

Table 2. Efficiency Scores of State Universities in the 2014–2015 Academic Year

University	Efficiency score	Reference set	Super efficiency score (%)	Super efficiency rank
Abant İzzet Bay. Uni.	1,707	5 (0,01) 22 (0,74) 36 (0,25)	170,67	27
Adnan Menderes Uni.	2,041	5 (0,03) 22 (0,59) 36 (0,38)	204,06	40
Afyon Kocatepe Uni.	1,864	5 (0,02) 22 (0,62) 36 (0,36)	186,39	33
Akdeniz University	1,867	5 (0,03) 22 (0,06) 26 (0,33) 36 (0,59)	186,74	34
Anadolu University	**1,000**	**33**	**3,85**	**2**
Ankara University	**1,000**	**2**	**95,43**	**9**
Atatürk University	1,109	5 (0,05) 6 (0,14) 26 (0,68) 32 (0,14)	110,90	14
Boğaziçi University	1,007	5 (0,00) 22 (0,60) 36 (0,40)	100,73	11
Bülent Ecevit Uni.	2,023	5 (0,02) 22 (0,69) 36 (0,29)	202,31	39
Celal Bayar University	1,951	5 (0,03) 22 (0,50) 26 (0,30) 36 (0,17)	195,08	36
Cumhuriyet University	2,211	5 (0,03) 22 (0,43) 36 (0,54)	221,08	43
Ç.Onsekiz Mart Uni.	1,693	5 (0,02) 22 (0,43) 26 (0,55)	169,27	26
Çukurova University	1,652	5 (0,02) 6 (0,01) 16 (0,27) 22 (0,14) 36 (0,56)	165,16	24
Dicle University	1,981	5 (0,02) 22 (0,33) 36 (0,66)	198,14	37
Dokuz Eylül Uni.	1,468	5 (0,02) 19 (0,44) 26 (0,29) 36 (0,26)	146,81	20
Ege University	**1,000**	**3**	**97,74**	**10**
Erciyes University	1,257	5 (0,02) 22 (0,14) 26 (0,21) 36 (0,63)	125,67	16
Fırat University	1,374	5 (0,01) 16 (0,02) 22 (0,36) 36 (0,60)	137,39	18
Gazi University	**1,000**	**1**	**90,21**	**8**
Gaziantep University	1,658	5 (0,02) 22 (0,46) 26 (0,36) 36 (0,16)	165,76	25
Gaziosmanpaşa Uni.	1,630	5 (0,01) 22 (0,66) 26 (0,02) 36 (0,31)	163,03	22
Gebze Yüksek Tek. Enst.	**1,000**	**31**	**Big**	**1**
Hacettepe University	**1,000**	**0**	**86,38**	**7**

Table 2. Continue

University	Efficiency score	Reference set	Super efficiency score (%)	Super efficiency rank
Harran University	2,168	5 (0,01) 22 (0,60) 36 (0,39)	216,77	**42**
İnönü University	1,911	5 (0,02) 16 (0,14) 22 (0,42) 36 (0,42)	191,08	35
İstanbul Teknik Uni.	**1,000**	**20**	**71,53**	**4**
İstanbul University	**1,000**	**0**	**76,88**	**5**
Kah. Sütçü İmam Uni.	1,829	5 (0,01) 22 (0,64) 26 (0,26) 32 (0,08)	182,91	**31**
Karadeniz Teknik Uni.	1,486	5 (0,02) 22 (0,16) 26 (0,51) 36 (0,31)	148,60	21
Kırıkkale University	1,645	5 (0,01) 22 (0,71) 26 (0,12) 36 (0,15)	164,51	23
Kocaeli University	1,760	5 (0,04) 22 (0,36) 26 (0,19) 36 (0,40)	175,99	28
Marmara University	**1,000**	**5**	**78,54**	**6**
Mersin University	1,984	5 (0,02) 22 (0,45) 26 (0,20) 36 (0,33)	198,38	38
Mustafa Kemal Uni.	1,830	5 (0,02) 22 (0,63) 36 (0,35)	183,01	32
Ondokuz Mayıs Uni.	1,319	5 (0,01) 22 (0,20) 26 (0,22) 36 (0,57)	131,89	17
Orta Doğu Tek. Uni.	**1,000**	**27**	**69,11**	**3**
Pamukkale University	1,811	5 (0,03) 22 (0,43) 26 (0,19) 36 (0,35)	181,05	30
Sakarya University	1,045	5 (0,02) 22 (0,50) 32 (0,48)	104,52	12
Selçuk University	1,102	5 (0,02) 22 (0,08) 26 (0,83) 32 (0,07)	110,15	13
Süleyman Demirel Uni.	1,423	5 (0,03) 22 (0,26) 26 (0,40) 36 (0,32)	142,28	19
Trakya University	2,150	5 (0,02) 22 (0,47) 26 (0,29) 36 (0,22)	215,03	41
Uludağ University	1,764	5 (0,03) 22 (0,07) 26 (0,23) 36 (0,68)	176,37	29
Yıldız Tek. Uni.	1,177	5 (0,01) 22 (0,47) 26 (0,39) 32 (0,14)	117,74	15

The efficient universities active in the 2014–2015 academic year in Turkey, based on Table 2, include Gebze Teknik University, Anadolu University, Orta Doğu Teknik University, İstanbul Teknik University, İstanbul University, Marmara University, Hacettepe University, Gazi University, Ankara University, and Ege University. Overall, 10 of the 43 state universities were efficient in the 2014–2015 academic year.

According to the super efficiency model results, Gebze Teknik University took first place and Cumhuriyet University took last place in efficiency ranking. When we look at the reference sets for Cumhuriyet University, we see Anadolu University, Gebze Yüksek Teknoloji Enstitüsü, and Orta Doğu Teknik University. Therefore, the effectiveness of Cumhuriyet University would increase if the input and output values of Cumhuriyet University were arranged according to universities in its reference set. Cumhuriyet University should increase its inputs (total expenses, number of faculty members, number of lecturers) 3% according to Anadolu University, 43% according to the Gebze Institute of Technology, and 54% according to Middle East Technical University, without changing output values (number of supported public and infrastructure projects; number of citations; number of publications in SCI, SSCI, AHCI indices; total number of undergraduate students; total number of graduate students) in order to become more effective.

According to the DEA results, 23% of state universities in Turkey were found to be effective and 77% of them to be ineffective. The average activity of universities in the 2014–2015 academic year was 1.509 (from Table 2). According to this finding, it should be mentioned that there is a decrease in the performance of state universities. These results are parallel to those of other studies in the literature. Six of 71 state universities were found to be effective in the study conducted by Karacabey (2001) in 2000. Babacan, Kartal, and Bircan (2007) determined that the activity of state universities was low between 2000 and 2005. Similarly, 24 of 53 state universities were found to be effective between 2000 and 2005; Kutlar and Babacan (2008) reached the conclusion that state universities have a low efficiency. Additionally, 21 of the 52 state universities were found to be effective in 2009–2010 in Özel's (2014) study. Therefore, the performance of state universities could be improved.

The variables that may affect efficiency values are examined by a Tobit regression model. The efficiency values are considered to be dependent variables for the Tobit regression model. Tobit activity values were taken as the dependent variable for regression analysis. Based on the study of Fethi et al. (2000), the following transformation was applied to efficiency scores given in Table 2 to use the censored Tobit regression at zero proposed by Green (1993).

$$y_i = 1 - \left(\frac{1}{\text{Efficiency scores}} \right)$$

With this transformation, the efficiency scores are between 0 and 1. After transformation, the efficiency scores of efficient universities are 0. However, the model results should be interpreted carefully because the signs of model coefficients are interpreted opposite of what might be intuitive. In other words, a positive sign means increasing ineffectiveness, and a negative sign means increasing effectiveness. The results of the Tobit regression are given in Table 3:

Table 3. The Tobit Results Related to Efficiency Scores of State Universities in the 2014–2015 Academic Year

Variables	Estimation	Standard error	Z value	p-value
Constant	0,6013796	0,1594064	3,773	0,000162***
h-index	-0,0073520	0,0019890	-3,696	0,000219***
Number of students/Number of faculty members	-0,0015298	0,0057119	-0,268	0,788831
Number of graduate students	-0,0002162	0,0000694	-3,11	0,001868**
Presence of medical school	0,3294876	0,0871625	3,78	0,000157***
Number of faculty	-0,0050038	0,0072577	-0,689	0,490539
Age of university	-0,0004811	0,0020467	-0,235	0,814153
Log(σ)	-2,1257400	0,1268826	-16,754	0,0000***

***0.001, **0.01,*0.05

According to the results of the Tobit model, the h-index, number of graduate students, and presence of a medical school were found to be significant variables affecting the efficiency scores of the university. As previously mentioned, the negative coefficients indicate an increase in efficiency. In this case, while the increase in h-index value and the number of graduate students are increasing the efficiency of universities, the presence of medical schools is decreasing the efficiency of universities. According to DEA, universities with medical schools lag in the ranking.

Beta regression was used to determine the variables affecting the performance of state universities by applying the transformation of the efficiency scores obtained by DEA, provided that these values were between 0 and 1. The results are given in Table 4:

Table 4. Beta Regression Results Related to Efficiency Scores of State Universities

Variables	Estimation	Standard Error	Z value	p-value
Constant	1,4212939	0,8044608	1,767	0,077267
h-index	-0,0384462	0,0105920	-3,630	0,000284***
Number of students/Number of faculty members	-0,0213102	0,0282590	-0,754	0,450788
Number of graduate students	-0,0009093	0,0003542	-2,567	0,010260*
Presence of medical school	0,9488898	0,2499640	3,796	0,000147***
Number of faculty	-0,0180491	0,0369839	-0,488	0,625531
Age of university	-0,0009883	0,0102991	-0,096	0,923555
ϕ	11,403	2,487	4,585	0,0000***

***0.001, **0.01,*0.05; Pseudo-R^2=0,7154

The dispersion parameter ϕ given in Table 4 was found to be statistically significant. When examining Table 4, the h-index, number of graduate students, and presence of a medical school were found to have an impact on the effectiveness of the university. Accordingly, we conclude that while the increase in the h-index and number of graduate students increase the efficiency of universities, the presence of a medical school decreases their efficiency. The regression coefficients in Table 3 can be interpreted as the odds ratio in the logistic regression model. According to this, the efficiency of non-medical faculties of universities is more than $(e^{0,9488898} / e^{-0,9488898} = 6,67)$ times the efficiency of medical faculties of universities. Tobit and beta regression analysis showed similar results as reported in the literature. The number of faculty had a negative effect on efficiency when the efficiency of state universities was examined by Tobit regression in Selim and Bursalıoğlu's (2015) study. Erkoç (2016) has determined that the efficiency scores of universities with medical schools are lower.

As seen from Tables 3 and 4, according to Tobit and beta regression models, the factors affecting the efficiency of universities are h-index, number of graduate students, and presence of medical schools. In addition, while h-index and number of graduate students increase the efficiency of universities, the presence of medical schools decreases it. It was determined that the lack of a medical school in a university increased the efficiency about six times. This finding explains why the Gebze Technology University, established two years, ago took first place according to DEA super-efficiency values.

Discussion

In recent years in Turkey, although there have been major developments in terms of university education, there should not have done. Determining the problems related to education in universities and investigating which factors have played important roles in university performance are useful strategies for generating solutions. It is important to educate human resources and equip them with required information for business and life, as well as to produce information in universities to contribute to industry. However, there are various constraints on the units, such as the number of faculty members and financial resources necessary to reach these goals, in state universities.

The competition between universities is directed toward using resources properly and improving performance. DEA can be used to determine efficiency scores and help universities use their resources effectively.

In this study, the efficiency values of state universities were determined by DEA. Then, Tobit regression analysis and first time beta regression analysis were used to determine factors affecting those efficiency scores. For this purpose, firstly, Tobit regression analysis was used to determine the factors affecting effectiveness. Unlike other studies, factors affecting efficiency were first determined by beta regression analysis. As the results of the study show, the Tobit regression analysis determined similar factors compared to beta regression analysis.

In the study of Baysal, Alçılar, Çerçioğlu, and Toklu (2005), which used a BCC model, 25 of the 50 state universities are determined as efficient according to the efficiency values. Osmangazi University was found as the university with the lowest efficiency value. In the study of Çınar (2013), the result of the DEA was that the research activities of public universities were higher than the educational activities. Gazi University and Middle East Technical University are efficient in both education and research fields; Dumlupınar, Kocaeli, Marmara, and Sakarya Universities are efficient in the field of education; and Erciyes and İzmir Advanced Technology Institute are efficient in the field of research.

In the study of Özel (2014), Cukurova University, Dokuz Eylül University, Galatasaray University, Gazi University, Karadeniz Technical University, and Middle East Technical University were stated as super-efficient state universities between 2009 and 2010 according to the results of the BCC super-efficiency model. In the study of Selim and Bursalıoğlu (2015), according to the efficiency values of the BCC model, Balikesir University, Dumlupınar University, Erciyes University, Galatasaray University, Gebze Technical University, Kafkas University, Marmara University, Nigde University, Middle East Technical University, and Selçuk University are determined as efficient universities between 2006–2010. In the second step, analysis of Tobit regression was applied to efficiency values, and it is shown that the effectiveness of universities between 2006 and 2010 was positively influenced by the number of female students and negatively influenced by the number of male students and the number of faculty.

Arık and Seyhan (2016) ranked Turkish universities in the top 500 in the world until 2016 according to the results of the CCR and BCC model efficiency values. According to the results of both models, Bogazici University, Gazi University, Istanbul University, Istanbul Technical University, Middle East Technical University, and Sabancı University were found to be efficient universities. Erkoç (2016) has found that the effectiveness of public universities in Turkey was not good; although there was no regular activity improvement in 2005–2010, there was a slight improvement from the 2008–2009 academic year. When Tobit regression was applied to the efficiency scores, it is found that the rate of full-time academic staff and having a medical faculty had an effect on the efficiency performance.

In this study, it was determined that 10 of the 43 state universities were efficient during the 2014–2015 academic year. These universities are Gebze Technical University, Anadolu University, Middle East Technical University, Istanbul Technical University, Istanbul University, Marmara University, Hacettepe University, Gazi University, Ankara University, and Ege University. Cumhuriyet University has the lowest efficiency score. These results are similar to the previous studies. As in the other studies, this study showed that the performance of state universities is still insufficient.

The fact that the average efficiency in state universities is low indicates that in order to make universities more effective, it is necessary to determine which factors are important for efficiency. From this point on, according to the applied Tobit regression and beta regression analysis, state universities should increase their h-index and the number of graduate students in order to improve their performance. The presence of a medical school at a university reduces its efficiency value. These results are similar to those obtained in Erkoç (2016). In addition, in this study, differently from other studies performed in this area until now, beta regression, which is used for the data of between 0 and 1, is useful for determining the factors affecting the efficiency.

International organizations such as Times Higher Education and Shangai determine the most successful universities each year. In this order, ODTÜ, Boğaziçi University, ITU, and Hacettepe University are among the most successful 400 universities. This result shows the success of our universities if the numbers are small. Either this result or the quantitative growth in higher education in recent years are positive developments in terms of state universities in Turkey. However, the results of this study and previous studies also indicate that there are problems with educational quality and research performance in our universities. From the results of this research aimed to achieve results that reflect this reality by analyzing with the factors including less missing value in the future researches. In addition, the factor values of the years 2014–2017 can be used to compare each year's efficiency.

References

Afonso, A., & Santos, M. (2005). *Students and teachers: A DEA approach to the relative efficiency of Portuguese public universities*. New Economic Papers.

Agasisti, T. (2011). Performances and spending efficiency in higher education: A European comparison through non-parametric approaches. *Education Economics*, *19*(2), 199-224.

Akal, Z. (2002). *İşletmelerde performans ölçüm ve denetimi çok yönlü performans göstergeleri* (2nd ed.). Ankara: MPM Yayınları.

Al, U. (2008). Bilimsel yayınların değerlendirilmesi: h-endeksi ve Türkiye'nin performansı. *Bilgi Dünyası, 9*(2), 263-285.

Amemiya, T. (1984). Tobit models: A survey. *Journal of Econometrics*, *24*(1-2), 3-61.

Arık, N., & Seyhan, B. (2016). Üniversite öğrencilerinin kariyer planlamasında teknoloji bilgisi ve gelecek beklentilerinin rolü. *İnsan ve Toplum Bilimleri Araştırmaları Dergileri*, *5*(7), 2218-2231.

Aubyn, M. S., Garcia, F., & Pais, J. (2009). *Study on the efficiency and effectiveness of public spending on tertiary education* (No. 390). Directorate General Economic and Financial Affairs (DG ECFIN), European Commission.

Avkıran, N. K. (2001). Investigating technical and scale efficiencies of Australian universities through data envelopment analysis. *Socio-Economic Planning Sciences*, *35*(1), 57-80.

Babacan, A., Kartal, M., & Bircan, H. (2007). Cumhuriyet Üniversitesi'nin etkinliğinin kamu üniversiteleri ile karşılaştırılması: Bir VZA tekniği uygulaması. *CÜ İktisadi ve İdari Bilimler Dergisi*, *8*(2), 97-114.

Bal, V. (2013). Vakıf üniversitelerinde veri zarflama analizi ile etkinlik belirlenmesi. *Manas Sosyal Araştırmalar Dergisi*, *2*(1), 1-14.

Balyer, A., & Gündüz, Y. (2011). Türk yükseköğretim yönetim sisteminde YÖK ile yaşanan paradigmatik dönüşüm: Vakıf üniversiteleri çelişkisi. *Erciyes Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *31*(1), 69-84.

Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science*, *30*(9), 1078-1092.

Baysal, M. E., & Toklu, B. (2001). Veri zarflama analizi ile bazı orta öğretim kurumlarının performanslarının değerlendirilmesi. *Süleyman Demirel Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, *6*(2), 203-220.

Baysal, M. E., Alçılar, B., Çerçioğlu, H., & Toklu, B. (2005). Türkiye'deki devlet üniversitelerinin 2004 yılı performanslarının, veri zarflama analizi yöntemiyle belirlenip buna göre 2005 yılı bütçe tahsislerinin yapılması. *Sakarya Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, *9*(1), 67-73.

Bektaş, B. (2007). *Türkiye'de faaliyet gösteren bankaların farklı yöntemlerle sınıflandırılması ve etkinliklerinin belirlenmesi üzerine bir araştırma* (Unpublished master's thesis). Gazi University, Graduate School of Natural and Applied Sciences, Ankara.

Boussofiane, A., Dyson, R. G., & Thanassoulis, E. (1991). Applied data envelopment analysis. *European Journal of Operational Research*, *52*(1), 1-15.

Bursalioglu, S. A., & Selim, S. (2015). Avrupa Birligi Ülkeleri ve Türkiye'de Yüksekögretimde Etkinligi Belirleyen Faktörler. *Bilig, 74*, 45-70.

Charnes, W., Cooper, E., & Rhodoes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operations Research*, *2*, 429-444.

Cribari-Neto, F., & Lima, L. B. (2007). *A misspecification test for Beta regressions.* Technical report.

Cuenca, J. S. (2011). Efficiency of state universities and colleges in the Philippines: A data envelopment analysis. *PIDS Discussion Paper Series*, 2011-2044.

Çetinsaya, G. (2014). *Büyüme, kalite, uluslararasılaşma: Türkiye yükseköğretimi için bir yol haritası*. Ankara: Yükseköğretim Kurulu.

Çınar, Y. (2013). Türkiye'de kamu üniversitelerinin eğitim-araştırma etkinlikleri ve etkinlik artışında stratejik önceliklerin rolü: Çok-aktiviteli VZA uygulaması. *Ankara Üniversitesi SBF Dergisi*, *68*(2), 27-62.

Depren, Ö. (2008). *Veri zarflama analizi ve bir uygulama* (Unpublished master's thesis). Yıldız Teknik University, Graduate School of Natural and Applied Sciences, İstanbul.

Erkoç, T. E. (2016). Measuring efficiencies of Turkish public universities with non-parametric efficiency estimation method [Türkiye'de kamu üniversitelerinin etkinliğinin parametrik olmayan yöntem ile ölçülmesi]. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, *29*(3), 124-136. doi:10.16986/HUJE.2016017221

Espinheira, P. L., Ferrari, S. L., & Cribari-Neto, F. (2008). On beta regression residuals. *Journal of Applied Statistics*, *35*(4), 407-419.

Eşme, İ. (2014). Türk üniversitelerinin eğitim-öğretim ve araştırma performansları. *Aljazeera Turk*. Retrieved from http://aljazeera.com.tr/gorus/turk-universitelerinin-egitim-ogretim-ve-arastirma-performanslari

Ferrari, S., & Cribari-Neto, F. (2004). Beta regression for modelling rates and proportions. *Journal of Applied Statistics*, *31*(7), 799-815.

Fethi, M. D., Jackson, P. M., & Weyman-Jones, T. G. (2000). Measuring the efficiency of European airlines: An application of DEA and tobit analysis. *European Journal of Operational Research, 204*(2), 189-198.

Green, F. (1993). The impact of trade union membership on training in Britain. *Applied Economics*, *25*(8), 1033-1043.

Gujarati, D. N. (2004). *Basic econometrics* (4th Ed.). New York: McGraw-Hill.

Gülcü, A., Çoşkun, A., Yeşilyurt, C., Çoşkun, S., & Esener, T. (2004). Cumhuriyet Üniversitesi'nin Diş Hekimliği Fakültesi'nin veri zarflama analizi yöntemi ile göreceli etkinlik analizi. *C.U. İktisadi ve İdari Bilimler Dergisi*, *5*(2), 87-104.

Gülsevin, G., & Türkan, A. H. (2015). Afyonkarahisar hastanelerinin etkinliklerinin veri zarflama analizi ile değerlendirilmesi. *Afyon Kocatepe Üniversitesi Fen ve Mühendislik Bilimleri Dergisi*, *12*(2), 1-8.

Gürüz, K. (2001). *Dünyada ve Türkiye'de yükseköğretim (Tarihçe ve bugünkü sevk ve idare sistemleri)*. Ankara: ÖSYM Yayınları.

Hirsch, J. E. (2005). An index to quantify an individual's scientific research output. *Proceedings of the National Academy of Sciences of the United States of America*, *102*(46), 16569-16572.

Karacabey, A. A. (2001). Veri zarflama analizi, *Ankara Üniversitesi SBF GETA Tartışma Metinler, 33*, 1-12.

Karlı, B., & Bilgiç, A. (2007). Factors affecting meat and meat products consumption quantities in Şanlıurfa province. *Akdeniz Üniversitesi Ziraat Fakültesi Dergisi*, *20*(1), 127-136.

Kempkes, G., & Pohl, C. (2007). *The efficiency of German Universities – some evidence from non-parametric and parametric methods.* CESifo Venice Summer Institute, 18-19 July.

Kempkes, G., & Pohl, C. (2010). The efficiency of German universities: Some evidence from non-parametric and parametric methods. *Applied Economics, 42*(16), 2063-2079.

Kutlar, A., & Babacan, A. (2008). Türkiye'deki kamu üniversitelerinde CCR etkinliği-ölçek etkinliği analizi: DEA tekniği uygulaması. *Kocaeli Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *15*(1), 148-172.

Kutlar, A., & Kartal, M. (2004). Cumhuriyet üniversitesinin verimlilik analizi: Fakülteler düzeyinde veri zarflama yöntemiyle bir uygulama. *Kocaeli Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *8*(2), 49-79.

Li, M., & Ye, L. R. (1999). Information technology and firm performance: Linking with environmental, strategic and managerial contexts. *Information & Management*, *35*(1), 43-51.

Liu, W. B., Wongcha, A., & Peng, K. C. (2012). Adopting super-efficiency and tobit model on analyzing the efficiency of teacher's colleges in Thailand. *International Journal On New Trends In Education And Their Implications*, *3*(3), 176-188.

McMillan, M. L., & Datta, D. (1998). The relative efficiencies of Canadian universities: A DEA perspective. *Canadian Public Policy/Analyse de Politiques*, *24*(4), 485-511.

Mikusova, P. (2015). An application of DEA methodology in efficiency measurement of the Czech public universities. *Procedia Economics and Finance*, *25*, 569-578.

Norman, M., & Stoker, B. (1991). *Data envelopment analysis: The assessment of performance*. New York: John Wiley & Sons.

Oruç, K. O. (2008). *Veri zarflama analizi ile bulanık ortamda etkinlik ölçümleri ve üniversitelerde bir uygulama* (Unpublished doctoral dissertation). SDÜ, Institute of Social Sciences, Isparta.

Ospina, R., Cribari-Neto, F., & Vasconcellos, K. L. (2006). Improved point and interval estimation for a beta regression model. *Computational Statistics & Data Analysis*, *51*(2), 960-981.

Özdemir, S. (1995). Eğitimde verimlilik ve toplam kalite yönetimi. *Kuram ve Uygulamada Eğitim Yönetimi*, *3*(3), 377-388.

Özden, Ü. H. (2008). Veri zarflama analizi (VZA) ile Türkiye'deki vakıf üniversitelerinin etkinliğinin ölçülmesi. *Istanbul University Journal of the School of Business*, *37*(2), 167-185.

Özel, G. (2014). Efficiency analysis of state universities: A case of Turkey. *Hacettepe University Journal of Education*, *29*(3), 124-136.

Özel, G. (2015). Efficiency analysis of foundation universities in Turkey. *Education and Science*, *40*(177), 31-41.

Peker, Ö. (1994). Toplam kalite yönetiminin eğitim sistemine uygulanabilirliği. *Amme İdaresi Dergisi*, *2*(27), 63-78.

Prokopenko, J. (1998). "*Verimlilik yönetimi*" (O. Baykal, N. Atalay, & E. Fidan, Trans.). Ankara: MPM Yayınları, No: 476.

Sarıca, S. (2007). *Üniversitelerin performansa göre yönetimi için veri zarflama analizi tabanlı bir karar destek sisteminin tasarımı ve geliştirilmesi* (Unpublished master's thesis). Osmangazi University, Graduate School of Natural and Applied Sciences, Eskişehir.

Selim, S., & Bursalıoğlu, S. A. (2015). Efficiency of higher education in Turkey: A bootstrapped two-stage DEA approach. *International Journal of Statistics and Applications*, *5*(2), 56-67.

Simas, A. B., Barreto-Souza, W., & Rocha, A. V. (2010). Improved estimators for a general class of beta regression models. *Computational Statistics & Data Analysis*, *54*(2), 348-366.

Tarım, A. (2001). *Veri zarflama analizi: Matematiksel programlama tabanlı göreli etkinlik ölçümü yaklaşımı* (1st ed.). Ankara: Sayıştay Yayınları.

Tobin, J. (1958). Estimation of relationships for limited dependent variables. *Econometrica: Journal of the Econometric Society*, *26*(1), 24-36.

Üçdoğruk, Ş., Akın, F., & Emeç, H. (2001). Türkiye hanehalkı eğlence kültür harcamalarında tobit modelin kullanımı. *İktisadi ve İdari Bilimler Fakültesi Dergisi*, *3*(3), 1-13.

Vassiloglou, M., & Giokas, D. (1990). A study of the relative efficiency of bank branches: An application of data envelopment analysis. *Journal of the Operational Research Society*, *41*(7), 591-597.

Yükçü, S., & Atağan, G. (2009). Etkinlik, etkililik ve verimlilik kavramlarının yarattığı karışıklık. *Atatürk Üniversitesi İktisadi ve İdari Bilimler Dergisi*, *23*(4), 1-13.