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A Case Study on Measuring Research Efficiency of Public Universities in Turkey[#]

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Abstract

This paper measures the research efficiency and productivity of public universities founded before 1981 in Turkey over the period 2013-2016. Data Envelopment Analysis is applied to assess the relative research efficiency of these universities, while Malmquist Total Factor Productivity Index is used to measure the total factor productivity change with respect to research inputs of universities. The analysis made here differ from the similar studies in terms of the diversity of data set and the measurement of university research efficiency and productivity changes together. The results indicate that the number of relatively efficient universities according to their reserach inputs declines continuously over the years. Also, the productivity of research activities decreases except the period 2013-2014. It is additionally observed that 2.3% fall in research productivity of the universities is due to deterioration in both technological and technical efficiency over the yaers.

Keyword: data envelopment analysis; efficiency; higher education; Malmquist total factor productivity index; research

Türkiye'deki Devlet Üniversitelerinde Araştırma Etkinliğinin Ölçülmesi Üzerine Bir Çalışma

Özet

Bu çalışmada, Türkiye'de 1981 yılından önce kurulan devlet üniversitelerinin 2013-2016 yılları arasındaki araştırma etkinliği ve verimliliği ölçülmektedir. Nispi araştırma etkinliğini ölçmek için Veri Zarflama Analizi kullanılırken, üniversitelerin girdilerine oranla toplam faktör verimliliğindeki değişimi ölçmek için Malmquist Toplam Faktör Verimliliği Endeksi kullanılmaktadır. Hem üniversitenin araştırma etkinliğini ve verimliliğini birlikte ölçmesi hem de veri setindeki çeşitlilik dikkate alındığında bu çalışma diğerlerinden farklılık göstermektedir. Sonuçlar araştırma girdileri temel alındığında göreli etkin üniversite sayısının yıllar itibariyle sürekli düştüğünü göstermektedir. Ayrıca, üniversitelerin araştırma verimliliği de 2013-2014 dönemi hariç düşmüştür. Bunlara ek olarak, üniversitelerin araştırma verimliliğinin yıllar içinde hem teknolojik hem de teknik etkinlikte görülen azalmadan dolayı %2,3 oranında düştüğü tespit edilmiştir.

Anahtar kelimeler: veri zaflama analizi; etkinlik; yükseköğretim; Malmquist toplam faktör verimliliği endeksi; araştırma

1. INTRODUCTION

The core outputs of universities, in return, are formation of human capital, new knowledge and technology. Universities, particularly public universities, receive considerable amount of share from government funds in order to produce these outputs. Turkey's Central Government Budget 2018 allocates 3.9% of total budget to Council of Higher Education (CoHE) and public universities (Maliye Bakanlığı [MB], 2018), and this grows a requirement for transparency and accountability of HEIs. It is demanded by government and taxpayers to know how much and in what ways public resources are allocated to universities so that efficiency and quality increase in higher education. This requires rational assessment criteria to measure efficiency of HEIs for allocating public funds consistently.

In Turkey, the recent expansion in higher education draws considerable discussion on various subjects, one of which is efficiency measurement of universities and selection of relevant and objective criteria for this. The Law#5018[1] enacted in 2003 brought performance based budgeting system which requires measurement of performance in public universities since public funds allocated to them would be determined based on their performance levels. Therefore, in relation to this development,

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[1] http://www.mevzuat.gov.tr/Metin.Aspx?MevzuatKod=1.5.5018&MevzuatIliski=0&sourceXmlSearch= (31.05.2018)

[#]An early version of this work was presented at 10th World Conference on Educational Sciences, 1-3 February 2018, Prague, Czech Republic efficiency measurement became an important issue in Turkish public universities due to their dependence on public money.

Since HEIs are non-profit organizations, it is needed to find appropriate methods to assess efficiency of universities. Yet, motivated by different goals and operating as non-profit institutions, efficiency measurement in HEIs is difficult due to some characteristic features of it. First of all, universities have a variety of inputs and outputs so that it becomes complicated to measure impact of each input on each output separately. Secondly, visions of universities and their relative importance to each stakeholder are diverse requiring distinct perspectives for efficiency measurement (Worthington, 2001; Engert, 1996; Yüksek Öğretim Kurulu [YÖK], 2007; Agasisti & Bonomi, 2014; Günay, Dulupçu & Oruç, 2017). Another complexity that makes measuremet of efficiency in HEIs difficult is that output of HEIs cannot be measured easily and quantitatively. Most of the outputs are linked to each other naturally so that they cannot be separated for measuring purposes. Besides, our knowledge is limited with respect to determination of accurate input and output of higher education. Although there is an extensive discussion about the shape of production function of higher education, a consensus has not been reached yet (Worthington, 2001). Lastly, being a non-profit organization and having various objective functions is another issue that complicates efficiency measurement in HEIs (Agasisti & Salerno, 2007).

The aim of this study is to examine research efficiency of some Turkish public universities in relation to total factor productivity change in terms of research inputs in 2013-2016 by using Data Envelopment Analysis (DEA) method. We use also Malmquist Total Factor Productivity Index (MPI) to measure the total factor productivity change with respect to research inputs of universities.

The next section reviews literature on research efficiency measurement in HEIs, section three explains the methodology, section four introduces the data and presents empirical findings, and section five summarizes the study.

2. LITERATURE REVIEW

It took a long time to realize multidimensional structure of higher education and study production function of HEIs by economists. Only after the expansion in number and variety of HEIs in 1960s, research on efficiency of HEIs started to reveal (Dundar & Lewis, 1995). In the literature, it is seen that techniques used to measure efficiency of HEIs can be classified in three groups: cost function estimation, stochastic frontier estimation and DEA. Of these techniques, the initial two are parametric, which requires determination of prior production function, and the last one is nonparametric, which does not need a predetermined production function (Günay et al., 2017). Since it is difficult to make presumption for a specific production function for HEIs, nonparametric DEA, developed by Ahn, Arnold, & Cooper (1989), has been used commonly in the literature. Tomkins & Green (1988) were the first to use DEA for measuring efficiency of HEIs.

In the literature, there are numerous studies measuring both education and research efficiency of universities or particular departments (Beasley, 1995; Abbott & Doucouliagos, 2003; Avkiran, 2001; Carrington, Coelli, & Rao, 2005; Fandel, 2007; Johnes, 2006; Warning, 2004). However, while some studies focus only on education efficiency (Ahn, et al., 1989; Agasisti & Bonomi, 2014; Abbott & Doucouliagos, 2003; Colbert, Levary, & Shaner, 2000), some analyze research efficiency specifically (Johnes & Yu, 2008; Ng & Li, 2000; Agasisti, Bianco, & Sala, 2011; Cherchye & Abeele, 2005; Johnes & Johnes, 1995).

Johnes & Johnes (1995) is accepted as the leading study measuring research efficiency of universities. Following a discussion on input/output selection problem, it is suggested to use research funds as research input and different type of academic publications as research output of universities. This study is a good example of interpretation of efficiency scores, as well.

Similar to Johnes & Johnes (1995), Beasley (1995) also used research funds as research input. On the other hand, Tomkins & Green (1988) and Kwimbere (1987) used research funds as research output, raising a debate on how to use research funds in measuring research efficiency.

Cherchye & Abeele (2005) suggested a micro-unit approach instead of macro-unit for research efficiency analysis in HEIs. It is concluded that a detailed micro-unit analysis, which also incorporates the effect of external funding and size of research programs on research efficiency, might generate more efficient allocation of researcs funds.

Ng & Li (2000) examined research efficiency of 84 Chinese HEIs and found that regional differences affect research efficiency of universities. Similarly, Johnes & Yu (2008) analyzed research efficiency of 109 Chinese universities by using DEA and revealed that comprehensive universities and coastal region universities are more efficient compared to specialist universities and western region universities, respectively.

In addition to considering universities as a whole, departments in universities can also be subject of efficiency analysis. Agasisti et al. (2011) investigated research efficiency of university departments in science, technology and medicine in Lombardy region of Italy.

While Karacabey (2001) used a very simple model with one output (number of publications) to measure research efficiency of Turkish universities, Çinar (2013) and Haktanırlar (2011) studied education and research efficiencies jointly. Nevertheless, the selected research input (university budget, number of academicians and number of students) do not include resources particularly allocated to research activities, so empirical findings are open to criticism. From this point, our study will be influential in measuring research efficiency of Turkish universities by using a diverse data set. Furthermore, change in research efficiency of Turkish universities in time has not been studied as to the authors' knowledge, so this study will be pioneering one.

3. METHODOLOGY AND DATA

DEA is a linear programming based technique aimed at measuring the relative performances of decision making units (DMUs) when it is difficult to compare inputs and outputs which have different measurement units or measured by multi-scale (Karacaer, 1998). This method is used to compare the production performance of enterprises by handling multiple inputs and outputs simultaneously, something that cannot be achieved using classical regression analysis (Baysal, Alçilar, Çerçioğlu, & Toklu, 2005). The enterprises which are examined in terms of efficiency are called DMUs and relative efficiency, not absolute efficiency, at a certain time is measured by DEA (Atan, 2003). DMUs must be homogeneous enterprises that use the same types of inputs to produce the same types of outputs, have the same objectives and operate in the same field (Oruç, Çuhadar, Kilinç, & Osmancik, 2014).

It is assumed that there are n DMUs to evaluate and each DMU has m different inputs and s different outputs in the CCR model (Charnes, Cooper, & Rhodes, 1978). The mathematical expression of the objective function to be maximized for each DMU is (Ulucan, 2000):

$$Max\ h_k = \frac{\sum_{r=1}^{s} u_{rk} Y_{rk}}{\sum_{i=1}^{m} v_{ik} X_{ik}}$$

Decision variables for this decision problem are the weights given for i inputs and r outputs of the k^{th} DMU, so these weights are shown by v_{ik} and u_{rk} respectively.

There are two constraints that may prevent DMUs from being biased by choosing the weights to make them effective. The first constraint implies that the assigned weights cannot produce a value greater than one if applied to any other DMU that k^{th} DMU is compared against. The equation below indicates the mathematical expression of this constraint where $X_{ij} > 0$ is and $Y_{rj} > 0$ are the known inputs and outputs of the *j-th* DMU (Ulucan, 2000):

$$\frac{\sum_{r=1}^{s} u_{rk} Y_{rj}}{\sum_{i=1}^{m} v_{ik} X_{ij}} \leq 1; \quad j = 1,\ldots,n$$

The second constraint implies that all weights must have a positive value like that is shown below (Ulucan, 2000):

$$u_{rk} \geq \varepsilon > 0; \quad r = 1,\ldots,s$$
$$v_{ik} \geq \varepsilon > 0; \quad i = 1,\ldots,m$$
$$\varepsilon : A\ sufficiently\ small\ number\ (\in \leq 10^{-6})$$

This model is formulated with respect to the constant returns to scale assumption. Therefore, in the CCR model, it is assumed that when inputs are increased proportionately without changing the composition ratio of DMUs' inputs, outputs will also increase by the same ratio (Oruç et al., 2014). The mathematical expression of the CCR model for output is as follows (Charnes, Cooper, Lewin, & Seiford, 1994):

$$Min\ h_k = \sum_{k=1}^{m} v_{ik} X_{ik}$$

Constraints:

$$\sum_{r=1}^{s} u_{rk} Y_{rk} - \sum_{i=1}^{m} v_{ik} X_{ij} \leq 0; \quad k = 1,\ldots,n$$
$$\sum_{i=1}^{m} u_{rk} Y_{rk} = 1$$
$$u_{rk} \geq \varepsilon > 0; \quad r = 1,\ldots,s$$
$$v_{ik} \geq \varepsilon > 0; \quad i = 1,\ldots m$$

For a DMU to become efficient, an output- oriented model focuses on maximizing outputs while maintaining the same level of input (Matthews & Mahadzir, 2006; Oruç et al., 2014). In this study, an output-oriented model was set in order to reach the optimum level of research output while not changing universities research inputs.

Next, DEA based Malmquist index (MPI) is used to measure the total productivity change of DMUs over time (Malmquist, 1953; Liu & Wang, 2008). MPI can be calculated based on distance functions with the following equation under the assumption of the constant returns to scale where $d_0^t(y^t, x^t)$ and $d_0^{t+1}(y^{t+1}, x^{t+1})$ are the distance functions at t and $t+1$; x_t and x_{t+1} input vectors at t and $t+1$; y_t and y_{t+1} are the output vectors at t and $t+1$ (Fare, Grosskopf, Norris, & Zhang, 1994; Deliktaş, 2002), respectively.

$$MPI_0\left(y^t, x^t, y^{t+1}, x^{t+1}\right) = \frac{d_0^{t+1}\left(y^{t+1}, x^{t+1}\right)}{d_0^t\left(y^t, x^t\right)} \times \left[\frac{d_0^t\left(y^{t+1}, x^{t+1}\right)}{d_0^t\left(y^t, x^t\right)} \times \frac{d_0^{t+1}\left(y^{t+1}, x^{t+1}\right)}{d_0^t\left(y^t, x^t\right)}\right]^{1/2}$$
$$MPI_0\left(y^t, x^t, y^{t+1}, x^{t+1}\right) = TEC \times TC$$

Here, the ratio outside the brackets measures the technical efficiency change between years t and $t+1$. This change could occur both by efficiency changes and shifts in the efficiency frontier. However, the geometric mean of the two ratios in the brackets displays the change in production technology between years t and $t+1$ (Fare et al., 1994). If the value of MPI is greater or less than unity, that implies improvement or deterioration in productivity between years t and $t+1$, respectively.

In a DEA model, technical efficiency value is called the pure efficiency when obtained with the increasing/decreasing return to scale assumption. Proportional difference of technical efficiency and pure efficiency is called scale efficiency. Relation between these efficiency values is as follows (Ulucan & Karacabey, 2002; Oruç & Altın, 2015):

Technical Efficiency = Pure Efficiency x Scale Efficiency

19 public universities founded before 1981, establishment year of CoHE, in Turkey were selected as DMUs for this research. But two of them (Fırat University and Selçuk University) cannot be used due to the lack of data. The data set covering the period 2013-2016 are used to evaluate the relative research efficiency of these universities. The inputs and outputs taken into account in this study are listed in Table 1.

Table 1. Inputs and Outputs

Inputs	Outputs
- Indoor space (m^2) - Project budget - Number of academic personnel (total)	- Number of graduate students - Number of publications (total) - Number of projects

The number of graduate students and academic personnel were taken from Higher Education Statistics published by CoHE (YÖK, 2017). The number of publications was obtained from the Turkish Academic Network and Information Center-Web of Science database (Ulakbim, 2017). On the other side, the number of projects and their budget amounts were taken from The National Scientific and Technological Research Council (Tübitak, 2017). Lastly, universities' indoor space amount allocated to reseach activities were collected from the annual action plan of universities. In addition, DEA and MPI calculations were conducted with the Win4DEAP software package program developed by Coelli (1996).

4. EMPIRICAL FINDINGS

The results of the research efficiency analysis of universities are presented in Table 2. In terms of the reseach efficiency, universities have highest (0.965) and lowest (0.929) mean scores in 2013 and 2014, respectively. Also, the highest number of efficient universities in terms of reseach activities was seen in 2013 with 12 universities. Morever, the number of relatively efficient universities (11 universities) stays the same after 2013 and in totally universities are inefficient in all years according to their mean scores. Morever, only 4 universities (Istanbul University, Middle East Technical University, Bogazici University and Dicle University) are relatively efficient in all years, but Uludag University is relatively worst performing university in terms of research efficiency over the four year period.

MPI of the universities with respect to reseach inputs between 2013 and 2016 are given in Table 3. Accordingly, total factor productivity of universities increased by an average of 0.92% in the 2013-2014 period, but decreased by 2.1% and 12.7% in the following periods, respectively. The number of productive universities in terms of reserach inputs has decresaed from 13 in 2013-2014, to 9 in 2014-2015 and 5 in 2015-2016 period. In addition, Hacettepe University and Anadolu University show the best performances with respect to the productivity increase in research activities. But it is intersting to say that only Middle Esat Technical University is relatively worst performing university regarding to research productivity in all periods. Inonu University, Anadolu University and Cumhuriyet University have the highest productivity increase in time. On the other hand, Cumhuriyet University, Dicle Univeristy and Istanbul Technical University are those showing the lowest productivity levels in terms of research productivity.

Table 2. Reseach Efficiency Scores of Universities (2013-2016)

	University	2013	2014	2015	2016
1	Istanbul	1.000	1.000	1.000	1.000
2	Istanbul Technical	1.000	1.000	1.000	0.854
3	Ankara	1.000	0.940	1.000	1.000
4	Ege	1.000	1.000	0.965	1.000
5	Karadeniz Technical	1.000	1.000	0.930	1.000
6	Middle East Technical	1.000	1.000	1.000	1.000
7	Ataturk	1.000	1.000	1.000	0.965
8	Hacettepe	0.999	1.000	1.000	1.000
9	Bogazici	1.000	1.000	1.000	1.000
10	Cukurova	1.000	0.786	0.880	1.000
11	Dicle	1.000	1.000	1.000	1.000
12	Anadolu	0.929	0.627	1.000	1.000
13	Cumhuriyet	1.000	0.649	0.437	0.696
14	Uludag	0.760	0.815	0.791	0.699
15	Inönü	0.800	1.000	1.000	0.823
16	Ondokuz Mayıs	1.000	1.000	0.990	0.967
17	Erciyes	0.920	0.968	1.000	1.000
	Mean	**0.965**	**0.929**	**0.941**	**0.941**
	E=1	**12**	**11**	**11**	**11**
	E<1	**5**	**6**	**6**	**6**

Table 3. MPI Scores of Universities (2013-2016)

	University	2013-2014	2014-2015	2015-2016
1	Istanbul	1.063	1.112	0.815
2	Istanbul Technical	1.046	1.118	0.578
3	Ankara	1.036	1.122	0.734
4	Ege	1.028	0.941	0.665
5	Karadeniz Technical	1.351	0.819	0.656
6	Middle East Technical	0.995	0.939	0.714
7	Ataturk	1.349	0.918	0.781
8	Hacettepe	1.060	1.132	1.282
9	Bogazici	0.919	1.142	0.736
10	Cukurova	0.868	1.232	1.432
11	Dicle	1.203	0.628	1.242
12	Anadolu	1.003	1.268	1.422
13	Cumhuriyet	0.686	0.648	1.622
14	Uludag	1.315	0.912	0.882
15	Inönü	1.546	1.014	0.719
16	Ondokuz Mayıs	1.268	0.872	0.759
17	Erciyes	1.152	1.128	0.639
	Mean	**1.092**	**0.979**	**0.873**
	MPI=1	**-**	**-**	**-**
	MPI<1	**4**	**8**	**12**
	MPI>1	**13**	**9**	**5**

Table 4 and Figure 1 show the changes of mean values of MPI and their components for all universities under consideration. As it is seen from Figure 1, MPI is mostly affected by technological efficiency so that in 2013-2016 period averages of both MPI and technological efficiency has decreased. On the other hand, average technical efficiency showed a slight increase during this period. If the components of technical efficiency are analyzed, as it is seen from Figure 2 that, scale efficiency presents an increase and a consecutive decrease while pure efficiency increases during the analysis period.

Overall, it is seen that MPI decreased by %2.3 with respect to research inputs and this decline is caused by both technological and technical recession between 2013 and 2016 (Table 4). Average technological and technical efficiency values of universities fall by %1.3 and %1, respectively. Moreover, %0.5 decline in both pure and scale efficiency leads to a decrease in technical efficieny of all universities. Technology in higher education could be defined as the policies that should help in improving research efficiency (research grants, support for publishing research results etc.) (Agasisti et al. 2011). Pure and scale efficiency represents administrative efficiency and whether the universities work or not in the appropriate scale (Kaya & Aktan, 2011; Oruç & Altın, 2015). Therefore, it can be stated that universities do not have proper policies and administration systems to use their research resources efficiently between 2013 and 2016. Also, they don't work on appropriate scale according to their research inputs.

Particularly, increase in universities' research productivity between 2013 and 2014 is mainly driven by technological improvement instead of efficient use of resources or administrative efficiency. On the other hand, from 2014 to 2016 although technical efficiency of universities remain almost the same (and a little higher than 1) technological efficiency has decreased remarkably leading to a decarease in overall research productivity of public universities under consideration. Hence, it can be said that the lack of effective research polies is the main reason of decline in reseach productivity of universities in the last three years.

Table 4. Changes in Mean Values of MPI and Its Components (2013-2016)

	2013-2014	2014-2015	2015-2016	Mean
MPI	1.092	0.979	0.873	0.977
Technological Efficiency	1.143	0.971	0.865	0.987
Technical Efficiency	0.955	1.008	1.009	0.990
Pure Efficiency	0.977	1.000	1.008	0.995
Scale Efficiency	0.977	1.008	1.001	0.995

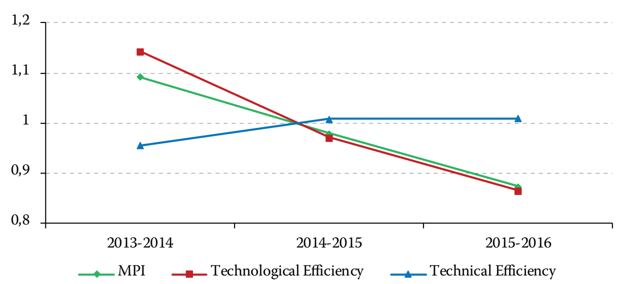

Figure 1. Changes in Mean Values of MPI, Technological Efficiency and Technical Efficiency (2013-2016)

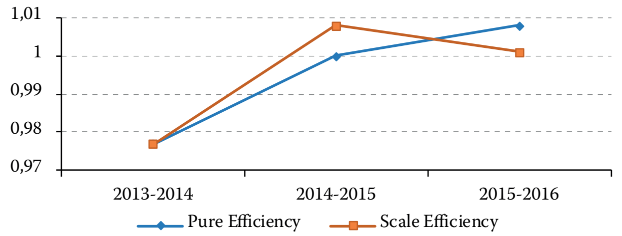

Figure 2. Changes in Mean Values Pure Efficiency and Scale Efficiency (2013-2016)

5. CONCLUSION

This research paper measured research efficiency of 17 public universities founded before 1981 in Turkey. DEA and MPI methods are applied to measure efficiency and change in total factor productivity of research for 2013-2016, respectively. It is found that 2/3 of universities are relatively efficient relative to other 1/3 with respect to research inputs. Both efficiency and productity of universities considering research inputs decrease in whole time period except the period 2013-2014. On the other side, overall research productivity of universities decreases by %2.3 and this decline is caused by both technological and technical recession. Therefore, it can be concluded that universities do not have effective research policies, administrative efficiency and scale efficiency to improve their research efficiencies. In this context, the results of this paper might be expected to provide important administrative information to the university administrations about their research activities. In this sense, we believe that this paper is just one of the preliminary study for Turkish higher education to measure reseach efficiency. The results might be improved by diversifiying data and increasing number of universities analyzed.

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