ANADOLU ÜNİVERSİTESİ SOSYAL BİLİMLER DERGİSİ
ANADOLU UNIVERSITY JOURNAL OF SOCIAL SCIENCES
Cilt/Vol.: 11 - Sayı/No: 1: 13–26 (2011)

MEASURING RELATIVE EFFICIENCIES OF TURKISH UNIVERSITIES IN 2007: A DEA CASE STUDY IN R

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ABSTRACT

Measuring relative efficiency of academic units which have similar area of research, methodology and resource profiles, has often been the subject of interest. To have such similarities among those units, make sense for the comparison of those units via data envelopment analysis(DEA). In this paper, we briefly discuss most widely used DEA models sufficient for using on our test case. Then we present our own case, based on 2007 statistics of Turkish universities and some preliminary information about the preferred environment (GNU R) and details of our application experience will follow. After presenting obtained results, some conclusion remarks will be given.

Keywords: *universities, relative efficiency, data envelopment analysis (DEA), GNU R*

TÜRK ÜNİVERSİTELERİNİN 2007 ETKİNLİKLERİNİN ÖLÇÜLMESİ: R' DE BİR VZA ÖRNEK ÇALIŞMASI

ÖZ

Benzer araştırma alanlarına, yöntemlerine ve kaynak profiline sahip akademik birimlerin etkinliklerinin ölçülmesi sıklıkla ilgi konusu olmuştur. Bu birimler arasında böyle benzerliklere sahip olmak, bu birimlerin veri zarflama analizi (VZA) yardımıyla karşılaştırılabilmelerini anlamlı kılmaktadır. Bu çalışmada, örnek olay çalışması için yeterli olduğu düşünülen, en çok kullanılan VZA modelleri kısaca tartışıldıktan sonra; Türk üniversitelerinin 2007 yılın istatistiklerine dayanan örnek olay sunulacaktır. Tercih edilen uygulama platformu (GNU R) hakkında bazı ön bilgiler verilecek ve uygulama deneyimlerinin detayları aktarılacaktır. Elde edilen sonuçlar sunulduktan sonra, bazı nihai düşüncelere yer verilecektir.

Anahtar Kelimeler: *üniversiteler, göreli etkinlik, veri zarflama analizi (VZA), GNU R*

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1. INTRODUCTION

Relative efficiencies of the academic units which have similar area of research, methodology and resource profiles, has often been the subject of interest for researchers. To have such similarities among those units make sense for the comparison of relative efficiencies, reflecting academic and non-academic aspects, via data envelopment analysis.

In this study, overall (i.e. output performance based on both academic publishing and instructing) performances of Turkish universities based on 2006-2007 period data is going to be investigated via an output oriented data envelopment model. In Turkish universities, there is not any distinct “research academic position” or “instructing position” which are both supposed to be carried by academic personnel. Relying on this fact; comparison of overall performances, over both academic (number of papers published) and non-academic (number of students instructed) outputs produced on per-input (academic personnel) basis should make sense.

In the following section we’ll give a brief review of the literature about data envelopment analysis . The next section after this, will provide a short introduction to general efficiency and data envelopment concepts and notation used throughout the paper will be explained. We will introduce our case study and data within the fourth section and share the experience we gained during the analysis. And finally some conclusion and remarks will be given in the last section.

2. LITERATURE REVIEW

Data Envelopment Analysis (DEA) dates back to the study of Farrel in 1957.Farrel was first to develop a method to compute production efficiencies of industries (i.e. different areas of economic activity) in his pioneering work (Farrell, 1957, p. 262). It is generally evaluated as an initial work of micro-economic perspective of production possibility curve analysis rather than concerning practical efficiency issues of decision making units. Since then, until the seminal work of Charnes, Cooper and Rhodes, the issue of comparing efficiencies of similar production units have not come into the agenda of operation researchs academia. This study has reshaped Farrell’s analysis and thus the tool since then known as data envelopment analysis was born (Charnes, Cooper, & Rhodes, 1981, p. 669).

There are numerous published scientific papers about application of DEA on various problems of many fields that is impossible to mention here. There is an important study that was commenced by Ali Emrouznejad for compiling DEA bibliography data and is publicly available in his homepage[1] .

It is not uncommon to see DEA applications in literature concerning service oriented industries. One such a big industry branch suitable for DEA analysis is educational institutions including universities. One of the most elaborate applications was about measuring academic efficiencies of British universities’ economic departments carried by Johnes et al. at University of Oxford (Johnes & Johnes, 1993, p. 336-337).

If Turkish literature is to be investigated, it can be seen that there has been some research conducted about Turkish universities’ performances. In (Baysal, Alçılar, Çerçioğlu, & Toklu, 2005, p. 72) , Baysal et al. have performed DEA analysis over Turkish state universities in 2004 in order to allocate budget of year 2005. In (Dikmen, 2007) Dikmen has tried to measure efficiencies of again Turkish state universities based on 2000 - 2001 period data. In this study many DEA models have been tested trying to measure overall, just instruction or just academic publishing performances to name a few which are all tested under constant return and variable return to scale assumptions.

1 Please have a look at Ali Emrouznejad’s homepage for DEA bibliography data:
http://www.deazone.com/bibliography/ (Access Date: 20.05.2009)

3. DATA ENVELOPMENT ANALYSIS

Data Envelopment Analysis, or commonly abbreviated as DEA, is the most widely used technique for measuring efficiencies of similar producers that attain various levels of output while utilizing different amounts of input. The term "producer" used in a manner that stands for both commodity or service producing facilities and generally these facilities are called *Decision Making Units* abbreviated as *DMU*. A DMU is an independent decision maker on its own choice of efficiency related decisions, thus determining its level of efficiency, such as hospitals, schools or bank branches etc.

DEA is an nonparametric efficiency measuring method based on exploitation of linear programming. Unlike any other expected value based statistical technique that has *a priori* weights, DEA tries to maximize the efficiency of the benchmark DMU, given that every input it utilizes and every output it produces has a weight. In other words it is the main principle in DEA method that it always tries to measure relative efficiencies (Ramanathan, 2003, p. 26).

Let us consider a trivial example consisted of three DMUs say *DMU-1, DMU-2* and *DMU-3*; and let us assume that these DMUs consume same amounts of only one identical input and produce two different type of outputs say *Output-1* and *Output-2*. The amount of outputs produced by three DMUs is given in Table 1 and it is plotted in Figure 1 . In Figure 1 points A, B and C are standing for output combinations of DMU-1, DMU-2 and DMU-3 respectively.

Table 1. Amounts of outputs produced by DMUs

DMUs	Input (units)	Output-1 (units)	Output-2 (units)
DMU-1	100	120	90
DMU-2	100	140	60
DMU-3	100	180	50

For this trivial example, it is obvious that DMU-1 produces more Output-2 than DMU-2 and DMU-3 per inut. Also DMU-3 produces more Output-1 than DMU-1 and DMU-2. Then it is reasonable for someone to think of a *virtual* producer that is formed with a convex combination of output abilities of DMU-1 and DMU-3 can yield a better output possibility than DMU-2. In other words, for some $0<\alpha<1$ there exists, $\alpha A(x,y)+(1-\alpha)C(x,y)\geq B(x,y)$, i.e. a better virtual DMU than DMU-2 producing at point B'. From Figure 1 it can be clearly seen that a convex combination of DMU-1 and DMU-3 that is represented by point B' can yield a better output level than DMU-2.When dealing with one input-two output and two input-one output cases two dimensional graphical representation may be very helpful to identify outputs per input or inputs per output. But as the dimension increases, utilization of two dimensional graphs becomes impossible and that is why we need linear programming.

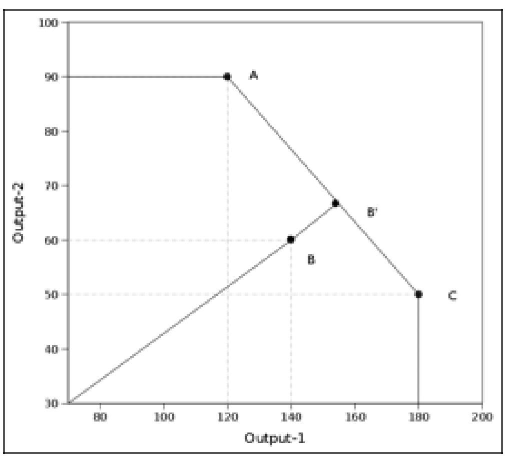

Figure 1. Production possibilities of DMUs.

Efficiency in DEA is generally defined as the ratio of total outputs to total inputs.

$$Efficiency = \frac{Output}{Input}$$

Given that there are I inputs and J outputs of a DMU, let x_i represents i^{th} input and y_j represents j^{th} output and if there are weights $u_i \geq 0$, $v_i \geq 0$ for inputs and outputs respectively then we can obtain efficiency of a DMU as the ratio of weighted sum of outputs (i.e. virtual outputs) to weighted sum of inputs (i.e. virtual inputs).

$$Efficiency = \frac{Virtual\ Output}{Virtual\ Input} = \frac{\sum_{j=1}^{J} v_j y_j}{\sum u_i x_i}$$

For N DMUs to be compared for their efficiencies, and if the reference DMU slected is k^{th} one then the fractional program for the k^{th} DMU is written as following:

$$\begin{aligned} max\ E_k \quad &= \quad \frac{\sum_{j=1}^{J} v_{jk} y_{jk}}{\sum_{i=1}^{I} u_{ik} x_{ik}} \\ s.t. \quad & \\ & 0 \leq \frac{\sum_{j=1}^{J} v_{jk} y_{jn}}{\sum_{i=1}^{I} u_{ik} x_{in}} \leq 1; n = 1,2,...,N; \\ & u_{ik}, v_{jk} \geq 0; i = 1,2,...,I; j = 1,2,...,J \end{aligned} \quad (1)$$

In order to transform this program into a linear one, all the needed action is to normalize the denominator of the objective function. This means simply equalizing the denominator to 1 for the reference DMU .

$$\begin{aligned} max\ E_k \quad &= \quad \sum_{j=1}^{J} v_{jk} y_{jk} \\ s.t. \quad & \sum_{i=1}^{I} u_{ik} x_{ik} = 1; \\ & \sum_{j=1}^{J} v_{jk} y_{jn} - \sum_{i=1}^{I} u_{ik} x_{in} \leq 0; n = 1,2,...,N; \\ & u_{ik}, v_{jk} \geq \varepsilon; i = 1,2,...,I; j = 1,2,...,J \end{aligned} \quad (2)$$

In Equation 2, ε stands for non-Archimedean constant, generally implemented as a very small real number in software implementations though it is not a number in theory.

Equation 2 may be rewritten in matrix-vector notation as below:

$$
\begin{aligned}
& max \quad z = V_k^T Y_k \\
& s.t. \\
& \qquad U_k{}^T X_k = 1; \\
& \qquad V_k{}^T Y - U_k{}^T X \leq 0; \qquad (3) \\
& \qquad V_k{}^T, U_k{}^T \geq \varepsilon
\end{aligned}
$$

This primal linear program is classified as general *output maximizing* or *output oriented additive CCR* DEA model.

A more detailed derivation of formulation of output oriented additive model is given in the third chapter of the book (Cooper, Seiford, & Tone, 2006, p. 58) by Cooper et al or in the second chapter of book (Ramanathan, 2003, p.38-46) by Ramanathan.

3.1. The Dual Additive CCR (Charnes-Cooper-Rhodes) Model

In DEA literature there are some terms coined to specific form of the same model. The models like 2 or 3 that involve weights of inputs or outputs are called *multiplier DEA models* (Ramanathan, 2003, p.58-59).

Dual model below can be derived from output oriented multiplier type models following standard steps for taking dual of a linear program:

$$
\begin{aligned}
& min \quad \theta k \\
& s.t. \\
& \qquad \sum_{n=1}^{N} y_{jn}\lambda_n \geq y_{jk}; j = 1,2,...,J; \\
& \qquad \sum_{n=1}^{N} x_{in}\lambda_n \leq \theta_k x_{ik}; i = 1,2,...,I; \qquad (4) \\
& \qquad \lambda_n \geq 0; n = 1,2,...,N
\end{aligned}
$$

And the above dual model can be rewritten in matrix-vector notation as follows:

$$
\begin{aligned}
& min \quad \theta k \\
& s.t. \\
& \qquad Y\lambda \geq Y_k; \\
& \qquad X\lambda \leq \theta_k X_k; \qquad (5) \\
& \qquad \lambda \geq 0; \ \theta_k \ unbounded
\end{aligned}
$$

This type of dual models like Equation 4 and 5 which involve weights of firms are called *envelopment DEA programs*. These envelopment models are for corresponding output oriented multiplier programs. Similarly, for input oriented multiplier models, the same steps can be followed in order to obtain input oriented envelopment models.

3.2. Economies of Scale and BCC (Banker-Charnes-Cooper) Model

As known from microeconomics and utility theory, there are many assumptions concerning the marginal utility of an additional input. The utility of an additional input may be constant, and the case is classified as constant return to scale (*CRS*); it may decrease after a certain level is reached and thus the case is classified as decreasing return to scale (*DRS*) or inversely it may increase and hence increasing return to scale (*IRS*) . Whether, IRS or DRS is the case or both of them is available in a utility function, that case is said to be variable return to scale (*VRS*).

CRS assumption is very restrictive for modeling economical situations which is totally a theoretical simplification for keeping models clear. Because CCR model we've discussed so far, has also CRS pre-assumption, one should also incorporate VRS in DEA models for a more realistic assumption of economies of scale. This task was done by Banker, Charnes ad Cooper in paper (Banker, Charnes, & Cooper, 1984) with an addition of extra constraint to the original CCR model . This additional constraint handles VRS assumption, via imposing a constraint that dictates the sum of DMU weights of dual model to be equal to 1. The well known model is given in Equation 6 in matrix-vector notation.

$$\begin{aligned} &\min \quad \theta_k \\ &s.t. \\ &\quad Y\lambda \geq Y_k, \\ &\quad X\lambda \leq \theta_k X_k, \\ &\quad e^T \lambda = 1, \\ &\quad \lambda \geq 0; \ \theta_k \ \textit{unbounded} \end{aligned} \tag{6}$$

Please have a look at (Färe & Hunsaker, 1986) for an interesting discussion of notions of efficiency from a more economical perspective by Färe and Hunsaker.

4. CASE STUDY AND ANALYSIS

4.1. Preliminary Information

The case study we have considered is the overall relative efficiency of Turkish universities for the year 2007. The data used in the analysis was derived partly from 2007 statistics declared by The Council of Higher Education (YÖK) and partly from the Ministry of Education (MEB) of Turkey . The first part of the data which is consisted of cumulative account for published articles in refereed journals which are indexed by SCI, SSCI and AHCI is taken from YÖK statistics. The remaining part of tha data is the number of students who is enrolled to undergraduate, graduate and Ph.D. programs of universities and taken from MEB statistics.

Table 2. Data used in the analysis provided by YÖK and MEB

	Academics	SCI	SSCI	AHCI	Undergraduate	Graduate	Phd
ABANT	240	149	8	0	15952	820	186
ADYMN	16	5	0	0	3886	0	0
AMEND	412	185	6	0	16101	638	322
AFYON	352	218	9	0	22010	1230	313
AHEVN	49	13	0	0	8343	0	0
AKDEN	583	265	16	5	18803	816	589
AKSRY	33	24	0	0	3989	0	0
AMSYA	33	3	0	0	6224	0	0
ANADL	659	187	11	1	868780	1130	660
ANKRA	1621	921	78	9	32258	5601	3688
ATATRK	1050	418	18	0	31723	2740	1457
ATILM	76	55	5	0	2974	433	0
BAHCE	84	17	3	0	5527	1034	0
BLKSR	277	82	0	0	24218	680	132
BSKNT	353	445	27	1	7928	676	401
BYKNT	96	9	1	0	5726	1731	0
BLKNT	319	219	59	13	11111	693	402
BOGAZ	363	207	23	6	8692	1864	682
BOZOK	22	29	0	0	5412	0	0
CLBYR	387	173	9	1	23258	953	341
CMHRY	419	209	11	1	22926	740	445
CAGUN	33	0	0	0	1537	102	0
CKALE	232	163	1	0	19365	962	97
CNKYA	71	57	2	0	3601	243	0
CKROV	764	373	15	0	29138	3147	1055
DICLE	486	247	4	0	17867	852	463
DOGUS	71	28	7	1	1922	123	0
DEYLUL	1129	494	40	0	36184	4077	1912
DLPNR	255	59	3	0	27804	1513	94
DUZCE	161	60	1	0	5617	0	125
EGEUN	1380	778	37	1	38842	1790	2031
ERCYS	549	474	11	1	25643	1700	823
ERZNC	88	6	0	0	6226	0	0
ESOGU	474	227	9	0	13164	1242	565
FATIH	135	98	4	4	5508	375	49
FIRAT	629	350	7	0	19037	1053	800
GTSRY	117	16	10	0	2105	709	85
GAZIU	1569	839	41	4	48143	6880	2811
GANTP	302	200	7	1	12515	285	343
GOPSA	272	154	6	0	11343	595	142
GYTE	134	134	11	0	783	1146	305
GIRSN	30	11	0	0	8161	0	0
HCTPE	1354	1007	55	1	25598	2209	1920
HALIC	79	12	0	0	2609	263	0
HARRN	293	181	7	1	8206	246	155
HITIT	42	4	0	0	4843	0	0
ISIKU	52	31	5	0	1683	65	52
INONU	398	266	4	0	16073	640	362

Table 2. Data used in the analysis provided by YÖK and MEB (Cont.)

IBILG	122	3	12	1	7212	1924	46
IBILM	48	18	2	0	374	9	18
IKLTR	116	32	8	0	5975	418	83
ITU	854	558	25	4	15187	4515	1708
ITICU	55	12	0	0	4351	477	0
IU	2268	1211	83	13	50224	5253	4056
IZEKO	62	19	5	1	4755	244	17
IYTE	125	78	1	1	1422	445	152
KDRHS	56	18	1	1	3717	300	192
KFKAS	170	107	0	0	12629	471	83
KMSIU	238	129	10	0	14224	632	141
KTU	596	348	10	1	31050	1932	906
KSTMN	41	9	0	0	6647	0	0
KKALE	291	178	8	0	13669	416	227
KCELI	428	225	6	0	49564	1686	615
KOCUN	140	122	25	2	3101	365	16
MALTP	123	13	1	0	4649	390	33
MARUN	981	359	18	2	40932	7655	2874
MAKIFE	48	11	0	0	11974	0	0
MERSN	417	182	12	2	21043	724	311
MSINU	271	2	0	0	4751	509	262
MUGLA	263	82	9	0	20559	668	44
MKMLU	297	151	1	0	14085	301	89
NKMLU	128	14	0	0	10385	0	0
NIGDE	179	102	3	0	10775	355	35
OKAN	36	2	2	0	1199	72	0
ODMYS	718	466	13	0	21898	803	928
ORDU	34	6	0	0	5661	0	0
ODTU	727	635	68	9	15930	3970	2210
PKALE	466	242	12	1	22610	632	298
RIZE	50	25	0	0	6277	0	0
SBNCU	154	86	15	1	2726	367	116
SKRYA	475	139	3	0	36108	2729	535
SELCK	897	407	17	1	74827	8778	1678
SDEMU	598	281	5	1	31350	1017	778
TOBB	46	60	10	0	1177	44	0
TRKYA	401	212	11	0	21124	1152	614
UFUK	89	16	0	0	807	136	32
ULDAG	730	381	17	3	39003	863	960
USAK	60	7	0	0	7899	0	0
YASAR	40	4	1	0	1795	31	0
YTEPE	464	140	3	0	12545	2298	334
YLDZT	536	196	4	0	18793	2039	741
YZNCL	369	206	3	0	14740	1479	382
ZONGU	326	192	11	0	20461	588	274

In Turkish universities, academic staff is responsible for both education - instruction duties and both research studies. There are no separate types of employment contract, as a research staff or instructing staff, as opposed to many European and American universities. So, evaluating academic performance, by taking just one aspect into account, would not be so meaningful. In our model; taking the number of academic staff as input, number of students in all three levels and number of papers published in a journal fall under these three citation index are outputs competing for the same input. The input - output relationship of model is resumed in Table 2 . It is natural that, publishing performances of academic staff is directly affected by the number of students instructed. This is generally ignored when comparing universities academic productivity.

Table 3. Input- output relationship of model.

Input	**Academic Publishing Outputs**			**Instructing Outputs**		
Academic staff	SCI	SSCI	AHCI	Undergraduate	Graduate	Ph.D.

4.2. Application and Results

The preferred platform for the computation requirements of our application is GNU R statistical computation system. The reason for us to prefer GNU R is that it is a powerful, robust and an interactive environment for many kind of statistical and scientific computation purposes. One other very important reason is that GNU R is a free software as in the definition of *Free Software Foundation*.[2]. In GNU R, DEA analysis can be accomplished via a third party R library called *DEA* . This *DEA* package uses GLPK linear programming solver as its internal solver and implements several types of DEA models out of the box. For setting up *DEA* package the process is as simple as installing any other GNU R package. Within an interactive R session just type the following

```
> install.packages()
```

and this should prompt for a myriad of ftp mirrors of GNU R all araound the world. After selecting an appropriate one, this time another prompt emerges asking the user to select the package that's been desired to install. After selecting *DEA* package the rest of the process should be done automatically (i.e. compiling and installing GLPK routines) if the underlying operating system has an already installed C compiler.

GNU R is able to read tabular bidimensional data, rather it is tab-seperated or comma-seperated. In order to import data without any trouble into R environment, data should first be converted into a *csv* file or a tab-seperated plain text file(R Development Core Team, 2008). This is extremely easy if the data is arranged or edited within a spreadsheet file. Assuming that we have comma-seperated data file named "data.csv" and an interactive R session is started under the same directory with this file, the needed interactive commands should be as follows:

```
> data <- read.csv("data.csv", header=TRUE)
> input <- data[1]
> output <- data[2:7]
```

2 For the definition of Free Software please have a look at: http://www.fsf.org (Access Date: 14.06.2009) or http://www.gnu.org/philosophy/free-sw.html (Access Date: 14.06.2009)

Here, all the data residing in *data.csv* file is read into a variable called *data*, so that the necessary R object for holding data in working environment is obtained. Assigning first column of this frame object to a different variable called *input* and rest of columns to another one called *output* are the following two commands. Hence, necessary steps before calling DEA methods are taken.

After these preliminary steps, the DEA analysis can be accomplished first importing (or attaching) necessary package into current R working space issuing following command.

```
> library(DEA)
```

This command should be sufficient for loading the DEA library if the installation process was finished with success. The DEA library comes with a variety of DEA routines for different kind of computations with a handful of different options. Most notably it handles standard CCR additive and BCC multiplicative DEA models. Because all the routine names within the DEA package begin like *dea.**,if command completion feature is not defunct, after typing *dea*. and hitting tabs key twice should produce following output on the terminal:

```
> dea.
dea.add.env      dea.bcc.oo.env  dea.ccr.oo.env  dea.sbm.bcc.oo
dea.add.mul      dea.bcc.oo.mul  dea.ccr.oo.mul  dea.sbm.ccr
dea.bcc.io.env  dea.ccr.io.env  dea.sbm.bcc      dea.sbm.ccr.io
dea.bcc.io.mul  dea.ccr.io.mul  dea.sbm.bcc.io  dea.sbm.ccr.oo
```

As in any case, when ambiguity about a command arises within R environment, interactive help can be called with suitable format (i.e. *help*(*command*)) for online documentation or by simply putting a question mark in front of the command name. So, in order to see the usage and other details of a routine, for example *dea.ccr.oo.env*, of the DEA package issuing a command like below may be helpful:

```
> ?dea.ccr.oo.env
```

Thus, result of an output oriented CCR model of universities can be obtained issuing following command holding the result object in a variable called *result*:

```
> result<-dea.ccr.oo.env(input,output)
```

This R object has three components which can be seen again by hitting tab key twice after writing *result*$, if command completion is enabled.

```
 > eff<-result$
-result$eff      -result$lambda   -result$slack
```

Here *eff* component holds efficiency values, *lambda* component holds lambda coefficients of corresponding dual models and finally *slack* component holds total slack value of each DMU. Efficiencies belonging to both CCR model and BCC model can be obtained via an interactive R session like similar to above or a batch script can accomplish the same task. Below is a batch script that computes relative efficiencies according to output oriented CCR and BCC models and write the efficiency values to a $\LaTeX 2_\varepsilon$ document suitable for scientific reporting:

```
# dea_uni.r: Apply output oriented
# CCR and BCC DEA models to Turkish
# universites 2007 case data.

# Import necessary packages.
library(DEA)
library(Hmisc)

# Read data.
all_data <- read.csv("data.csv", header=TRUE)

# Assign input and output to some objects.
input <- all_data[1]
output <- all_data[2:7]

# Result objects obtained adter running
# intended DEA models.
r1 <- dea.ccr.oo.env(input,output)
r2 <- dea.bcc.oo.env(input,output)

# Create an accumulated data frame
# from efficiency components of result
# objects.
eff <- as.data.frame(r1$eff)
eff[2] <- as.data.frame(r2$eff)

# Write results to into (La)TeX file
# in a tabular format.
Hmisc::latex(eff,longtable=TRUE, caption="Relative efficiencies of
Turkish universites in 2007.")
```

This script can be loaded from R environment via issuing the following command within the same directory:

```
> source("dea_uni.r")
```

In the following table, efficiency values derived from output oriented CCR and BCC envelopment models are given:

Table 4. Relative efficiencies of Turkish universities in 2007

DMU	CCR-OO-ENV	BCC-OO-ENV
ABANT	1.72245225292164	1.592120062435513
ADYMN	2.84476625751383	1.000000000000000
AMEND	2.35874674978689	2.328333883927637
AFYON	1.72346609401451	1.503591622784838
AHEVN	3.62118109603775	3.488682041416991
AKDEN	2.00430552726436	1.861916611129738
AKSRY	1.81250000000000	1.739371931039295
AMSYA	5.70094076290942	4.170940984896256
ANADL	1.00000000000000	1.000000000000000
ANKRA	1.36621845451892	1.000000000000000
ATATRK	2.11926229985911	1.709419068179558
ATILM	1.36875928225725	1.333445234650106
BAHCE	1.24414912509706	1.235555419158029
BLKSR	2.92892339035882	2.635834001527341
BSKNT	1.00000000000000	1.000000000000000
BYKNT	1.00000000000000	1.000000000000000
BLKNT	1.00000000000000	1.000000000000000
BOGAZ	1.18033262882451	1.168404589531485
BOZOK	1.00000000000000	1.000000000000000
CLBYR	2.17227069830634	2.043115114942175
CMHRY	1.99267159236607	1.992665710402526
CAGUN	5.08960417814318	3.454115854382711
CKALE	1.48663762480247	1.377668963120664
CNKYA	1.42167229619666	1.412767958996419
CKROV	1.79653736461886	1.556802291784019
DICLE	2.06412380136098	2.026864100131379
DOGUS	1.85475434486534	1.685886098246696
DEYLUL	1.71420909687291	1.396498031405866
DLPNR	2.02776133729947	1.797099166735210
DUZCE	2.70595746828984	2.705873521247288
EGEUN	1.70503662544107	1.205827949191773
ERCYS	1.24853567463733	1.137797847737327
ERZNC	11.40129985960875	10.916998135462235
ESOGU	2.01893915419940	1.938754436934190
FATIH	1.07230228106152	1.067195196895809
FIRAT	1.79930801003398	1.664174250602181
GTSRY	1.51735535601638	1.490894919293024
GAZIU	1.53144448178669	1.000000000000000
GANTP	1.63063671488728	1.630623741320030
GOPSA	2.04175897894326	1.911414184507127
GYTE	1.00000000000000	1.000000000000000
GIRSN	2.47262494371705	2.225604868665521
HCTPE	1.44146559550005	1.000000000000000
HALIC	3.66219614421265	3.617195938285572
HARRN	1.94358420050221	1.916548636513801
HITIT	7.53367599664431	7.061083593594732
ISIKU	1.59875742600287	1.421132857383083
INONU	1.70555488964866	1.704123277909466
IBILG	1.00000000000000	1.000000000000000
IBILM	3.15371956932818	2.949940642035130

Table 4. Relative efficiencies of Turkish universities in 2007 (Cont.)

IKLTR	1.90867847732679	1.862547182467583
ITU	1.33696015278993	1.119393399510892
ITICU	1.64651850349577	1.587863901227385
IU	1.64916647268716	1.000000000000000
IZEKO	1.63889667977995	1.409933616336988
IYTE	1.52903852719609	1.519583524588714
KDRHS	1.00000000000000	1.000000000000000
KFKAS	1.77182643479225	1.700823463541586
KMSIU	1.99188958197895	1.874541462570063
KTU	1.60815689521937	1.530440424688500
KSTMN	4.13800178658263	4.081407237520353
KKALE	1.86921452860150	1.868770814905008
KCELI	1.63941239742984	1.500232101062052
KOCUN	1.08701740543095	0.999999999999999
MALTP	3.99824642833799	3.996207175608526
MARUN	1.00000000000000	1.000000000000000
MAKIFE	3.31091232781569	3.300011068185704
MERSN	2.24962887658336	2.191236241938521
MSINU	3.34619779120168	3.141100094096514
MUGLA	2.74142783191273	2.487695389455912
MKMLU	2.42467783973710	2.315944306236550
NKMLU	8.28975581438364	7.664330633781361
NIGDE	2.04956253419598	1.952715820430439
OKAN	3.00943155265209	2.391126558985893
ODMYS	1.61286570233804	1.367318578192589
ORDU	4.61453103992470	4.185013427342016
ODTU	1.00000000000000	1.000000000000000
PKALE	2.17979814862388	2.014602046192408
RIZE	2.50439647192442	2.303186222755893
SBNCU	1.65574137864310	1.578756127780131
SKRYA	1.71325693161580	1.654285386287626
SELCK	1.04649400368941	1.000000000000000
SDEMU	1.94650933362414	1.944526441373976
TOBB	1.00000000000000	1.000000000000000
TRKYA	1.71045005448598	1.710320042473032
UFUK	5.43675775446412	5.352955560593181
ULDAG	1.81614052877157	1.633971554385775
USAK	6.38377481011778	6.275111116387116
YASAR	6.05950209525487	5.016162195056129
YTEPE	2.24016353580128	1.881816582564659
YLDZT	1.92431443408999	1.883010604221055
YZNCL	1.82406299518431	1.550289747550044
ZONGU	1.85941046445101	1.850210586280253

5. CONCLUSION

Our DEA model considers merely number of academic staff as input, while outputs are diversified through inclusion of both academic and non-academic goals. By doing so we think that a more fair comparison among universities can be accomplished among both state and private universities. Because of the nature of the selected inputs and outputs, it should not be unfair to judge universities on the basis of results found by these DEA models.

As one might expect, the result of the analysis shows that universities which offer intense study programs or have a distinct research profile or having both is found to be relatively efficient.

Universities whose efficiency values are found exactly **1.0** (some outcomes might be floating point numbers very close to 1 because of the rounding errors arising from multi-precision computation of software, such as 0.999999, should be interpreted by as 1) is said to be efficient. Some universities which are found to be inefficient by CCR model are considered as efficient by BCC model; or their efficiency values have found to be closer to **1.0**, which is, a natural consequence of mathematical properties of BCC model. Because BCC model incorporates variable return to scale, excess production of a superior DMU on a specific output will have a diminishing return to scale. Considering this fact, we think that outcome of the BCC model is more reliable than CCR model.

It might easily be concluded that , "GNU R" together with "DEA" package, is a quite comfortable and suitable environment for both interactive exploration and batch processing of this kind of computation. Due to inconsistencies among the formats of published data by YÖK and MEB, and moreover, only 2006-2007 data was made available via WWW by MEB, our analysis consists of only 2006 - 2007 period. If it is to be considered that R has a wide variety of support and available drivers for different database management systems, it should be fairly easy to make such a computation on a regular basis , such as every year; if government institutions like YÖK or MEB had taken the necessary actions to hold such data on publicly accessible database servers. This might also ease and automate the process of evaluation of universities on the efficiency basis, and publishing these results via WWW or another medium.

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