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IDENTIFICATION OF CONGESTION WITH DEA APPROACH APPLIED TO A SAMPLE OF TURKISH UNIVERSITIES

Feyyaz Cengiz Dikmen[1]
[1]Kocaeli University Business and Administration Faculty Ä°zmit, Turkey

ABSTRACT

The economic concept of ''congestion" is a widely observed phenomenon either in micro or macro level of industry. The presence of congestion is an economic state where inputs are overly invested. Congestion is identified and said to be present whenever reduction in one or more input can be associated with increases in one or more output or proceeding in reverse, when increases in one or more input can be associated with decreases in one or more output without worsening any other input or output. In other words, congestion is identified with input increments that result in output decrements. The presence of congestion impacts the overall efficiency of a firm. In such a case it is inevitable not to measure the presence and the amount of congestion. There are different approaches to measure congestion from an empirical perspective. One of the approaches that deal with congestion is the one which is introduced by Cooper, W.W. & et al. in 1996. The approach uses DEA efficiency models to investigate congestion. The primary aim of the present study is to determine the amount of congestion in Turkish universities using the DEA approach.

Keywords: Data envelopment analysis (DEA), Congestion, High education.

1. INTRODUCTION

The economic concept of ''congestion" is a widely observed phenomenon either in micro or macro level of industry. According to various authors congestion is a phenomenon in the production process when there are negative returns to inputs in production. In other words congestion exists whenever the employment of additional units of inputs obstructs the output [1]. The problem of congestion is the result of an excessive use of one or more inputs [2]. Typical examples of congestion are mostly given from the mining, agriculture, transport and electric sectors. In a mining sector, when too many workers are crowded in a narrow underground mining pit, the amount of minerals excavated will be reduced Kao [3]. Cooper, et al. [4] use this example to clarify the topic of congestion: "excess raw material inventory congesting a factory floor in a way that interferes with production. Congestion refers to the amount of this inventory that is

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accompanied by an improvement in production when it is removed. The excess inventory remaining after removal of the congesting component represents "technical inefficiency" because it reflects idle capital but does not otherwise interfere with production". So the interference of congesting inventory in production would probably reduce the output of DMU[1] being evaluated.

There are several definitions for congestion in DEA literature. The definition that is mostly accepted is that [5-7]: "evidence of congestion is present when reductions in one or more inputs can be associated with increases in one or more outputs- or, proceeding in reverse, when increases in one or more can be associated with decreases in one or more outputs- without improving any other input or output". That is, congestion is characterized with input increments which yield output decrements.

The topic of congestion is handled by many authors either theoretically or emprically in literature. Congestion is first examined theoretically by Fare and Svensson [8] in an article in 1980. Subsequently Fare and Grosskopf [9] proposed an implementable form of congestion model in the framework of data envelopment analysis in 1983 [6, 7]. In 1996 Ahn, et al. [10] introduced a different model to identify congested inputs and the amount of congestion. The third approach which identifies congestion has been put forward by Tone and Sahoo in 2004 [2]. Briefly, there are three types of models in the data envelopment analysis literature which handles congestion with different models and approaches [4]: the Fare-model, the Cooper-model and Tone-model. In this study, Cooper-model would be followed to investigate congestion in Turkish universities. In the sections below, first a brief introduction to DEA is given as a technique to measure the performance of DMUs and an explanation of the DEA model proposed by Cooper et al. to identify and measure congestion. In the last section the application of Cooper-model is shown to Turkish universities with the aid of a spreadsheet.

2. DEA

DEA was originated by the seminal paper of Charnes, Cooper and Rhodes in 1978 [10]. Since then DEA has become a well known technique to help managers in improving their firm performances. It was originally designed to measure performance for non-profit organizations as universities, hospitals, and schools. Later on DEA has been adopted and applied to measure the performance of profit organizations. There have been a large number of theoretical and empirical research papers that applied and extended this methodology. DEA applications involve a wide range of context such as education, health care, banking, market research, transportation, courts, public housing, airports, manufacturing and etc,. For taxonomy of DEA applications interested readers should look at the paper by Gattoufi, et al. [11].

In brief DEA is a technique that measures performance of DMUs. In evaluating the efficiency of DMUs, DEA:

- Compares DMU under study considering all resources used and identifies the most efficient or best practice units (branches, departments, individuals)

[1] In DEA context, DMU means "decision making unit" which is an entity responsible for converting inputs into outputs.

- Calculates the amount of cost and resource savings that can be achieved by making each inefficient unit as efficient as the best practice (efficient) units.

In the comparison of DMU performances DEA basically constructs an envelopment surface or efficient frontier from the best practice units that observed and benchmarks the DMUs with this frontier to measure their efficiency. To be efficient the DMU under study must lie on this surface. Units that do not lie on this surface are termed as inefficient. As stated in the preceding paragraph the DEA analysis identifies the sources and amount of inefficiency and/or provides a summary measure of relative efficiency. The geometry of this envelopment surface is prescribed by the specific DEA model employed. According to the type of envelopment surface the DEA models can be classified as: the CCR ratio model (1978), the BBC model (1984), the Multiplicative models (1982), the Additive model. Besides these basic DEA models, there are more than hundred various models that have been applied to diverse fields.

In this present study, data envelopment analysis is adapted to the efficiency analysis of universities to identify congestion. The data for this study were taken from the Council of Higher Education of Turkey for the time period 2000 to 2001. As a sample only 20 of the state universities are randomly selected for the sample. Applications of DEA to measure the efficiency of educational units have extensively been reported in literature. The application of DEA to higher education has focused on various issues, such as the efficiency of academic departments, universities, academic research, university libraries, and university administrative services. We can mention here some of the literature that measure performance of the education sector using DEA: Bessent, et al. [12] applied DEA on the occupational- technical programs in San Antonio College; Haksever and Muragishi [13] provide an assessment of MBA programs; Cooper and Cohn [14]; Chu and Li [15] studies the research performance of the individual departments of the higher educational units; Johns [16] measures teaching efficiency of higher education in UK universities; Avkiran [17] examines the relative efficiency of Australian universities; Tomkins and Green [18]; Köksal and Nalçaci [19] compares departments of a university. Flegg and Allen [2] examine three alternative approaches mentioned above to identify congestion in British universities in the period 1980/81-1992/93, from both theoretical and empirical perspectives. They conclude that the approach developed by Cooper et al. (Cooper-model) is superior to Fare-model in terms of its ability to measure the extent of congestion and to shed light on its underlying causes.

DEA is a non-parametric linear programming technique. Linear programming is the underlying methodology that makes DEA particularly powerful compared with alternative productivity management tools. DEA has been widely studied, used and analyzed by academics that understand linear programming.

To illustrate how DEA works in order to compare the DMU units, a CCR ratio model is going to be used. In CCR model the following assumptions are made. There are **n** DMUs, **m** inputs and **s** outputs. DMU_j ($j=1,2,\ldots,n$) consumes a vector of inputs, x_j ($=x_{1j},x_{2j},\ldots,x_{mj}$) to produce a vector of outputs, y_j ($=y_{1j},y_{2j},\ldots,y_{sj}$). The other assumption that is made is that the inputs and outputs have been correctly identified. Usually as the numbers of inputs increase more DMUs tend to get an efficiency rating of 1 as they become too specialized to be evaluated with respect to other units. On the other end, if there are too few inputs and outputs, more DMUs tend to be comparable. The other assumption DEA makes is that the inputs and outputs have been correctly identified. And an adequate sample size is selected. In order to discriminate effectively between efficient and inefficient units, a sample size larger than the product of number of inputs and outputs is selected. As a rule of thumb a sample size of at least 3 times larger than the sum of the number of inputs and outputs [17]. The DMU_{j0} is being the unit to be analyzed among others; the efficiency of DMU_{j0} can be measured by the following CCR model.

$$\begin{aligned} & \text{Min } \theta_{j0} \\ & \text{Subject to} \\ & \sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta_{j0} x_{ij0}, \; i = 1,2,\ldots,m \\ & \sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{rj0}, \; r = 1,2,\ldots,s \\ & \lambda_j \geq 0 \end{aligned} \tag{1}$$

When the optimal solution is reached, the optimal value for θ_{j0} shows the efficiency score. When it is equal to one, the specific DMU_{j0} under evaluation is a best practice (efficient unit) DMU. With the $\theta_{j0} < 1$ DMU_{j0} is inefficient. CCR model assumes that the envelope surface exhibits constant returns to scale (CRS). So the efficient DMU_{j0} is both technically and scale efficient. Besides the efficiency information, with the optimal solution we are informed about the unit's "comparables" (those DMU_j with nonzero λ_j), the "goal" inputs which is the difference between $x_{ij0}$and $\Sigma\lambda_j x_{ij}$.

In the model;

- λ_j is the weight given to DMU_j in its effort to dominate DMU_{j0}
- θ is the efficiency score. Since DMU_{j0} appears on the left hand side of the equations as well, the optimal θ cannot possibly be more than 1.

Linear programming modeling models can be solved using a variety of methods. The most known method is the simplex method. Improvements in IT technology made it easy to implement the simplex method as computer software. I used Excel's add-in Solver tool which is based on simplex method to solve the DEA models.

3. COOPER-MODEL

Cooper-model is based on the hypothesis of diminishing marginal returns. Congestion requires a negative marginal product to take place [20]. Congestion relates with technical inefficiency. By technical inefficiency it is implied that costs, prices or other such weights are not used in the analysis that may effect evaluations [21]. According to the Cooper-model approach inefficiency has two components: congestion and technical inefficiency. Hence to distinguish congestion from technical inefficiency they give two definitions to clarify the situation [4]. It is said that inefficiency exists when the evidence shows that it is possible to improve some input or output without worsening some other input or output. On the other side, congestion is present when reductions in one or more inputs can be associated with increases in one or more outputs-without worsening any other input or output. Proceeding in reverse, congestion occurs when increases in one or more inputs can be associated with decreases in one or more outputs-without improving any other input or output. According to the inefficiency definition, inefficiency refers to waste which represents an unnecessary expenditure of resources for some input that could have been avoided without having had to augment other inputs or reduce any outputs. And congestion is a severe form of inefficiency in the sense that benefits in both inputs and outputs could be secured by reducing the congesting input amounts [4]. Consequently for a DMU evaluated to be fully (100%) DEA efficient, there must be evidences to show that it is not possible to improve any of its inputs or outputs without worsening some of its other inputs or outputs [5]. Hence, for a DMU to be fully efficient there must be no waste [22].

The Cooper-model that measures congestion comprises two stages. The first stage is directed to find a target point for each DMU via the output-oriented version of the BCC model (Banker, Charnes and Cooper model). BCC model differs from CCR model by the addition of convexity condition that the sum of weights is equal to one ($\sum \lambda_j = 1$). The model incorporates slacks into the objective function which are used for the measurement of DEA congestion. In the first stage the inefficient DMUs and slacks are identified with the linear programming model [4-7, 21] given below:

$$
\begin{aligned}
&\max \theta + \left(\sum_{r=1}^{s} s_r^{+} + \sum_{i=1}^{m} s_i^{-} \right) \\
&\text{subject to} \\
&\theta y_{r0} - \sum_{j=1}^{n} y_{rj}\lambda_j + s_r^{+} = 0, r = 1,\ldots, s, \\
&\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^{-} = x_{i0}, i = 1,\ldots, m, \\
&\sum_{j=1}^{n} \lambda_j = 1, \lambda_j, s_r^{+}, s_i^{-} \geq 0, j = 1,\ldots, n, r = 1,\ldots, s, i = 1,\ldots, m.
\end{aligned} \tag{2}
$$

The symbol j=0 used in the model designates the DMU_j as the DMU_0 to be evaluated. For the DMU_0 to be efficient the following two conditions must be met:

(i) $\theta^* = 1$,

(ii) $s_r^{+*} = s_i^{-*} = 0 \ \forall r,i$.

The symbol * shows the optimum value of the decision variables. Cooper-model regards non-zero slacks as a form of technical efficiency. If the DMU0 is found efficient both input slacks s_i^- and output slacks s_r^+ will be zero and there is no need for the second stage.

If it is found inefficient then the second stage is utilized to determine congestion. As inefficiency is a necessary condition for the presence of congestion [4]. In this situation either one of or more input slacks or one of or more output slacks are greater than zero. Any input slack $s_i^- > 0$ indicates that a decrease in the corresponding x_{i0} can be done. Similarly any output slack $s_r^+ > 0$

indicates that a further increase in y_{r0} can be realized without worsening any other input or output. To proceed to the second stage new inputs and new outputs are defined for the inefficient DMU_0 with the formulas:

$$\begin{aligned} \hat{y}_{r0} &= \theta^* y_{r0} + s_r^{+*} \geq y_{r0}, r = 1,\dots, s \\ \hat{x}_{i0} &= x_{i0} - s_i^{-*} \leq x_{i0}, i = 1,\dots, m \end{aligned} \quad (3)$$

The newly defined inputs and outputs are called virtual inputs and outputs as they project the observed y_{r0} and x_{i0} into $\hat{y}_{r0}$ and $\hat{x}_{i0}$ on the efficiency frontier. The $\hat{y}_{r0} - y_{r0}$ and $\hat{x}_{i0} - x_{i0}$ differences indicates the amount of inefficiency in the r^{th} output and the amount of inefficiency in the i^{th} input respectively [5]. Those DMUs whose λ_j^* values greater than zero at the optimal solution of the model (2) are the peers for the evaluated inefficient DMU_0. So the $\hat{y}_{r0}$ and $\hat{x}_{i0}$ values are computed by the convex combination of these peers. To identify congestion and estimate its amount model (4) is utilized.

$$\max \sum_{i=1}^{m} \delta_i^-$$

$$\text{subject to}$$

$$\begin{aligned} &\hat{y}_{r0} = \theta^* y_{r0} + s_r^{+*} = \sum_{j=1}^{n} y_{rj}\lambda_j, r = 1,\dots, s, \\ &\hat{x}_{i0} = x_{i0} - s_i^{-*} = \sum_{j=1}^{n} x_{ij}\lambda_j - \delta_i^- = x_{i0}, i = 1,\dots, m, \\ &\sum_{j=1}^{n} \lambda_j = 1 \\ &s_i^{-*} \geq \delta_i^- \end{aligned} \quad (4)$$

At the optimal solution of the model (4), congestion is identified by the formula given below.

$$s_i^{-c*} = s_i^{-*} - \delta_i^{-*}, i = 1,\dots, m \quad (5)$$

Here s_i^{-*} is the total amount of slackness that can be attributed to inefficiency. s_i^{-c*} is the congesting amount in the total slack associated with s_i^{-*} in input i=1,…,m. And δ_i^{-*} is the amount of the total slack that can be assigned to “purely technical” inefficiency [4].

4. COOPER-MODEL APPLIED TO UNIVERSITIES

In this study I used the data of Turkish universities belonging to the period 2009 to 2010 and applied the output-oriented BCC models (2) and (4). Table 1 shows data of Turkish universities used in the Cooper-model. These data are based on two inputs, number of academic and non-academic staff, and three outputs, number of graduate, post-graduate students and published articles.

Table-1. Data of Turkish universities (2009/2010)

		Inputs		Outputs		
DMU	**University**	**Academic**	**Non academic**	**Graduate**	**Post graduate**	**Published Article**
1	Adnan Menderes	501	900	5611	273	278
2	Atatürk	1143	1876	6152	1014	786
3	Balıkesir	326	467	6545	153	160
4	Celal Bayar	423	873	6124	412	284
5	Cumhuriyet	520	1108	6358	296	227
6	Çukurova	753	2247	6050	1175	540
7	Dicle	624	1130	3368	600	377
8	Dokuz Eylül	1231	2441	6941	1102	657
9	Dumlupınar	259	578	7244	685	172
10	Erciyes	533	1440	4720	615	679
11	Boğaziçi	430	780	1440	653	399
12	Galatasaray	125	248	245	322	39
13	Gaziantep	298	807	2464	199	300
14	Gaziosman Paşa	303	666	4543	196	205
15	Hacettepe	1394	3974	4903	920	1246
16	Harran	364	711	2512	250	243
17	İstanbul	2606	5829	9369	4910	1630
18	Karadeniz Teknik	754	1374	6796	565	533
19	Orta Doğu Teknik	754	1234	2600	1392	998
20	Kocaeli	671	1058	12101	363	366
21	Pamukkale	494	1103	6437	454	308
22	Trakya	487	1091	4136	397	220
23	Selçuk	1293	1588	17235	2037	760
24	Ondokuz Mayıs	745	1546	4559	437	632
25	Mersin	528	865	5030	273	267
26	Marmara	1230	1364	7860	3060	510
27	İnönü	481	1072	3744	506	292
28	Gazi	1932	2627	9512	2500	1158
29	Ege	1532	3335	6146	1190	1175
30	Fırat	697	1184	4010	1654	441
31	Yıldız Teknik	605	711	3384	512	330
32	Yüzüncü Yıl	487	1040	3374	554	336

In the first stage model (2) is first solved via Excel solver to determine if there exists inefficiency and the input and output slack. The computed results for the universities are shown in Table 2.

Table-2. Stage 1: Total inefficiency

			Input Slacks		Output Slacks		
DMU	**University**	θ^*	s_1^-	s_2^-	s_1^+	s_2^+	s_3^+
1	Adnan Menderes	1,44				287	
2	Atatürk	1,27				704	
3	Balıkesir	1,00					
4	Celal Bayar	1,23				134	
5	Cumhuriyet	1,51		157,46		52	
6	Çukurova	1,23		1.127,42			
7	Dicle	1,77					
8	Dokuz Eylül	1,48		149,18			
9	Dumlupınar	1,00					
10	Erciyes	1,00					
11	Boğaziçi	1,26		16,33			
12	Galatasaray	1,00					
13	Gaziantep	1,02		57,63		261	
14	Gaziosman Paşa	1,28				431	
15	Hacettepe	1,00					
16	Harran	1,55				363	
17	İstanbul	1,00					
18	Karadeniz Teknik	1,27				259	
19	Orta Doğu Teknik	1,00					
20	Kocaeli	1,00					
21	Pamukkale	1,29		94,70			
22	Trakya	1,89		82,88			
23	Selçuk	1,00					
24	Ondokuz Mayıs	1,30		164,14		590	
25	Mersin	1,59				585	
26	Marmara	1,00					
27	İnönü	1,69		67,04			
28	Gazi	1,00					
29	Ege	1,05				1.221	
30	Fırat	1,01		204,85	2.582		
31	Yıldız Teknik	1,30	170,46				
32	Yüzüncü Yıl	1,62		46,16			

According to the efficiency scores, out of thirty-two universities twenty-one university is inefficient and therefore eleven of them are efficient. The values under the heading θ^* with $\theta^* > 1$ show that there is inefficiencies in the outputs since the appearance of output slacks represent shortfalls in output and the input slacks represent excess in the associated input which suggests the possible presence of congestion [5]. Briefly, these inefficiencies hint that, there may be "congestion" as well as "technical inefficiency" in these universities. To illustrate this situation, we can into consideration Yıldız Teknik University.

Academic input of 605 persons used in the university can be associated with an employment 170.46 excess of academic persons. The employment excess of academic personnel yields with a value of $\phi^* = 1.30$ which indicates an output shortfall of %30 for period 2009/10 in Yıldız Teknik. Most of the inefficient universities (%95) suffers from having input excess in non-academic staff.

Thus we can conclude easily that if congestion exists, it may be due to input excess in non-academic staff. Furthermore, some of the universities have only ouput slacks, like Adnan Menderes, Atatürk, Celal Bayar universities and the others. The inefficiencies in these universities can be attributed solely to managerial (technical) inefficiencies.

For the inefficient universities the peers (the "virtual" DMUs that the inefficient university should imitate to be efficient) are shown in Table 3.

Model (2) when applied, gives efficiency scores as well as a subgroup of the universities referred to as the efficiency reference set or the peers. This subgroup comprises the group of universities against which each inefficient university was found to be most directly inefficient. For example, Adnan Menderes University was found to have operating inefficiencies in direct comparison to Dumlupınar, Erciyes, Orta Doğu Teknik, and Kocaeli universities. The λ values imply that the relative weights assigned to each efficiency reference set member in calculating the efficiency rating (ϕ). Beside the information given in Table 3, the bottom line of the table shows the number of times an efficient university referenced by the inefficient universities. This reference number may be used to identify the most worthy role models, i.e. the universities that are referenced most are more likely to be appropriate role models for other universities.

The results show that Orta Doğu, Dumlupınar, Erciyes, Selçuk and Galatasaray universities are the most referenced universities, respectively. Orta Doğu Teknik University is being the top role model for the other universities.

Table-3. Peers of the inefficient universities

		Lambda (λ)										
DMU	**University**	**3**	**9**	**10**	**12**	**15**	**17**	**19**	**20**	**23**	**26**	**28**
1	Adnan Menderes		0,43	0,05				0,16	0,36			
2	Atatürk						0,11	0,57		0,30		0,02
4	Celal Bayar		0,55	0,18				0,05	0,21			
5	Cumhuriyet		0,32	0,13					0,55			
6	Çukurova		0,30					0,42		0,21	0,08	
7	Dicle		0,26	0,21				0,40	0,04	0,09		
8	Dokuz Eylül					0,29	0,02	0,22		0,47		
11	Boğaziçi		0,04	0,06	0,46			0,44				
13	Gaziantep		0,07	0,40	0,53							
14	GaziO.Paşa		0,71	0,10	0,13			0,07				
16	Harran		0,39	0,08	0,29			0,25				
18	Kara. Teknik			0,46				0,12	0,19	0,22		
21	Pamukkale		0,36	0,29					0,33	0,02		
22	Trakya		0,47	0,34					0,10	0,09		
24	Ondok. Mayıs			0,44				0,40		0,16		
25	Mersin	0,05	0,60					0,19		0,17		
27	İnönü		0,48	0,31				0,16		0,06		
29	Ege					0,22	0,32	0,38		0,08		
30	Fırat		0,46					0,18			0,36	
31	Yıldız Teknik	0,39	0,13		0,14			0,34				
32	Yüzüncü Yıl		0,45	0,24				0,29		0,02		
	Reference Number	2	16	14	5	2	3	17	7	12	2	1

To determine "congesting amount" in the total slack and the amount of slack that can be attributed to "purely technical" inefficiency" model (4) is utilized. To proceed with model (4), the left-hand values in (3) are used as new inputs and outputs for the inefficient universities. Model (4) optimal solution is shown in Table 4.

Table-4. Stage 2: Model(4) optimal solution

DMU	University	$\sum_{i=1}^{m}\delta_i^-$	δ_1^{-*}	δ_2^{-*}
1	Adnan Menderes	0,0	0,0	0,0
2	Atatürk	0,0	0,0	0,0
4	Celal Bayar	0,0	0,0	0,0
5	Cumhuriyet	0,0	0,0	0,0
6	Çukurova	0,0	0,0	0,0
7	Dicle	0,0	0,0	0,0
8	Dokuz Eylül	0,0	0,0	0,0
11	Boğaziçi	0,0	0,0	0,0
13	Gaziantep	0,0	0,0	0,0
14	Gaziosman Paşa	0,0	0,0	0,0
16	Harran	0,0	0,0	0,0
18	Karadeniz Teknik	0,0	0,0	0,0
21	Pamukkale	0,0	0,0	0,0
22	Trakya	0,0	0,0	0,0
24	Ondokuz Mayıs	0,0	0,0	0,0
25	Mersin	0,0	0,0	0,0
27	İnönü	0,0	0,0	0,0
29	Ege	0,0	0,0	0,0
30	Fırat	0,0	0,0	0,0
31	Yıldız Teknik	0,0	0,0	0,0
32	Yüzüncü Yıl	0,0	0,0	0,0

According to the Model (4) solution results δ_1^{-*} and δ_2^{-*} values (amount of technical inefficiency) are all zero which implies that the inefficiencies that was found in twenty-one universities is not due to technical inefficiency. As a result, these universities suffer inefficiency either from academic or non-academic input congestion.

The amount of congestion s_i^{-c*} and the amount of total slack δ_i^{-*} that is attributed to technical inefficiency for the associated input $i=1,..., m$ can be captured by using (5). The congestion amounts either in academic or non-academic input are shown in Table 5.

Table-5. Stage 2:Congestion amounts in input *i*

DMU	University	Academic $s_1^{-c} = (s_1^{-*} - \delta_1^{-*})$	Non academic $s_2^{-c} = (s_2^{-*} - \delta_2^{-*})$
5	Cumhuriyet		157,46
6	Çukurova		1127,42
8	Dokuz Eylül		149,18
11	Boğaziçi		16,33
13	Gaziantep		57,63
21	Pamukkale		94,70
22	Trakya		82,88
24	Ondokuz Mayıs		164,14
27	İnönü		67,04
29	Ege		
30	Fırat		204,85
31	Yıldız Teknik	170,46	
32	Yüzüncü Yıl		46,16

Since there is no technical inefficiency we can easily conclude that total inefficiency is due to input congestion in thirteen universities shown in Table 5. They could have produced a larger output by reducing the number of academic or non-academic staff. More preferably, university administrative should revise their non-academic recruitment policies.

5. CONCLUSION

The purpose of this study is to determine congestion in Turkish universities in DEA context. As stated previously there three approaches to deal with congestion. Each approach has some merits and demerits. The merits and demerits of the approaches are extensively debated in DEA literature.

The debates on this issue can be found in studies [2, 6, 22, 23] I have chosen the Cooper approach to determine congestion as the model is more comprehensible than the others. One should keep in mind that if the chosen sample changes the efficient frontier or the production possibility set may change.

So a DMU which is inefficient in one sample may be efficient in the other. The data I have used in this study belongs to period 2009/10 as I could not find necessary data for recent years. The data should be updated to have a better understanding about congestion in Turkish universities.

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