Determinants of University Efficiency Focusing on Entrepreneurship and Innovation Activities

Özge Saygın Karagöz, Şenay Üçdoğruk Birecikli, and İpek Deveci Kocakoç

Abstract One of the main and most important locomotives of knowledge transfer is higher education institutions. The productivity, efficiency, and effectiveness issues in higher education institutions are of high importance for policymakers and higher education professionals in the construction of innovative strategies. In this context, the topic of the research is about the measurement of efficiency and determining the factors that affect the performance of the university efficiency in the focus of entrepreneurship and innovation activities, which is considered as the third role of the universities. Based on the data for the years 2011–2016, firstly it is aimed to calculate the efficiency scores of the top 50 universities in the "Entrepreneurial and Innovative University Index" between 2012–2017 by data envelopment analysis, secondly, it is aimed to examine the environmental factors affecting the efficiency scores with the panel data analysis and to analyze in detail the elements necessary for higher ranking of successes. According to the results obtained, it was observed that 35 universities in Turkey, which are included in the scope of the study, do not use resources effectively and provide a systematic improvement periodically. According to the panel Tobit model results, presence of technopark, GDP per capita by region, the score of the graduates of the doctorate level, the establishment of the university after 1992 and the foundation year have a positive effect on the efficiency scores in the focus of entrepreneurship and innovation activities. Additionally, concerning the results, the efficiency of the universities in the Central Anatolia and Marmara Region is higher than the universities in the Blacksea, Eastern, and Southeastern Regions. Moreover, being a public university, the presence of a medical faculty, the number

Ö. Saygın Karagöz (✉)
İzmir Bakırçay University, İzmir, Turkey
e-mail: ozge.karagoz@bakircay.edu.tr

Ş. Üçdoğruk Birecikli · İ. Deveci Kocakoç
Department of Econometrics, Dokuz Eylül University, İzmir, Turkey
e-mail: s.ucdogruk@deu.edu.tr

İ. Deveci Kocakoç
e-mail: ipek.deveci@deu.edu.tr

A. Horobet et al. (eds.), *Global, Regional and Local Perspectives on the Economies of Southeastern Europe*, Springer Proceedings in Business and Economics,
https://doi.org/10.1007/978-3-030-57953-1_19

of undergraduate students per academician, and the existence of a vocational high school adversely affect efficiency.

Keywords Efficiency · Efficiency in higher education · Data envelopment analysis · Panel data analysis

1 Introduction

The Bayh–Dole Act came into force in response to the lack of sufficient patent numbers received by US research institutes before 1980 and the lack of a technology transfer mechanism to efficiently commercialize the patented inventions. A new era has started in the cooperation between the research universities, the state and the industry with the related law, the transfer of research results from the universities to the industrialization has gained great momentum (Sukan et al. 2002, p. 3).

The development of universities in the historical process takes place as the first, second, and third generations. As third-generation universities are emerging worldwide, a major transition phase of universities is currently in progress (Wissema 2009, p. 3). In most regions around the globe, higher education has undergone a considerable transformation due to the globalization and increasing expectations from the knowledge-based economy. With this transition, universities have experienced important changes from traditional teaching and research tasks, including the entrepreneurial role as the third mission that fully fulfills their potential to contribute to traditional socio-economic development (Sam and Sijde 2014, p. 3). In this context, it is inevitable for universities to focus on new functions for information transfer in the face of these changes in the ecosystem. Universities play an important role in the formation of human capital and at the same time provide new knowledge which will have a positive effect on the innovation systems of the regions. In this sense, with the increasing emphasis on knowledge and innovation, universities must respond immediately to industry needs (Berbegal-Mirabent et al. 2013, p. 2). There is empirical proof that in numerous academic systems the development and commercialization of intellectual property have become institutional goals (Etzkowitz et al. 2000, p. 1).

Despite different views on the third mission of the universities, the common one addresses the university's entrepreneurial function in socio-economic growth, underpinning the notion of an entrepreneurial university in which cooperation between university and external stakeholders is emphasized (Sam and Sijde 2014, p. 1). It is hard and ambiguous to obtain a single definition of the Entrepreneurial University across the European Higher Education Area (OECD, s. 2). There are many ways to define the University of Entrepreneurship in the literature. With the simplest definition, an entrepreneurial university is a university that can take on several roles in society and the innovation (eco) system (Sam and Sijde 2014, p. 11). Röpke (1998) states that entrepreneurial university may imply three things: as an institution,

the university becomes entrepreneurial, University members-faculty, students, staff-somehow become entrepreneurs, University-environmental interaction, the "structural coupling" between university and region, follows entrepreneurial patterns. To become an entrepreneurial university, to boost regional development, a university should improve entrepreneurial abilities and become a competent bloc for regional development (Röpke 1998, p. 2).

The higher education system in Turkey is officially supervised and controlled by the Council of Higher Education (CoHE) which was established with the Law No. 2547 dated 6 November 1981. Today, there are 206 universities including 129 public universities, 72 private universities, 5 private vocational schools. In the context of Turkey's objectives in the field of economy and science for the year 2023, at the forefront strategies focusing on higher education are the creation and development of the information transfer ecosystem and human resources system (Council of Higher Education (CoHE)).

Today, one of the main and most important locomotives of knowledge transfer is Higher Education Institutions. The productivity, efficiency, and effectiveness issues in Higher Education Institutions are of high importance for policymakers and higher education professionals in the construction of innovative strategies. In this context, the topic of the research is about the measurement of the universities efficiencies in the focus of entrepreneurship and innovation activities, which is considered as one of the third mission and determining the factors that affect the efficiency of universities. At the first stage efficiency of 35 higher education institutions for the academic years 2011–2016 in Turkey computed, and in the second stage of the application, the efficiency scores, which were obtained with DEA, were taken as dependent variables and the factors determining the efficiency scores of the universities analyzed.

The rest of this paper is structured as follows: In Sect. 2, an overview of the literature on measuring the efficiency of higher education institutions was given. Section 3 and Sect. 4 data, methodology, data envelopment analysis (DEA), changes in total factor productivity levels of the universities, panel Tobit model results, and conclusions presented, respectively.

2 Literature

There is comprehensive literature on measuring the efficiency of educational institutions, including various higher education institutions. Despite variations in techniques used for this purpose and details of model specification, all current studies share similar approaches to higher education activity account as using main inputs to generate significant outputs such as education, research, and knowledge transfer (Agasisti 2017, p. 2). Information about some of the studies in this rich literature is given below.

Torre et al. (2017) investigated the impact of knowledge transfer indicators on the efficiency analysis of the higher education sector in their study of 47 state universities in Spain. In the study by applying various DEA models with different specifications,

results showed that the estimates for technical efficiency in the Spanish Higher Education system change when knowledge transfer indicators are included. Rossi (2014) analyzed the relative efficiencies of university institutions that use their financial and human resources to produce a broad range of knowledge transfer outputs (intellectual property disclosures, research and consultancy contracts, public events, etc.) by using data from the United Kingdom. According to the results universities operating either at a very small or at a very large scale are more likely to be efficient. Moreover, it was stated that the intensity of research and teaching had no significant influence on the transfer of knowledge. Berbegal-Mirabent et al. (2013) focused on the impact of academic initiatives (spin-off) on university performance as a direct knowledge transfer mechanism. The findings have shown that regional factors related to technological development and entrepreneurial culture have a strong influence on universities' efficiency and their involvement in knowledge transfer activities. Agasisti et al. (2019) examined the relationship between the performance of universities and the regions which they are located, considering the indicators of teaching, research, and third mission as outputs. According to their research, the existence of efficient universities facilitates local economic development.

Lee (2011), first analyzed the research performance of 37 Australian universities by DEA then investigated the determinants of efficiency by regressing efficiency scores on potential environmental variables. The findings have shown that the location of the university, the proportion of Associate Professors, and Professors to total academic staff and institutional grants scheme have a positive, actual student load has a negative effect on efficiency. Mousa and Ghulam (2018) studied the efficiency of 61 higher education institutions for the academic years 2008–2014 in Saudi Arabia first and at the second stage employed regression analysis to identify determinants of efficiency scores. According to the results obtained, it is observed that the ownership of the institution has no significant effect on the efficiency scores. Besides, being a university and having more than 20 years of experience have a positive effect on efficiency scores. Also, an increase in female staff in tertiary education reduces the efficiency level of HEIs. Srairi (2014) investigated the relative efficiency of eleven public universities in Tunisia and examined determinants of efficiency by the panel Tobit model. Research results have shown that being in the developed region, the proportion of professors and associate professors, the share of female academics, and a higher quality of student in secondary education increases the efficiency. On the other hand, the size of the university and load per teacher has a negative effect on efficiency. Selim and Bursalioglu (2013) conducted a two-stage DEA for 51 public universities in Turkey between 2006 and 2010. The results of the panel Tobit model showed that the number of female students has a positive, the number of male students, and the number of faculty has a negative effect on the relative efficiency of universities. Kempkes and Pohl (2010) calculated efficiency scores in the first step, then they regressed the efficiency scores on regional GDP per capita, the existence of the medical school and engineering faculty regarding a panel set of 72 German universities in 1998–2003. They found that GDP as a proxy for the location of university characteristics has a positive; the existence of medical or engineering faculties

has a negative and significant effect on the efficiency of universities. Wolszczak-Derlacz and Parteka (2011) aimed to analyze efficiency and its determinants based on a sample of 259 public higher education institutions from 7 European countries for the period of 2001–2005. They applied a two-stage DEA analysis by first calculating DEA scores then regressing on potential variables by use of bootstrapped truncated regression. At the second stage of the analysis of higher education characteristics as the size of the institution, universities with medical/pharmacy faculty, gender structure of academic staff have a positive effect on efficiency. Additionally, young universities (proxied by the foundation year of university) have a negative effect on the efficiency of universities.

In studies on the efficiency analysis of universities in Turkey, as far as known, there has been no study using current data given the "entrepreneurial and innovative" aspects of the universities. The study has an original value in measuring the efficiency of universities in the context of "entrepreneurship and innovation" activities based on the data for the years 2011–2016 and examining the environmental factors affecting the efficiency scores with the panel data analysis.

3 Data, Methodology, and Results

3.1 Data and Variables

The data used in this study obtained from the Council of Higher Education (CoHE) and The Scientific and Technological Research Council of Turkey (TUBITAK). The data is based on the data for the years 2011–2016 of 35 universities, which managed to stay in the top 50 for five years in the Entrepreneurial Innovative University Index 2012–2017. Description of variables used in the DEA and panel Tobit model are given in Tables 1 and 2.

The output of the DEA score is based on the Entrepreneurial and Innovative University Index prepared by the Scientific and Technological Research Council of

Table 1 Description of variables used in DEA

Variables	Description
Inputs	
Number of professors and associate professors	Sum of professors and associate professors
Number of other academic staff	Sum of assistant professors, instructor, and other academic staff
Number of Ph.D. students	Number of Ph.D. students
Output	
Entrepreneurial and Innovative University Index Score	

Table 2 Description of variables used in panel Tobit model

Variables	Description
Dependent variable: DEA scores	–
Independent variables: University type	1: public university, 0: foundation university
Presence of medical school	1: if the university has a medical school, 0: otherwise
Presence of technopark	1: if the university has a technopark, 0: otherwise
Regional GDP per capita	Per capita gross domestic product by provinces (NUTS-3) (2009 based)
Geographical Region	7 Geographical Regions: Eastern Anatolian, Central Anatolia, Blacksea, Mediterranean, Aegean, Marmara, Southeastern Anatolia
Central Anatolia Region	1: the university is located in the Central Anatolia Region, 0: otherwise
Marmara Region	1: the university is located in the Marmara Region, 0: otherwise
Aegean Region	1: the university is located in Aegean Region, 0: otherwise
Mediterranean Region	1: the university is located in the Mediterranean Region, 0: otherwise
Blacksea, Eastern and Southeastern Regions	1: the university is located in Blacksea or Eastern or Southeastern Regions, 0: otherwise
Presence of vocational school	1: if the university has a vocational school, 0: otherwise
Number of undergraduate students per academic	The ratio of the number of undergraduate students to the number of total academic staff
Doctoral Graduate Score	URAP doctoral graduate student score
Founded before 1992	1: if university established before 1992, 0: otherwise
Year of establishment	Establishment year of the university

Turkey (TUBITAK) since 2012. The Index consists of 5 pillars which consist of scientific and technological research competence, intellectual property pool, cooperation and interaction, entrepreneurship and innovation culture, and economic contribution and commercialization. Detailed information about the 5 pillars from 23 indicators can be found in Appendix.

Table 3 summarizes the dataset for inputs and output variables that were used in DEA, Malmquist Total Factor Productivity (TFP) Index, and panel Tobit model Analysis.

Table 3 Descriptive statistics of inputs, output, and environmental variables

Variable	Mean	Std. Dev.	Min.	Max.	Obs.
Input					
Number of professors and associate professors	503.966	461.609	10	2084	210
Number of other academic staff	1281.062	846.414	49	3677	210
Number of Ph.D. students	1416.39	1535.559	10	7844	210
Output					
Entrepreneurial and Innovative University Index Score	52.146	16.414	28.84	95.03	210
Environmental variables					
University type	0.714	0.452	0	1	210
Presence of medical school	0.628	0.484	0	1	210
Presence of technopark	0.761	0.426	0	1	210
Regional GDP per capita	31,329.2	11,447.8	8264	54,933	210
Central Anatolia Region	0.314	0.465	0	1	210
Marmara Region	0.342	0.475	0	1	210
Aegean Region	0.142	0.350	0	1	210
Mediterranean Region	0.114	0.318	0	1	210
Blacksea, Eastern and Southeastern Regions	0.085	0.280	0	1	210
Presence of vocational school	0.771	0.420	0	1	210
Number of undergraduate students per academic	0.052	0.024	0.0007	0.170	210
Doctoral Graduate Score	121.982	40.509	14.12	199	210
Founded before 1992	0.4	0.491	0	1	210
Year of establishment	1980.229	18.487	1924	2007	210

3.2 Data Envelopment Analysis (DEA) Results

Various methods were used in studies on the efficiency of higher education (De Witte and Lopez Torres 2017). Within these various methods, DEA has found widespread use due to the advantages of usage. The DEA, which has been frequently used for over 30 years to evaluate educational activities of countries, universities, schools, and libraries, is a useful method for identifying the sources of educational inefficiency and providing suggestions for possible improvements in respective educational performance metrics (Emrouznejad and Cabanda 2014). The first implementation of DEA in the field of education was carried out by Charnes et al. (1978) to assess the efficiency of educational programs in public schools. DEA is an approach to measure the relative efficiency of peer decision-making units (DMUs) with multiple inputs and outputs (Chen et al. 2009). The main feature that distinguishes DEA from other methods of similar purpose is that it makes it possible to evaluate when there is a large number of inputs and outputs.

In this study based on the data for the years 2011–2016, efficiency scores of the top 50 universities in the "Entrepreneurial and Innovative University Index" between 2012 and 2017 calculated by DEA and changes in total factor productivity levels of these universities measured by Malmquist Total Factor Productivity (TFP) Index. While determining the input and output variables to be used in the study, both the past studies and the official published statistics were taken into consideration. As a result of the model experiments made, inputs such as human resources (number of academicians, number of Ph.D. students) and due to data limitation "Entrepreneurial and Innovative University Index Score" was taken as output. The Win4DEAP package program was used to calculate the efficiencies of the universities via the DEA method and to obtain the results of the Malmquist Total Factor Productivity (TFP) Index. Tables 4 and 5 presents the DEA and Malmquist Total Factor Productivity (TFP) Index results respectively.

As a result of the analyses made, it is concluded that 2 out of 35 universities included in the study are efficient in all periods. Also, the most significant number of universities with 6 universities are efficient in the year 2016. According to the results of the Malmquist Total Factor Productivity (TFV) index, which is used to determine the change in the efficiency of the universities over time, total factor productivity increased by 0.1% and 0.6% in the period of 2011–2012 and 2013–2014, respectively.

3.3 Panel Tobit Model Results

The topic of the research is about the measurement of the university efficiency in the focus of entrepreneurship and innovation activities, which is considered as one of the third role (mission) and determining the factors that affect the efficiency of universities. At the first stage efficiency of 35 higher education institutions for the academic years, 2011–2016 in Turkey computed, and in the second stage of the application, the efficiency scores which were obtained with DEA were taken as dependent variables and the factors determining the efficiency scores of the universities analyzed.

When the relationship between external factors and efficiency scores is evaluated in the second stage of DEA, the use of Tobit regression is frequently encountered (Hoff 2007). If the dependent variable has a censored structure, consistent parameter estimators cannot be obtained by LS regression estimation. For this reason, it is recommended to use the Maximum Likelihood Method in estimating the Tobit model (Güriş et al. 2015). While the random-effects model allows estimating the coefficients for the variables that are time-varying and time-invariant, it is only possible to estimate the coefficients of the time-varying explanatory variables that change only over time by the fixed-effects model. As the explanatory variables examined in the panel Tobit model analysis have a time-invariant structure, random effects panel Tobit model analysis was performed in the study. As estimated DEA efficiency scores are limited between 0 and 1, due to the censored nature of the data panel Tobit model analysis conducted. Tobit model estimates were obtained by using STATA 15 software. The results for the two different models are shown in Table 6.

Table 4 Efficiency scores of the 35 universities

	University	2011	2012	2013	2014	2015	2016
1	Akdeniz University	0.464	0.489	0.439	0.455	0.443	0.406
2	Anadolu University	0.357	0.558	0.663	0.601	0.530	0.560
3	Ankara University	0.440	0.486	0.468	0.434	0.491	0.463
4	Atilim University	0.481	0.631	0.647	0.569	0.640	0.722
5	Bahcesehir University	0.548	0.510	0.483	0.404	0.408	0.380
6	Bogazici University	0.774	0.889	0.931	0.901	0.843	0.903
7	Cankaya University	1.000	0.677	1.000	1.000	1.000	1.000
8	Cukurova University	0.488	0.546	0.527	0.488	0.451	0.448
9	Dokuz Eylul University	0.417	0.446	0.459	0.487	0.458	0.455
10	Ege University	0.560	0.617	0.602	0.614	0.581	0.593
11	Erciyes University	0.548	0.518	0.520	0.638	0.556	0.565
12	Firat University	0.345	0.388	0.362	0.363	0.403	0.346
13	Gazi University	0.524	0.638	0.579	0.560	0.530	0.508
14	Gaziantep University	0.393	0.486	0.499	0.485	0.543	0.579
15	Gebze Institute of Technology	0.679	0.637	0.697	0.684	0.819	1.000
16	Hacettepe University	0.583	0.659	0.647	0.615	0.543	0.577
17	Bilkent University	0.833	0.964	0.919	0.883	0.870	0.897
18	İstanbul Teknik University	0.798	0.844	0.876	0.848	0.846	0.906
19	İstanbul University	0.357	0.377	0.458	0.445	0.448	0.446
20	İzmir University of Economics	0.443	0.478	1.000	1.000	1.000	1.000
21	İzmir Institute of Technology	0.690	0.794	0.833	0.830	0.741	0.856
22	Karadeniz Teknik University	0.381	0.462	0.396	0.405	0.400	0.401
23	Kocaeli University	0.714	0.746	0.903	0.865	0.827	0.476
24	Koc University	0.440	0.513	0.512	0.467	0.440	0.866
25	Mersin University	0.409	0.501	0.476	0.373	0.442	0.442
26	Middle East Technical University	0.988	1.000	1.000	0.972	0.903	0.960
27	Ozyegin University	***1.000***	***1.000***	***1.000***	***1.000***	***1.000***	***1.000***
28	Pamukkale University	0.345	0.347	0.353	0.375	0.431	0.463
29	Sabancı University	***1.000***	***1.000***	***1.000***	***1.000***	***1.000***	***1.000***
30	Selcuk University	0.512	0.643	0.723	0.669	0.618	0.575
31	Suleyman Demirel University	0.536	0.518	0.523	0.459	0.413	0.369
32	TOBB University of Economics and Technology	0.773	0.827	0.931	1.000	1.000	1.000
33	Uludag University	0.440	0.465	0.527	0.530	0.476	0.521
34	Yeditepe University	0.476	0.535	0.483	0.482	0.456	0.483
35	Yıldız Teknik University	0.488	0.578	0.697	0.723	0.712	0.756

Table 5 Malmquist total factor productivity index results

Period	effch (efficiency change)	techch (technology change)	pech (pure efficiency change)	sech (scale efficiency change)	tfpch (total factor productivity change)
2011–2012	2.390	0.419	1.091	2.191	1.001
2012–2013	1.211	0.719	1.052	1.151	0.871
2013–2014	1.205	0.834	0.974	1.238	1.006
2014–2015	1.012	0.975	0.987	1.026	0.987
2015–2016	1.044	0.925	1.020	1.023	0.966
Geometric average	1.298	0.743	1.024	1.268	0.965

According to the analysis results, the Wald test statistic (Prob > $chi^2 = 0.0000$) was significant for both models and concerning LR test results which compares the pooled estimator with the panel estimator, the panel-level effect is important. Since Rho is different from "0" in both models (0.834 and 0.716), panel-level data analysis is found to be important.

First, the results of Model 1 and Model 2 in Table 6 will be evaluated together. Being a public university and the presence of a medical faculty in the university reduce the effectiveness. The conclusion regarding the negative impact of the presence of a medical faculty in the university on the efficiency is consistent with the results of Kempkes and Pohl (2010); contradicts with the research of Wolszczak-Derlacz and Parteka (2011), which indicates that the universities with a medical faculty or engineering faculty have higher efficiency. The fact that the university has technopark and GDP per capita by region increases the efficiency. The finding of the positive effect of GDP per capita by region on efficiency is coherent with the evidence presented by Kempkes and Pohl (2010). Likely, university-industry cooperation opportunities that can be realized in the region where universities are located, the higher possibility of technology transfer, and the higher qualification of R&D infrastructures in the regions with high GDP might have a positive impact on university efficiency in the focus of entrepreneurship and innovation activities. In Model 1, the increase in the number of undergraduate students per academician decreases productivity and accordingly the efficiency. The negative impact of the number of undergraduate students per academician on efficiency is similar to that obtained by Srairi (2014) and Lee (2011).

According to the results of Model 2, the existence of a Vocational High School at the university has a negative effect on the efficiency scores. The establishment of the university after 1992 and the foundation year have a positive impact on the efficiency. Based on this result, it can be thought that the younger universities are more comfortable adapting to new trends within the scope of entrepreneurship and innovation activities. Contrary to this result Mousa and Ghulam (2018) found that

Table 6 Random effect panel Tobit model results

Independent variables	Model 1			Model 2		
	Coef.	Std. Err.	Marginal effect	Coef.	Std. Err.	Marginal effect
Presence of medical school	−0.2210544***	0.0742654	−0.2210544	−0.1594791***	0.0571243	−0.1594791
Presence of technopark	0.1474821***	0.0422062	0.1474821	0.1527101***	0.0421349	0.1527101
University type (1: public, 0: foundation)	−0.2732128***	0.0898609	−0.2732128	−0.2015239***	0.0841466	−0.2015239
Number of undergraduate students per academic	−1.624711*	0.82663	−1.624711	–	–	–
Doctoral Graduate Score	0.0012533**	0.0005836	0.0012533	–	–	–
Regional GDP per capita (2009 based)	0.0445247*	0.031089	0.0445247	0.0679076***	0.0285352	0.0679076
Presence of vocational school	–	–	–	−0.1570662**	0.0704973	−0.1570662
Founded before 1992	–	–	–	0.2367065***	0.0903844	0.2367065
Year of establishment	–	–	–	0.0048733*	0.0025895	0.0048733
Central Anatolia	–	–	–	0.1780317*	0.1024637	0.1780317
Marmara Region	–	–	–	0.1784511*	0.0996654	0.1784511
Aegean Region	–	–	–	0.1220353	0.1104926	0.1220353
Mediterranean Region	–	–	–	0.1742675	0.115714	0.1742675
Constant	0.3460183	0.3591928	–	–	5.224331	–
Log-likelihood	117.99963		–		118.30156	–
Left-censored observations	0		–		2	–
Uncensored Observations	183		–		181	–
Right-censored observations	27		–		27	–
Rho	0.834		–		0.716	–
LR test of sigma_u	217.68		–		154.69	–

(continued)

Table 6 (continued)

Independent variables	Model 1			Model 2		
	Coef.	Std. Err.	Marginal effect	Coef.	Std. Err.	Marginal effect
Wald	44.27		–	67.43		–

Base category: Blacksea, Eastern and Southeastern Regions
*, ** and *** indicate statistical significance at 1%, 5% and 10%

being a university and having more than 20 years of experience have a positive effect on efficiency scores.

Another question investigated in the study is whether the region where the universities are located has an impact on efficiency. In that regard, formed by combining five of the seven geographical regions of Turkey and one region was chosen as a base class. Regarding the results, the efficiency of the universities in the Central Anatolia and Marmara Region is higher than the universities in the Blacksea, Eastern, and Southeastern Regions. The DEA confirms this result, the fact that universities with the highest efficiency score (Çankaya University, METU, Özyeğin University, Sabancı University) are located in Ankara and Istanbul. Unfortunately, compared to the base class (Blacksea, Eastern and Southeastern Regions) the effects of being in the Aegean and Mediterranean regions were not found significant.

4 Conclusion

In this study first efficiency of 35 higher education institutions in Turkey for the academic years 2011–2016 computed and in the second stage, the efficiency scores which were obtained with DEA were taken as dependent variables and the factors determining the efficiency scores in the focus of entrepreneurship and innovation activities analyzed. The study provides significant findings for future work and policymakers since the efficiencies of the universities are measured by focusing on entrepreneurship and innovation activities, although the study has some limitations due to the inadequacy of the published data.

As a result of the analysis made, it is concluded that 2 out of 35 universities included in the study are efficient in all periods. Besides, the most significant number of universities with 6 universities are efficient in the year 2016. However, according to the results of the Malmquist Total Factor Productivity (TFV) index, which is used to determine the change in the efficiency of the universities over time, total factor productivity decreased by 0.1% and 0.6% between 2011 and 2012 and 2013–2014, respectively. According to the results obtained, it was observed that 35 universities in Turkey, which are included in the scope of the study, do not use resources effectively and provide a systematic improvement periodically.

With regard to Turkish universities, panel Tobit model analysis revealed that drivers of the university efficiency in the focus of entrepreneurship and innovation activities are the presence of technopark, GDP per capita by region, the score of the graduates of the doctorate level, the establishment of the university after 1992 and the foundation year which contributed positively to the efficiency. Also, the efficiency of the universities in the Central Anatolia and Marmara Region is higher than the universities in the Blacksea, Eastern, and Southeastern Regions. Besides, being a public university, the presence of a medical faculty, the number of undergraduate students per academician, and the existence of a Vocational High School adversely affect efficiency.

In light of this evidence, to achieve third generation university model, higher education institutions are obliged to change their old patterns by enhancing university-industry collaboration, knowledge transfer and applying strategies to increase the interest of students in graduate programs to meet the need of qualified personnel of the industry. In this context, it is critical to take measures to reduce the course load to ensure that academicians spend more time in R&D studies and to reduce the number of students per academician.

As a result, it can be said that within the framework of Turkey's goals in the economy and science for the year 2023, there are many factors that universities need to develop in terms of "entrepreneurship and innovation". The higher education system needs to implement innovative strategies for producing high value-added products and for technology-based entrepreneurship.

Acknowledgements This study was supported by the Dokuz Eylul University Scientific Research Coordination Unit as part of the project: Performance Comparison and Efficiency Measurement of Universities in Turkey: Panel Data Analysis (Project Number: 2018.KB.SOS.004).

Appendix

Information on 5 dimensions and 23 parameters that form the Entrepreneurial and Innovative University Index.

The output of the DEA score is based on the Entrepreneurial and Innovative University Index prepared by the Scientific and Technological Research Council of Turkey (TÜBITAK) since 2012. The Index consists of 5 pillars and 23 indicators which are given below.[1]

1. Scientific and Technological Research Competence (20%)—6 indicators
   - Number of scientific articles and citations
   - Number of projects and the monetary amount of project funds
   - Number of scientific prizes
   - Number of graduates having Ph.D. degree
2. Intellectual Property Pool (15%)—4 indicators
   - Number of national and international patent applications
   - Number of national patent grants
   - Number of utility model/industrial design grants
3. Cooperation and Interaction (25%)—5 indicators

[1]Information about Entrepreneurial and Innovative University Index is gathered from the presentation of Yasemin Aslan, Head of STI Policies Department, accessed 20 April 2020, https://www.oecd.org/sti/Session5_Yasemin%20Aslan.pdf.

- Number of university-industry collaboration project and the amount of university-industry collaboration project funds
- Number of international collaboration project and the amount of international collaboration project funds
- Number of academicians/students who are in circulation

4. Entrepreneurship and Innovation Culture (15%)—4 indicators

- Number of undergraduate and graduate-level courses
- Number of training/certification programs
- The activities of the Technology Transfer Office
- Number of full-time working people for the management

5. Economic Contribution and Commercialization (25%)—4 indicators

- Number of firms that are founded or co-founded by academicians/students—last five years graduates and their employment
- Number of employees of firms that are founded or co-founded by academicians
- Number of licensed patent/utility model/industrial design.

References

Agasisti, T. (2017). Management of higher education institutions and the evaluation of their efficiency and performance. *Tertiary Education and Management, 23*(3), 187–190. https://doi.org/10.1080/13583883.2017.1336250

Agasisti, T., Barra, C., & Zotti, R. (2019). Research, knowledge transfer, and innovation: The effect of Italian universities' efficiency on local economic development 2006–2012. *Journal of Regional Science, 59*(5), 819–849. https://doi.org/10.1111/jors.12427

Berbegal-Mirabent, J., Lafuente, E., & Solé, F. (2013). The pursuit of knowledge transfers activities: An efficiency analysis of Spanish universities. *Journal of Business Research, 66*(10), 2051–2059. https://doi.org/10.1016/j.jbusres.2013.02.031

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision-making units. *European Journal of Operational Research, 2,* 429–444. https://doi.org/10.1016/0377-2217(78)90138-8

Chen, Y., Liang, L., & Zhu, J. (2009). Equivalence in two-stage DEA approaches. *European Journal of Operational Research, 193*(2), 600–604. https://doi.org/10.1016/j.ejor.2007.11.040

Council of Higher Education. (CoHE). https://yuzikibinbursu.yok.gov.tr/Sayfalar/HaberDuyuru/100-2000-doktora-projesi-nedir.aspx. Accessed April 20, 2020.

De Witte, K., & Lopez-Torres, L. (2017). Efficiency in education: A review of the literature and a way forward. *Journal of the Operational Research Society, 68*(4), 339–363. https://doi.org/10.1057/jors.2015.92

EC/OECD. (2012). A guiding framework for entrepreneurial universities. Final version 18 December 2012. https://www.oecd.org/site/cfecpr/EC-OECD%20Entrepreneurial%20Universities%20Framework.pdf. Accessed April 20, 2020.

Emrouznejad, A., & Cabanda, E. (2014). Managing service productivity: Uses of frontier efficiency methodologies and MCDM for improving service performance. In *The Series of International Series in Operations Research & Management Science*. Berlin: Springer.

Etzkowitz, H., Webster, A., Gebhardt, C., & Terra, B. R. C. (2000). The future of the university and the university of the future: Evolution of ivory tower to entrepreneurial paradigm. *Research Policy, 29*(2), 313–330. https://doi.org/10.1016/s0048-7333(99)00069-4

Güriş, S., Sacakli Sacildi, I., & Guneren Genc, E. (2015). Determining the effects of factor on FDI in the global crisis period. *International Journal of Economics and Financial Issues, 5*(1), 1–10.

Hoff, A. (2007). Second stage DEA: Comparison of approaches for modeling the DEA score. *European Journal of Operational Research, 181,* 425–435. https://doi.org/10.1016/j.ejor.2006.05.019

Kempkes, G., & Pohl, C. (2010). The efficiency of German universities—Some evidence from nonparametric and parametric methods. *Applied Economics, 42*(16), 2063–2079. https://doi.org/10.1080/00036840701765361

Lee, L. B. (2011). The efficiency of the research performance of Australian universities: A reappraisal using a bootstrap truncated regression approach. *Economic Analysis and Policy, 41,* 195–203. https://doi.org/10.1016/S0313-5926(11)50032-3

Mousa, W., & Ghulam, Y. (2018). Exploring efficiency differentials between Saudi higher education institutions. *Managerial and Decision Economics, 40*(2), 180–199. https://doi.org/10.1002/mde.2995

Röpke, J. (1998). *The Entrepreneurial University. Innovation academic knowledge creation and regional development in a globalized economy*. Working Paper. Marburg: Philipps Universitat.

Rossi, F. (2014). The efficiency of universities' knowledge transfer activities: A multi-output approach beyond patenting and licensing. Working Papers 16, Birkbeck Centre for Innovation Management Research, revised Feb 2014.

Sam, C., & Sijde, P. V. (2014). Understanding the concept of the entrepreneurial university from the perspective of higher education models. *Higher Education, 68*(6), 891–908. https://doi.org/10.1007/s10734-014-9750-0

Selim, S., & Bursalioglu, A. S. (2013). Analysis of the determinants of university efficiency in Turkey: Application of the data envelopment analysis and panel Tobit model. *Procedia-Social and Behavioral Sciences, 89,* 895–900.

Srairi, S. A. (2014). The efficiency of Tunisian universities: An application of a two-stage DEA approach. *Journal of Knowledge Globalization, 7*(2), 31–57.

Sukan, F. V., Akdeniz, C., & Hepbasli, A. (2002). Üniversite-Sanayi İşbirliğinde Ar-Ge Merkezlerinin Rolü: Ebiltem Uygulaması. *Endüstri Mühendisliği, 13*(2), 12–19.

Torre, E. M., Agasisti, T., & Perez-Esparrells, C. (2017). The relevance of knowledge transfer for universities' efficiency scores: An empirical approximation on the Spanish public higher education system. *Research Evaluation, 26*(3), 211–229.

Wissema, J. G. (2009). *Towards the third generation university: Managing the university in transition*. Cheltenham: Edward Elgar.

Wolszczak-Derlacz, J., & Parteka, A. (2011). The efficiency of European public higher education institutions: A two-stage multi-country approach. *Scientometrics, 89,* 887–917.