

Original Research

A Data Envelopment Analysis (DEA) Approach to Evaluate the Research Efficiency of Iranian Universities

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Abstract

University rankings are often based on measurable outputs. Research institutes and universities are expected to be evaluated based on their capabilities, inputs, and outputs and it is important to do balanced and comprehensive evaluations. Criticisms towards global ranking systems have led them to reform their methodologies, consider the differences in the mission of universities, normalize data based on subjects, and consider the size and age of universities. The data envelopment analysis (DEA) method is a complementary tool to increase the ranking transparency. This study aimed to evaluate the research efficiency of Iranian universities ranked in the Times Higher Education World University Rankings by using the DEA method and to discover the relationship between universities' performance, their rank, research scores, and their citation score in the Times Higher Education Ranking System. The research population included 47 universities. Three inputs and 15 outputs were used in different models. The Microsoft Excel and DEAP software were used to extract the data, define the scenarios and analyze the data. The results showed the relatively good performance of the universities. There was no relationship between the universities' efficiency score and their research score in the Times Ranking System, but a significant positive relationship was observed between the efficiency score and the universities' rank and the citation score in the Times Ranking System (0.719 and 0.613, respectively). It seems that the DEA method can be used as a complementary tool to evaluate the technical performance and allocate funds to universities and research institutes.

Keywords: Research Efficiency, Data Envelopment Analysis, Iranian Universities, World

University Ranking, World University Ranking, THE.

Introduction

The number of universities and educational institutions has shown rapid growth all around the world. As such, there is intense competition between universities to attract students. Evaluation of the performance of universities and institutions is an attractive and dominant concept in higher education that is done to help allocate funding rationally, prioritize investment, and direct candidate students toward an institution to continue their studies (Ioannidis et al., 2007). Various evaluations are adopted by universities including internal and external evaluations. The international ranking of universities and academic institutions has received wide attention in the last few years (Aguillo, Bar-Ilan, Levene & Ortega, 2010) and is influencing the perception of success and excellence in higher education (Ahmad & Shah, 2018; Altbach & Hazelkorn, 2017). Studies have shown that the rank of universities in global ranking systems is an important factor to be considered by the candidates (Ahmad & Shah, 2018; Gong & Huybers, 2015). In this way, higher education institutes try to enter and get better ranks in international ranking systems. But there are some criticisms of global ranking systems. According to previous studies, they mainly emphasize publications, citations, reputation, and institutional resources while they may not truly represent university quality (Frey & Rost, 2010; Moed, 2017; Saisana, d'Hombres & Saltelli, 2011; Taylor & Braddock, 2007; Vernon, Balas & Momani, 2018).

Times Higher Education (THE)¹ is one of the leading ranking systems (Perez-Esparrells & Orduna-Malea, 2018), which has been working since 2010. Thirteen indicators are considered in five areas: teaching (the learning environment); research (volume, income, and reputation); citations (research influence); international outlook (staff, students, and research); and industry income (knowledge transfer) (Muñoz-Suárez, Guadalajara & Osca, 2020). One advantage of THE ranking system is that it includes industry income and it also publishes global rankings by subject (Perez-Esparrells & Orduna-Malea, 2018).

Iranian universities have attempted to enter the universal ranking systems. The number of universities in the Islamic Republic of Iran which entered THE rankings has increased during the last decade from 1 in 2012 to 47 in 2021 (World University Rankings, 2021). However, there is low transparency in the methodology applied by THE; thus, some other methodologies are used for performance measurement and benchmarking (González-Garay et al., 2019).

Data envelopment analysis (DEA) is a reliable and robust evaluation method. This non-parametric quantitative technique will assess the relative efficiency of evaluated units, commonly known as decision-making units (DMUs) (Ji & Lee, 2010; Lin, Lee & Chiu, 2009; Samoilenko & Osei-Bryson, 2013). DMU was the name employed by Charnes, Cooper, and Rhodes (1978) to explain the units being analyzed in DEA. "The purpose of the DEA is to establish the relative efficiency of each DMU within a sample" (Samoilenko & Osei-Bryson, 2008).

"It has been applied in various industries" (Montoneri, Lin, Lee & Huang, 2012, p.383), and higher education; DEA has been widely applied to assess their efficiency. Dumitrescu, Costică, Simionescu and Gherghina (2020) conducted research using DEA to investigate the sustainability of funding in Romanian public universities (ibid). Salas-Velasco (2020) applied DEA to analyze the technical performance of higher education in Spain. The spearman test showed that the universities' performance score matched their score in global ranking systems

such as SCImago Institutions Rankings and Academic Ranking of World Universities. According to this study, DEA is an excellent tool for benchmarking in Higher education (Salas-Velasco, 2020).

The performance and efficiency of the medical universities in Iran were analyzed using DEA and Malmquist index. Forty-five medical universities were studied in three periods - 2010, 2013, and 2016. According to the findings, only one type 1-university was determined as efficient, and other efficient medical universities were among type two and three universities² (Mehrolohasani, Goudarzi, Yazdi Feyzabadi, Pourhosseini & Darvishi, 2019).

Yang, Fukuyama and Song (2018) reported the inefficiency of 64 research universities in China using the two-stage DEA model. The inputs included teaching and research staff, government block funds, and R&D funds, and the outputs were the total number of students, the total number of patents, the number of SCI/SSCI publications, and the number of other intellectual property forms. Finally, they suggested that a performance-based budget management system should be applied according to the universities' performance to allocate the budget based on the selected indices (Yang et al., 2018). Abramo, Cicero and D'Angelo (2011) used bibliometrics data for five years to examine the Italian universities. Three inputs were the number of the faculty members by their ranks (full professors, associate professors, and assistant professors) and the scientific strength was the output. They attempted to measure the technical and allocative efficiency of the universities at a national level. They finally suggested DEA as a proper methodology for evaluation.

To search out which indicators had the most important impact on students' learning performance, Martín (2006) used the DEA methodology. He selected research and teaching indicators to analyze the performance of the departments of the University of Zaragoza in Spain and to present some solutions to improve their performance. In another study, Abbott and Doucouliagos (2003) assessed the teaching and research performance of Australian public universities. DEA has been used to determine the performance of institutes over the years. Some Iranian universities entered the global ranking systems such as THE, and they try to compete in the national and international atmosphere. In this way, they try to have better performance. This study aims at analyzing the performance of Iranian universities that are in THE system to compare their efficiency. This study can suggest several initiatives to improve their performance.

Materials and Methods

This section includes a brief description of DEA and the scenarios; the DUMs, the data sources, and model parameters are presented followed by the comparison of the models.

DEA Model and Different Scenarios

To analyze the efficiency of the Iranian universities, Data Envelope Analysis (DEA) was applied in this study. The Iranian universities in the Times Ranking System were selected. DEA is an "input-oriented" approach used to measure the efficiency of organizational units that have the same goals and objectives. The units of analysis are called decision-making units (DMUs), converting multiple inputs into multiple outputs (Torres-Samuel et al., 2020). Some advantages have been mentioned for DEA, which is a non-frontier method, over some frontier methods such as regression analysis and stochastic frontier analysis (SFA) (Wu, Zhang, Zhu & Zhou, 2020). DEA is a useful technique not only for evaluating the efficiency of DMUs but

also for ranking them, and it has been proven to be a successful technique in performance benchmarking (Rabar, 2017). If the efficiency value equals 1, the evaluated unit is efficient (with optimal performance); if the efficiency score is less than 1, the evaluated unit needs to be improved. In returns to scale, DEA is divided into constant returns to the scale (CRS) models or variable returns to scale (VRS) models. Returns to the scale (CRS) models measure total efficiency (TE), which implies they take into account both scale efficiency and purely technical efficiency (PTE). Variable return scale models evaluate the scale efficiency (SE) from total efficiency (Wu et al., 2020). In this study, the output-oriented model was applied.

DEA methods have been widely used to evaluate the universities and research centers' performance at the national level. On the other hand, scientometric indicators are appropriate inputs and outputs, which increase the tendency towards this type of evaluation (Abramo et al., 2011). In this study, the bibliometrics indicators as output were used for 5 years based on THE methodology. The present study was developed in seven scenarios. In all scenarios, there were three inputs including the total number of students, the total number of faculty members, and the ratio of students to faculty members. The outputs consisted of 15 bibliometrics indices combined in different methods. For example, scholarly output, citation per paper (CPP), cited publications, and field-weighted citation impact were four outputs in the fourth scenario while ten outputs were examined in the 1st scenario. The inputs and outputs for each scenario are presented in Table 1.

Data source and DMUs

The data covers 47 Iranian universities which are ranked in THE Ranking System in 2021. One of the important inputs in performance evaluation is budget, but since we had no access to this data, only Iranian universities were selected to be investigated because the research budget allocation in different countries may be different and incomparable. This study aimed to measure the Iranian universities' performance at the international level based on the available data.

Universities and research institutes in Iran are classified into six categories: research centers, comprehensive universities, industrial universities, art universities, medical sciences universities, and Azad universities (ISC, 2021). Their missions are different so that comprehensive universities cover a wide range of majors such as engineering, humanities, and basic sciences while industrial universities cover only engineering majors. Medical sciences universities educate clinical and medical students. Forty-seven Iranian universities were studied, which were ranked in THE Ranking System in 2021 including 30 comprehensive universities, nine medical sciences universities, and eight technical universities. The input and output data related to 47 universities were extracted from Times Ranking System and SciVal, respectively. The outputs were gathered using Times Ranking System methodology (including all document types, i.e., article, review, proceedings, book, and book chapters excluding letter, correction, and editorial material in Scopus) over five years.

Input and output variables

Inputs included three variables: the number of full-time students, the number of faculty members, and the ratio of the students to faculties. The data was gathered from the Times Ranking System website in 2021. Fifteen research indicators were considered as outputs gathered from SciVal on December 4, 2020. Different indicators were applied in different

scenarios. Table 1 demonstrates the inputs and outputs. When selecting the variables, the raw data were entered in Excel, and five scenarios were executed in DEAP version 2.1. It should be noted that the logarithms of two outputs (scholarly output, and citation) and one input (No. of FTE students) were calculated because their scale was large, and then DEAP software was used. The Kappa agreement coefficient was used to estimate the agreement between the models.

Table 1
Definition of inputs and outputs in different Scenarios

Variable	Input/ Output	Definitions of Variable	Included in the Models
Scholarly Output	Output	The total number of universities' publications (article, review, book chapter, and book) indexed in Elsevier's Scopus database from 2015 to 2019.	1,2,3,4,5,6,7
Citation	Output	citations to the universities' publications made in the 5 years.	1,2,3,4
CPP	Output	citations per paper.	1,2,3,4,5,6,7
Cited publication	Output	The percentage of universities' publications cited by other documents.	1,2 ,3,5,6,7
FWCI	Output	field-weighted citation impact.	1,2,5,6
Q1(%)	Output	publications in Q1 Journal Quartile by SJR (%).	1,2
Patent-Citations Count	Output	The count of patents citing the scholarly output published by each university.	1,3
Patent-Citations per Scholarly Output	Output	The average patent citations received per 1,000 scholarly outputs published by each university.	1,3,4
Patent-Cited Scholarly Output	Output	The count of scholarly output published by each university.	1,3
Citing-Patents Count	Output	The count of patents citing the scholarly output published by each university.	1,3
1% Citation Percentiles (%)	Output	Output in Top 1% Citation Percentiles (%).	6
Citation per Faculty	Output	The total number of citations for five years is divided by the number of academics in a university.	7
Number of Citing Countries	Output	The count of countries citing the scholarly output published by each university.	2
International Collaboration (%)	Output	The percentage of internationally collaborative publications by each university.	2,4
International Collaboration Impact	Output	The citation impact of publications with particular types of geographical collaboration.	2,4
No. of FTE Students	Input	The number of full-time equivalent students in each university.	1,2,3,4,5,6,7
No. of students per staff	Input	The ratio of full-time equivalent students to the number of academic staff.	1,2,3,4,5,6,7
Staff	Input	The number of academic staff.	1,2,3,4,5,6,7

Results

Efficiency scores

This study aims to evaluate the efficiency of the Iranian universities in the global THE ranking. The efficiency scores of the universities are presented in Table 2. In this table, M1 to M7 indicate the different scenarios. The highest mean of efficiency was 1 and the lowest was 0.739. This shows that the Iranian universities ranked by THE have relatively good efficiency.

In Table 2, the 15 universities with the highest efficiency in each model are marked in green, and the 15 universities with the lowest efficiency are marked in red. From this perspective, medical universities had the highest presence in the high-performance category (green colour) and, seven of the nine medical universities in this ranking system were among the top 15 universities in all models. Industrial universities performed better, and six of the eight industrial universities had high performance in all models and were in the first 15 categories. On the other hand, all 15 inefficient and red universities were among the comprehensive universities. It may be since medical and technical universities are more article-oriented than comprehensive universities, and they produce and publish more papers. As a rule, their national output influences their performance. In general, medical universities showed better efficiency. Five medical universities out of nine had a score of 1. The same efficiency score of universities in different scenarios indicated the stability of the results. On the other hand, it could be concluded that some parameters such as scholarly output, citation, and cited publication were the most important factors because, despite adding and combining other parameters in different scenarios, no large change was observed in the efficiency scores. In other words, it can be inferred that the indicators such as patent-related indicators or, for example, output in Top 1% Citation Percentiles, which were combined in different scenarios, did not have much effect in estimating the efficiency because the score of these indicators was relatively low in all universities.

Table 2

Efficiency scores from data envelopment analyses

	M1	M2	M3	M4	M5	M6	M7	Average ranking	Number of times in top 15	Number of times in bottom 15
Iran, Med. Univ	1	1	1	1	1	1	1	1	7	0
Kerman, Med. Univ	1	1	1	1	1	1	1	1	7	0
Kurdistan, Med. Univ	1	1	1	1	1	1	1	1	7	0
Shiraz, TU	1	1	1	1	1	1	1	1	7	0
Tabriz, Med. Univ	1	1	1	1	1	1	1	1	7	0
Tehran, Med. Univ	1	1	1	1	1	1	1	1	7	0
Sharif, TU	1	1	1	0.996	0.991	0.991	1	0.997	7	0
Babol Noshirvani, TU	1	1	1	1	0.976	1	1	0.997	7	0
Mashhad, Med. Univ	1	1	1	1	0.966	0.981	0.966	0.988	7	0
Amirkabir, TU	1	0.981	1	0.994	0.974	0.974	0.981	0.986	7	0
Isfahan, TU	0.975	0.999	0.966	0.97	0.966	0.966	0.982	0.975	7	0
Beheshti, Med. Univ	0.972	0.975	0.972	0.972	0.972	0.972	0.972	0.972	7	0
K.N. Toosi, TU	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	7	0
Shiraz, Med. Univ	0.94	0.958	0.94	0.94	0.938	0.938	0.938	0.942	4	0
Iran, TU	0.934	0.928	0.934	0.932	0.928	0.928	0.931	0.931	2	0
Tabriz, Comp. Univ	0.925	0.936	0.925	0.931	0.925	0.936	0.925	0.929	1	0
Isfahan, Med. Univ	0.926	0.942	0.926	0.93	0.918	0.918	0.918	0.925	1	0
Shiraz, Comp. Univ	0.916	0.92	0.916	0.916	0.916	0.916	0.916	0.917	0	0
Hakim Sabzevari, Comp. Univ	1	0.85	0.979	1	0.848	0.848	0.848	0.910	3	0

Kashan, Comp. Univ	0.905	0.904	0.902	0.902	0.902	0.909	0.902	0.904	0	0
Shahed, Comp. Univ	0.982	0.843	0.978	0.978	0.837	0.837	0.837	0.899	3	3
Tehran, Comp. Univ	0.915	0.916	0.885	0.908	0.885	0.887	0.885	0.897	0	0
Yasouj, Comp. Univ	0.912	0.912	0.892	0.87	0.892	0.908	0.892	0.897	0	0
Beheshti, Comp. Univ	0.878	0.904	0.878	0.878	0.878	0.878	0.878	0.882	0	0
Shahrood, TU	0.863	0.906	0.863	0.866	0.863	0.864	0.863	0.870	0	0
Ferdowsi, Comp. Univ	0.869	0.873	0.869	0.869	0.869	0.869	0.869	0.870	0	0
Isfahan, Comp. Univ	0.861	0.858	0.861	0.861	0.858	0.858	0.858	0.859	0	0
Razi, Comp. Univ	0.846	0.849	0.846	0.846	0.846	0.846	0.846	0.846	0	0
Shahrekord, Comp. Univ	0.847	0.856	0.847	0.847	0.842	0.842	0.842	0.846	0	0
Bu-Ali Sina, Comp. Univ	0.839	0.844	0.839	0.839	0.839	0.839	0.839	0.840	0	0
Guilan, Comp. Univ	0.838	0.839	0.838	0.838	0.838	0.838	0.838	0.838	0	1
Bahonar, Comp. Univ	0.837	0.837	0.837	0.837	0.837	0.837	0.837	0.837	0	7
Urmia, Comp. Univ	0.837	0.839	0.837	0.837	0.833	0.833	0.833	0.836	0	7
Mohaghegh Ardebili, Comp. Univ	0.825	0.825	0.825	0.825	0.821	0.864	0.821	0.829	0	6
Madani, Comp. Univ	0.826	0.828	0.826	0.826	0.826	0.833	0.826	0.827	0	7
Semnan, Comp. Univ	0.826	0.826	0.826	0.826	0.823	0.823	0.823	0.825	0	7
Kurdistan, Comp. Univ	0.821	0.841	0.815	0.815	0.811	0.843	0.811	0.822	0	5
Arak, Comp. Univ	0.817	0.828	0.817	0.817	0.817	0.817	0.817	0.819	0	7
Mazandaran, Comp. Univ	0.818	0.824	0.818	0.818	0.813	0.818	0.813	0.817	0	7
Chamran, Comp. Univ	0.816	0.817	0.816	0.816	0.814	0.814	0.814	0.815	0	7
Yazd, Comp. Univ	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0.812	0	7
Kharazmi, Comp. Univ	0.811	0.81	0.811	0.811	0.81	0.81	0.81	0.810	0	7
Lorestan, Comp. Univ	0.8	0.817	0.8	0.802	0.797	0.815	0.797	0.804	0	7
Alzahra, Comp. Univ	0.815	0.798	0.815	0.815	0.792	0.792	0.792	0.803	0	7
Rajaei, Comp. Univ	0.803	0.758	0.803	0.803	0.758	0.758	0.758	0.777	0	7
Birjand, Comp. Univ	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0	7
Sistan and Baluchistan, Comp. Univ	0.739	0.739	0.739	0.739	0.739	0.739	0.739	0.739	0	7

TU= Technical university, Med. Univ= Medical university, Comp. Univ= Comprehensive University

Comparison of models' results

Reliability between the models is presented in Table 3. Kappa coefficients showed that the agreement rate of the models was relatively high, and the models confirmed each other so that the lowest agreement between the models was the kappa coefficient of 0.84.

Table 3

Cohen's kappa coefficient (κ)

	M1	M2	M3	M4	M5	M6	M7
M1							
M2	0.808						
M3	1	0.808					
M4	0.936	0.872	0.936				
M5	0.936	0.841	0.936	0.872			
M6	0.84	0.872	0.84	0.84	0.904		
M7	0.936	0.841	0.936	0.872	1	0.904	

Correlation of DEA efficiency with Rank, Research productivity, and Citation

The positive correlation between the research efficiency of universities and the overall score in the Times ranking system (Spearman's rho = 0.719) indicated that the method used in

this study to evaluate the universities matched the International Times ranking system (Table 4).

To determine the correlation between the research performance and the research score of the universities in the Times ranking system, the Spearman correlation test was used. As table 4 indicates, there is no relationship between the average performance of the universities and research scores in the Times ranking system. In the Times ranking system, 30% of the total scores belong to research criteria. Only 6% is dedicated to research productivity and 18% and 6% to reputation survey and research income, respectively. More than half of the research scores are assigned to international reputation, which affects the universities' research scores. It seems there are some criticisms of the methodology of the global ranking systems. This can explain the reason for the difference between the efficiency scores of the Iranian universities and their research rankings in the Times ranking system.

The relationship between the universities' efficiency score and their citation rank in the Times ranking system was estimated using the Spearman test. The results demonstrated that there was a linear relationship (with a correlation coefficient of 0.613) between their efficiency score and citation score. Thirty percent of the scores in the final ranking of the Times ranking system were assigned to the Citation Index, which indicated research influence. In this way, there was a correlation between the research efficiency score by the DEA method and the research impact of citation. In other words, the better the performance in the citation index, the better the research efficiency.

Table 4

Correlation between DEA Score and Rank, Research Score and Citation of universities in TIMES

		DEA Score	Rank	Research Score	Citation
Spearman's rho	Correlation Coefficient	1	.719**	0.274	.613**
	Sig. (2-tailed)	.	0	0.062	0
	N	47	47	47	47

** Correlation is significant at the 0.01 level (2-tailed).

The reference model for inefficient universities

One of the main results of DEA analysis is introducing model enterprises for inefficient universities. Table 5 puts forward the model enterprises in front of each university. It means that universities can increase their efficiency levels by following the reference models. For example, Alzahra University can improve its efficiency by following enterprises number 34, 5, and 35, which are Shiraz university of technology, Babol Industrial University, and Tabriz University of Medical Sciences. Although the researchers are aware of the point that comparing the comprehensive universities with the technical and medical universities is not desirable, they aim to compare the research efficiency of the universities in the Global Times Ranking System.

Table 5
Firm Peers for inefficient DMUs

Code	DMUS	Peers Code			
1	Alzahra, Comp. Univ	34	5	35	
2	Amirkabir, TU	2			
3	Arak, Comp. Univ	34	36		
4	Shahid Madani, Comp. Univ	34	36		
5	Babol Noshirvani, TU	5			
6	Bu-Ali Sina, Comp. Univ	34	36		
7	Ferdowsi, Comp. Univ	34	36		
8	Guilan, Comp. Univ	34	36		
9	Hakim Sabzevari, Comp. Univ	9			
10	Iran, Med. Univ	10			
11	Iran, TU	31	2	34	36
12	Isfahan, Med. Univ	34	35	36	
13	Isfahan, TU	36	31	34	5
14	K.N. Toosi, TU	34	36		
15	Kerman, Med. Univ	15			
16	Kharazmi, Comp. Univ	34	35	36	
17	Kurdistan, Med. Univ	17			
18	Lorestan, Comp. Univ	34	35	36	
19	Mashhad, Med. Univ	19			
20	Mazandaran, Comp. Univ	34	35	36	
21	Razi, Comp. Univ	34	36		
22	Semnan, Comp. Univ	17	34	36	
23	Shahed, Comp. Univ	17	5	9	35
24	Bahonar, Comp. Univ	34	36		
25	Beheshti, Comp. Univ	34	36		
26	Beheshti, Med. Univ	10	34	36	
27	Chamran, Comp. Univ	34	35	36	
28	Shahid Rajaei, Comp. Univ	5	35	34	
29	Shahrekord, Comp. Univ	34	35	36	
30	Shahrood, TU	34	36		
31	Sharif, TU	31			
32	Shiraz, Comp. Univ	34	36		
33	Shiraz, Med. Univ	10	35	34	36
34	Shiraz, TU	34			
35	Tabriz, Med. Univ	35			
36	Tehran, Med. Univ	36			
37	Birjand, Comp. Univ	34	36		
38	Isfahan, Comp. Univ	35	34	36	
39	Kashan, Comp. Univ	5	36	34	17
40	Kurdistan, Comp. Univ	5	34		
41	Mohaghegh Ardebili, Comp. Univ	36	17	34	
42	Sistan and Baluchistan, Comp. Univ	34	36		
43	Tabriz, Comp. Univ	34	36		
44	Tehran, Comp. Univ	31	36		
45	Urmia, Comp. Univ	34	35	36	

Code	DMUS	Peers Code		
46	Yasouj, Comp. Univ	5	34	17
47	Yazd, Comp. Univ	34	36	

Discussion

This study attempted to assess the research performance of Iranian universities ranked by THE using DEA. The relationship between their overall ranking, research score, and citation score in THE and their efficiency score were calculated. The results revealed that there was a relatively high correlation between the efficiency score with the overall ranking ($r = 0.719$) and citation score ($r = 0.613$) in the Times ranking system. Salas-Velasco studied Spanish universities based on Shanghai University Ranking and the SCImago institution ranking and found that the average efficiency among Spanish universities was about 92%. His study confirmed a positive relationship between the efficiency scores of Spanish universities and their rank in Shanghai and SCImago rankings (Salas-Velasco, 2020). Therefore, our study was consistent with the finding of the above study. This implies that the DEA method can be a relatively practical method to evaluate the universities' performance. The results showed no relationship between the universities' performance and research scores in the Times Ranking System. This may be because Iranian universities have no high international reputation. So that, despite their relatively high efficiency, they had relatively poor research scores in the international systems because 18% of the 30% weight of the research index in the Times Ranking System belongs to the Reputation Survey. It implies that Iranian universities do not rank well in terms of international visibility.

The poor performance of old and main universities compared to relatively young showed that budgeting should be done according to the performance of the universities. The results of the study conducted by Mehrolohasani et al. (2019) showed that large universities did not necessarily have high efficiency in research. In this regard, Yang et al. (2018) also suggested that the performance-based budget management system be used in the budgeting of institutions. Another study, considering the funding allocated to the students as the input, emphasized that research institutes should be categorized based on the goals of the educational process (Dumitrescu et al., 2020). Thus, it can be concluded that allocating funds to research institutes should be done based on their goals and missions as well as their performance.

On the other hand, this study focused on an output-oriented model; therefore, the input would be constant while the output would continue to improve the universities' performance. In this way, inefficient universities can follow the efficient universities to get better performance.

The results indicated that technical and medical universities had better research performance than comprehensive universities; this can be due to their publishing and citation behaviour. As Noroozi Chakoli and Ghazavi (2016) normalized the indicators in different disciplines, they found that original papers had a higher weight in science, engineering, and medical sciences while in the area of humanities and social sciences, books received a higher weight.

It should be mentioned that the comprehensive, medical, and industrial universities are somehow heterogeneous; this may be a limitation of the study. According to the findings, medical and industrial universities had better international research output, and they published

more international papers, while the disciplines in the comprehensive universities may have more national productions in Persian, and their publication may be more in book formats. This study was conducted on research scores, focusing on bibliometric indicators and comparing the efficiency of universities in terms of research. Therefore, the superiority of one university over the other is only in terms of its international research efficiency and cannot be generalized to the overall performance of the universities. One of the limitations of this study was that some important indicators such as the research budget were not considered. We selected and compared Iranian universities to have a homogeneous sample, and omitting this indicator as an input variable plays no significant role in the results. We suggest that future studies consider other inputs.

Conclusion

It is critical for policymakers of higher education institutions to know how their universities are operating. According to the results, in terms of quantity and even in some quality indicators, Iranian universities had a good performance. For example, some Iranian universities received full scores in the citation index in the Times Ranking System, which shows their output impact at the international level. The relatively high efficiency of Iranian universities in this study compared with their unfavourable ranks in the Times Ranking System indicates that policymakers should pay more attention to the visibility of these universities and increase their international reputation.

The findings put forward that the size and age of a university might not necessarily be related to its rank. For example, the Babol University of Technology and Kurdistan University of Medical Sciences, despite being smaller and younger compared to some universities, were efficient in all scenarios. It can be recommended that research policymakers should adjust the budget by focusing on the universities' performance. They can also lead universities according to their capacity and employ encouraging mechanisms to have more efficient research. According to research findings, it is necessary to pay attention to the input of universities besides considering the size of universities, their publishing behaviour, citation behaviour, and subject normalizations. Therefore, the DEA technique can be used when allocating budget and resources to gain maximum efficiency.

Thus, ensuring efficiency in the management of resources has become an essential element in improving the competitiveness of universities. Therefore, research and development policymakers must be properly aware of the performance of universities and research institutes. The results of this research can help science and research policymakers and analysts to make better decisions when allocating the funds and to adjust the universities' missions based on their capacities. For example, comprehensive universities can contribute to meeting the national social needs through national outputs in Persian whereas industrial and medical universities can publish internationally and have international collaborations to improve the performance of the higher education system.

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Endnotes

1. <https://www.timeshighereducation.com/>.
2. Medical universities in Iran are classified in 3 types.

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