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DATA ANALYSIS of the TOP UNIVERSITIES in the WORLD via TOPSIS MODEL

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■Abstract

In this study, it is aimed to analyze the data of the ranking systems among the world universities and to rank them with the TOPSIS method. This study is an analysis of features and criteria of the ranking systems of world universities. Since there are dozens of different systems for ranking universities, this study focuses on the more popular systems. Considering that each of these systems has different criteria and systematics, the study is not for comparison purposes. It is possible to consider these criteria and to establish their structuring according to some of these criteria in order for the universities in Turkey, which have increased rapidly in recent years, to become compatible with the world. For universities in Turkey to rank higher, it would be beneficial to examine the characteristics of European and American universities, and then universities in the Near and Far East, such as scientific study, physical and social facilities, and the number of faculty members. Thus, each university can organize its mission and vision according to international developments.

Keywords Multi-Criteria Decision Making, Decision Support System, TOPSIS, World University, Ranking Criteria.

TOPSIS Modeli ile Dünyanın En İyi Üniversitelerinin Veri Analizi

■Özet

Bu çalışmada dünya üniversiteleri arasındaki sıralama sistemlerinin verilerinin analiz edilmesi ve TOPSIS yöntemi ile sıralanması amaçlanmıştır. Bu çalışma, dünya üniversitelerinin sıralama sistemlerinin özellik ve kriterlerinin bir analizidir. Üniversiteleri sıralamak için onlarca farklı sistem olduğundan, bu çalışma daha popüler sistemlere odaklanmaktadır. Bu sistemlerin her birinin farklı kriterleri ve sistematiği olduğu düşünüldüğünde, çalışma karşılaştırma amaçlı değildir. Türkiye'de son yıllarda hızla artan üniversitelerin dünya ile uyumlu hale gelebilmesi için bu kriterleri dikkate almak ve yapılanmalarını bu kriterlerden bazılarına göre oluşturmak mümkündür. Türkiye'deki üniversitelerin daha üst sıralarda yer alabilmesi için Avrupa ve Amerika üniversitelerinin ardından Yakın ve Uzak Doğu'daki üniversitelerin bilimsel çalışma, fiziki ve sosyal imkanlar ve öğretim üyesi sayısı gibi özelliklerinin incelenmesi faydalı olacaktır. Böylece her üniversite misyon ve vizyonunu uluslararası gelişmelere göre düzenleyebilir.

Anahtar Kelimeler: Çok Kriterli Karar Verme, Karar Destek Sistemleri, TOPSIS, Dünya Üniversiteleri, Sıralama Kriterleri

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INTRODUCTION

The progress of the nation is highly correlated with university excellence. When the top lists are analyzed, it becomes clear that these nations' universities hold the top spots. It is well known that many universities in our country are competing for a position in these lists. Universities such as METU, Bilkent, Sabancı, Istanbul Technical University and Koç University which are included in these rankings in some years, cannot be included in this ranking in some years. Ranking on this list and higher can be determined by recognizing and complying with these criteria.

There are many different systems as international or national for evaluating universities. Some of the international systems are categorized as The Times Higher Education- QS World University Rankings, Webometrics: World Universities' Ranking on the Web), Newsweek Magazine's Top 100 Global Universities of the World, Shanghai Jiaotong University World Universities, Academic Ranking of World Universities) and Google Search International University Rankings (G-Factor International University Rankings). In this study we obtained a dataset that collected value in terms of QS World University Rankings (Ismail, 2010; Catellani 2005).

We summarized some studies in the literature in releation to univerity ranking. Atici et al. (2021) aimed to reveal the connection between colleges' academic success and "becoming green." The results of their study confirmed earlier discussions on the significance of environmental sustainability policies put in place by university administrations using the sustainability ratings of institutions provided by UI GreenMetric and the four main academic ranking systems. The results revealed that being environmentally friendly affects university rankings and that environmental sustainability may give international universities a competitive edge. Perchinunno et al. (2020) claimed that the Indicators from education, research, and the environment are used in the GreenMetric World University Rankings, a global ranking of universities, to compare environmental sustainability across various campuses and assess the measures taken by academic institutions to build ecological infrastructures and encourage improvement. They analyzed in detail the GreenMetric ranking to confirm whether they are actually beneficial in evaluating the universities' sustainability. All campuses were categorized into homogeneous groups using cluster analysis based on the choice of the discovered characteristics. The findings determined the four sustainability levels and demonstrate a powerful correlation between the rankings of the various categories (transport, waste and water conservation and recycling, energy and climate change, environment and infrastructure), as well as particular criteria for assessing corporate policies. Pouris et al. (2010) proposed a citation-based ranking approach for papers conducted by universities in many scientific disciplines. In this context, their paper identified the international position of South African universities in different scientific disciplines, contrasts them with their position over time and focuses on the consequences for science and technology policy as well as higher education. Yavuz et al. (2011) conducted a literature review study that introduced the ranking systems among world universities. In their studies, they made

criticisms on the features and criteria of Ranking systems and these criteria. According to results of the study, it has been suggested that these criteria should be taken into consideration and structuring should be established according to some of these criteria in order for Turkey to become compatible with the world. Conejeroa et al. (2021) used a multi-criteria approach to rank the Vocational and Training Programs in Spain for 2009–2016, including TOPSIS and a worst-case scenario approach, compared to Pearson's well-known global sentiment analysis technique. With the help of performance indicators from the "University monitoring and assessment reports-2019" released by the Council of Higher Education Institution in Turkey, Gul and Yucesan (2022) created a model for rating universities. The Bayesian Best-Worst Method was used to weight 34 sub-criteria under five primary criteria in this situation after some of the performance criteria listed in these reports were filtered (BBWM). The TOPSIS technique is then used to rank the 189 listed public and private universities. The evaluations of 11 academic experts were joined and a weighting was applied by providing the reputation ranking of the performance criteria. Ding and Zeng (2015) used ranking preference techniques combined with TOPSIS and information entropy weight (IEW) to investigate the performance of 68 Chinese universities owned by the Ministry of Education (MOE) from 2002 to 2011. Research and development capability reflected short- and long-term performance, respectively. The ability to thrive, consisting of human and physical capital, was a key determinant that was scarcely absent from the previous assessment. The performance of universities showed that the current fiscal spending allocation mechanism in Chinese universities was unreasonable and that Chinese higher education as a whole was inefficient. Also, universities in the eastern region outperformed universities in the central and western regions, and comprehensive universities outperformed most specialist universities. In the study of Gürsev (2022) the details and features of education as Education 4.0 were examined and an effective education model was used. With the literature study, the methods have been determined because the concept of Education 4.0 was necessary. With the TOPSIS method, it was applied in the best way about the course from 4 different schools. Midodashvili et al. (2020) presented both positive and negative criteria developed to evaluate the performance of training programs. For data on the criteria, appropriate data from four higher education programs of Gori State Teaching University were used. The ratings of the programs were evaluated using the TOPSIS method. The paper also stated that it was possible to evaluate the performance of one of the training programs by using data obtained at different intervals regarding this program and thus to determined the degree of success or failure of the program by comparing the results. In the Wang et al. (2022) study, the Entropy method was used to determine the weight of the criteria. Then, TOPSIS was used to determine the ranking order of private universities. Spearman's rank correlation coefficient was then applied to evaluate the correlation between ordinal variables over the 2-year analysis selection. Finally, ANOVA was used to compare criteria between university groups. The combination of methods contributed to creating an objective environment for evaluating the performance of each university. Nagpal et al., (2015) used fuzzy TOPSIS and AHP to rank the usability of university

websites. TOPSIS method was used in different fields. Köse and Bülbül (2009), in their study on the Turkish Banking System after the 2008 global crisis, measured the financial performance of banks between 2005 and 2008 using the TOPSIS method. According to the study, they concluded that foreign banks in the Turkish banking sector were less affected by the crisis than Turkish banks. Yılmaz et al. (2016) measured the financial performance of companies operating in the foodstuffs industry using the topsis method. In the study of Supçiler and Cross (2011) quality, cost, delivery and service criteria were determined as the main criteria in order to select the most suitable supplier for a business and their sub-criteria were defined. At the end of the study, the most important criterion was determined as "quality" and "A2 supplier" was chosen as the supplier with the highest score among the existing suppliers of the enterprise.

AHP and TOPSIS methods were used together for the evaluation of service quality at airports (Tsaur, Chang and Yen, 2002), for the determination of the quality values of cotton fiber (Madumjar, Sarkar and Madumjar 2005), for developing a performance measurement model for manufacturing companies (Yurdakul and İç, 2005), for selection of the best care technology in the textile industry (Shyjith, Ilangkumaran and Kumanan, 2008), for the customer-oriented product design process (Lin, Wang, Chen, and Chang, 2008), for evaluating the service quality in the banking sector (Ustasüleyman, 2009).

In this study, we develop a data analysis about the world's top universities by TOPSIS model. In the study, we stated that the findings from TOPSIS model have parallel to the QS World University Rankings result. By this study, universities could consider the rankings to be in the list of top universities in the world.

1. METHODS and MATERIALS

1.1. QS World University Rankings

This ranking system, prepared jointly by the British Times Magazine and Quacquarelli Symonds, publishes the THES-QS World University Rankings annually. Times Magazine started this type of ranking study in 2003 to identify universities with better opportunities. Education across borders has become an inevitable reality of today, as higher education for students now depends on education at the best universities and satisfactory job opportunities (THS-QS, 2022).

1.2. Sorting Criteria and Weights

THES-QS evaluates world universities according to four basic criteria: quality of scientific research, employment rate of graduates, international reputation and quality of education.

For each criterion, the university in the best condition is given 100 points, and according to this score, the scores of other universities are calculated as a percentage of the highest score. The scores in each criterion are determined by making the total score to be calculated according to the weights.

University rankings are determined by ranking the calculated scores from the largest to the smallest (THS-QS, 2022).

This survey is a necessity for scoring, and some of the questions asked in the survey are not used in scoring but are still reported on the internet. Apart from university surveys, THES also conducts surveys of university graduates who find employment and employers who employ them. In addition to these, information about universities is collected with the help of referees who do not know what the purpose is. For the number of published scientific articles and citations, THES has been using the Scopus Database since 2007 instead of the ISI Web. In the query made in the Scopus Database, in order to scan the name of the university to be scored, the names of the university and the faculty members working at that university are scanned, taking into account all the different nomenclature.

1.3. TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) Method

The TOPSIS method is one of the MCDM method to deal with the problem in complex and uncertain situations, was improved by Hwang and Yoon in 1981 (Hwang and Yoon). A fundamental basis of the TOPSIS approach is that the better the alternative, the further away from the alternative pessimistic ideal solution and the closer to the alternative optimistic ideal solution. At the focus of the method, it is a system that is established without deciding on the closest and farthest alternatives to the result. The method basically consists of two separate points, the positive ideal point and the negative ideal point. By ordering the alternatives between these two decision points, values between 0-1 are calculated and these values are defined as the criterion weight points. While the positive ideal point indicates the optimal point, that is, the point that should be selected, the negative ideal solution point can be interpreted as the non-optimal most distant cost point. In the method, the positive ideal solution is represented as "1" and the negative ideal solution point is represented as "0". Decision points take values between these two points, when they get values of 1 or 0, they are considered as the highest and lowest points. The results calculated between these two values are called the closeness coefficient. The close coefficients are ordered from the largest to the smallest, and then the choice is made (Zhang and Dai, 2022).

The 6-step TOPSIS approach is divided into these steps. Below is the description of the steps of the TOPSIS method:

- Determination of alternatives and criterion weights
- Creation of normalized and weighted decision matrix
- Decision of Positive ideal point, Negative ideal point solutions
- Determination of discrimination criteria
- Calculation of the solution's proximity to perfection
- Sorting and choosing

The steps are as follows (Zhang and Dai, 2022):

Step 1: Creating the Decision Matrix (A)

The performance value of each alternative is expressed in the form of a matrix by specifying each criterion. While the columns of the decision matrix consist of criteria, the rows consist of the alternatives to be ranked. *m* indicates the number of decision points and *n* indicates the number of assessment factors(criteria) in the A_{ij} matrix.

The decision matrix is shown as below:

$$A_{ij} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ . & . & \cdots & . \\ . & . & \cdots & . \\ . & . & \cdots & . \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix}$$

(1)

Step 2: Creating the Standard Decision Matrix (R)

The components of the matrix Aij are used to generate the normalized decision matrix represented as R_{ij} using the formula below:

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} a_{kj}^2}} \tag{2}$$

the representation of the matrix is as follows:

$$R_{ij} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ . & . & \cdots & . \\ . & . & \cdots & . \\ . & . & \cdots & . \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \tag{3}$$

Step 3: Weighting the Normalized Decision Matrix

$$\sum_{j=1}^{n} w_j = 1 \tag{4}$$

The weight values (w_j) of the criteria are first calculated. After that, to create V_{ij}, each column of the R_{ij} matrix's elements is multiplied by the matching w_j value.

$$V_{ij} = \begin{bmatrix} w_i r_{11} & w_i r_{12} & \cdots & w_i r_{1n} \\ w_i r_{21} & w_i r_{22} & \cdots & w_i r_{2n} \\ . & . & \cdots & . \\ . & . & \cdots & . \\ . & . & \cdots & . \\ w_i r_{m1} & w_i r_{m2} & \cdots & w_i r_{mn} \end{bmatrix} \tag{5}$$

Step 4: Identifying Ideal and Negative Ideal Solutions

The positive-ideal solution (A*) and negative-ideal solution (A-) are determined according to the weighted normalized values. Calculating the ideal solution set is indicated in the following equations:

$$A^* = \left\{ (\max_i v_{ij} \middle| j \in J), (\min_i v_{ij} \,|j \in J' \right\} \; A^* = \{v_1^*, v_2^*, \dots, v_n^*\}$$
$$A^- = \left\{ (\min_i v_{ij} \middle| j \in J), (\max_i v_{ij} \,|j \in J' \right\} \; A^- = \{v_1^-, v_2^-, \dots, v_n^-\} \quad (6)$$

J' stands for the benefit (maximization) and loss (minimization) values in both formulations. The solutions of both the positive ideal and negative ideal points calculate the states of the specified criteria.

Step 5: Calculation of Discrimination Measures:

The n-dimensional Euclidean Distance Approach is used to calculate the distance between options. Each alternative's distance from the positive-ideal solution is determined as (S_i^*), while its distance from the negative-ideal solution is calculated as (S_i^-). The equation is indicated as follows:

$$S_i^* = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^*)^2}$$
$$S_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2} \quad (7)$$

Step 6: Calculating the Relative Closeness to the Ideal Solution

The percentage of the negative-ideal discrimination measure in the total discrimination measure that each alternative is related to the ideal solution (C_i^*), as determined by the positive-ideal and negative-ideal discrimination measures as follows:

$$C_i^* = \frac{S_i^-}{S_i^- + S_i^*} \quad (8)$$

1.4. Dataset

The QS World University Rankings® 2023 dataset based on 8 key ranking indicators of top universities from around the world, including nearly 1,500 institutions from various universities in Europe, Asia and North America, was obtained from the publicly available Kaggle website1. The variable in the dataset is indicated in Table 1.

[1] https://www.kaggle.com/datasets/jkanthony/world-university-rankings-202223

Table 1. Variable Names in Dataset

Ranking Definition	Variable Names in Dataset
Academic Reputation	ar rank
Employer Reputation	er rank
Faculty Student Ratio	fsr rank
Citations per faculty	cpf rank
International Faculty	ifr rank
International Student	isr rank
International Research Network	irn rank
Employement Outcome	ger rank

1.5. Data Visualization

The distribution of the univeristies in the world is presented in Figure 1.

Figure 1. Distribution of the Universities in the World.

In Figure 2, we indicated the number of universities in each country.

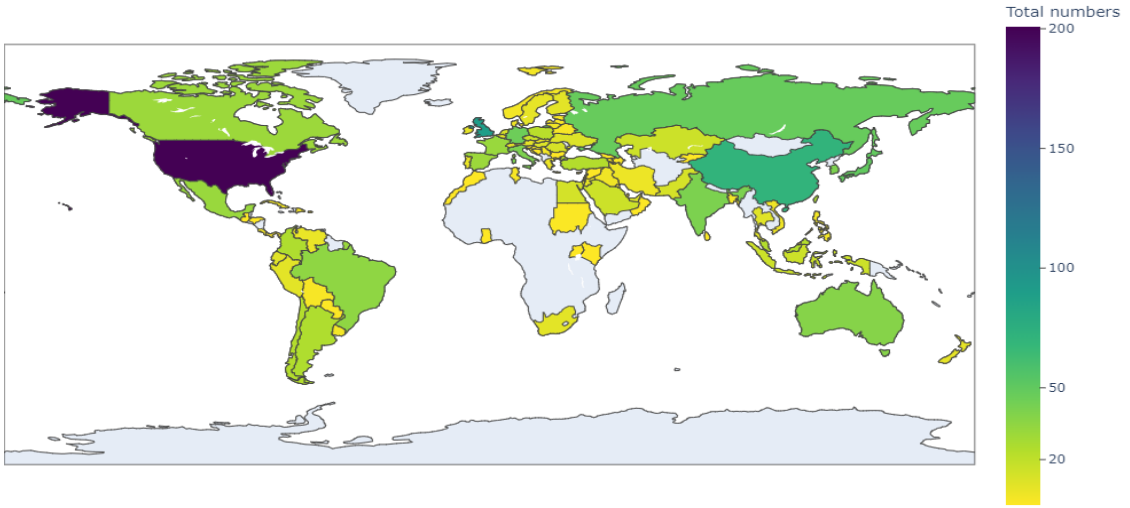

Figure 2. Total Number of Universities in Each Country.

US leads with 201 universities. Then UK, China, Japan, Russia, India, South Korea, Italy and North Korea has 90, 71, 50, 48, 41, 41, 38 respectively. Turkey has 34 universities.

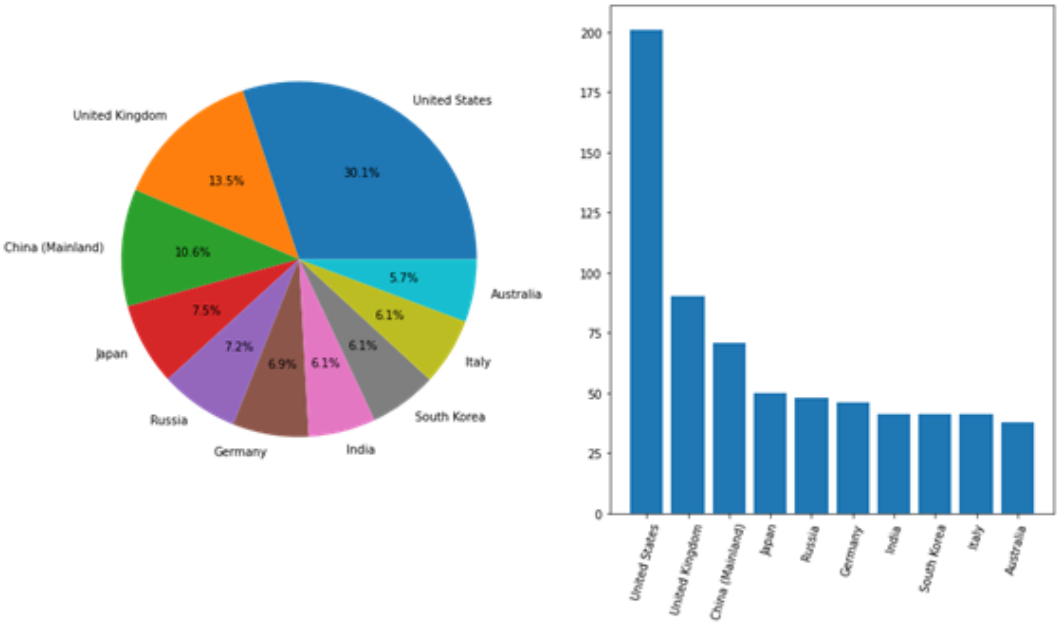

Figure 3. Top 10 Countries in QS Rankink List

Figure 3 illustrates the top 10 countries in QS Ranking list. Universities in the US are 30.1%, followed by the UK with 13.5%, and followed by China with 10.6%.

1.6. RESULTS OF TOPSIS MODEL

In this study conducted with the TOPSIS model, the data were obtained from a public platform. After preprocessing the data, the TOPSIS model was applied to the data set containing the world university rankings, and the best university ranking was realized. The results obtained are in parallel with the results of the QS ranking system, that is, the TOPSIS model approves the ranking system. 8 criteria and world university alternatives were used in the study. According to the TOPSIS results, first

the top 10 universities, then the middle ranked 10 universities and finally the last 10 universities are presented graphically. Figure 4 shows the sample matrix for dataset after normalization.

	Ar Puanı	Er Puanı	Fsr Puanı	Cpf Puanı	İfr Puanı	İsr Puanı	İrn Puanı	Ger Puanı
Massachusetts Institute of Technology (MIT)	0.087546	0.084259	0.066443	0.073195	0.059128	0.059976	0.044913	0.073398
University of Cambridge	0.087546	0.084259	0.066443	0.067559	0.059128	0.064174	0.046502	0.073398
Stanford University	0.087546	0.084259	0.066443	0.073122	0.059010	0.040184	0.045006	0.073398
University of Oxford	0.087546	0.084259	0.066443	0.065876	0.058419	0.065573	0.046689	0.073398
Harvard University	0.087546	0.084259	0.066044	0.073195	0.045470	0.044582	0.046736	0.073398
California Institute of Technology (Caltech)	0.084482	0.073390	0.066443	0.073195	0.059010	0.056710	0.034117	0.072517
Imperial College London	0.086058	0.084006	0.066111	0.063314	0.059128	0.066640	0.045848	0.065177
UCL	0.087021	0.083079	0.064848	0.056360	0.058655	0.066640	0.046736	0.066278
ETH Zurich - Swiss Federal Institute of Technology	0.086320	0.076928	0.049301	0.072610	0.059128	0.065307	0.044960	0.066866
University of Chicago	0.086845	0.077687	0.061726	0.063534	0.048249	0.050646	0.041875	0.072077
National University of Singapore (NUS)	0.087108	0.079288	0.053022	0.067193	0.059128	0.048980	0.042015	0.073104

Figure 4. Example Matrix From Dataset After Normalization

In Turkey there are 24 universities. Top 5 University is shown on the Figure 5. METU, Bilkent University, Sabancı University, Istanbul Technical University and Koç University have the higher ranking than orther universities in Turkey.

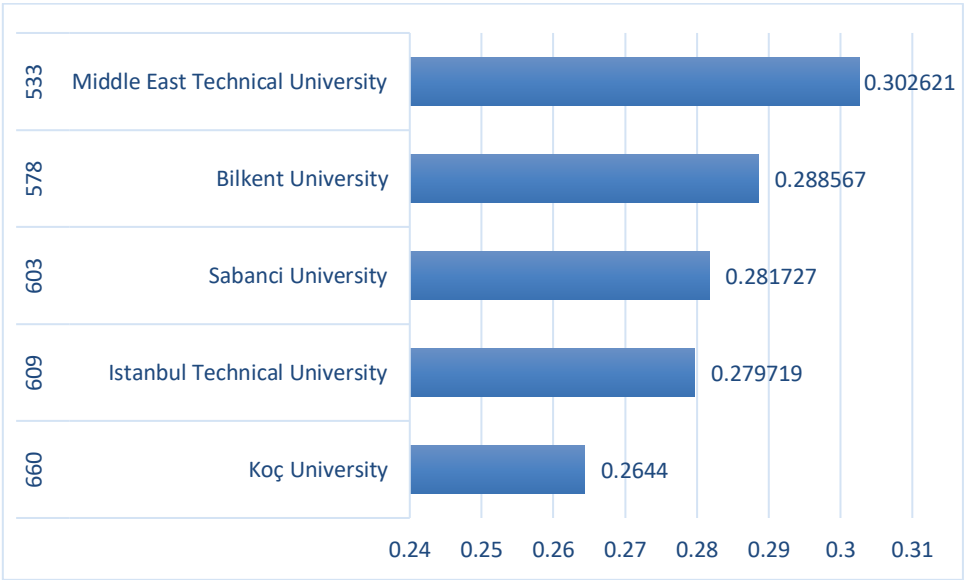

Figure 5. Top 5 Universities in Turkey

The Top 10 universities in the World are indicated in Figure 6. When we examine the universities in the World, University of Cambrigde has the highest criteria values with 0,9694, and then MIT follows with a slighltly low value vith 0,9658 and University of Oxford obtained 0,9632, Imperial College London is fourth with 0,9336 and UCL has 0.9111 value.

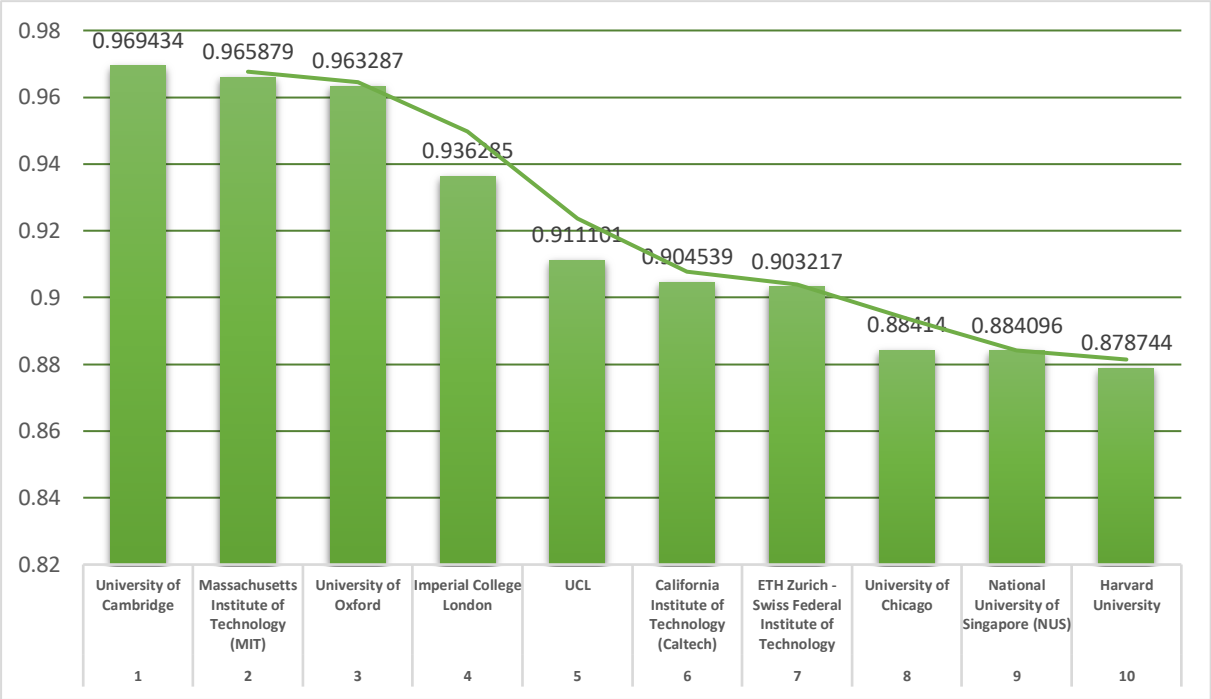

Figure 6. Top 10 University Rankings

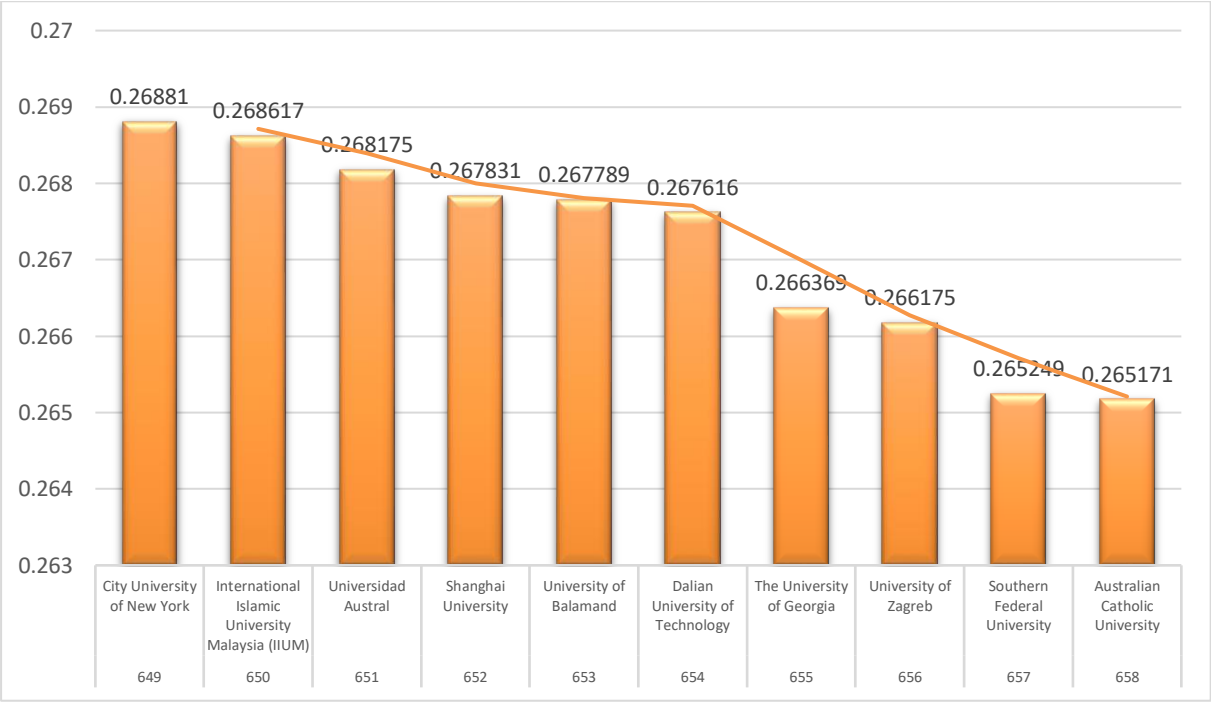

Figure 7. Universities in the Middle Rankings.

Findings from Figure 7 show that City of University is ranked 649th with a criterion weight of 0.2688. The International Islamic University Malaysia is ranked 650th with a weight of 0.2686 criteria. Universidad Austral with a criterion weight of 0.2681 is in the 651st rank, and Shanghai University with a weight of 0.2678 criteria is seen in the 652nd rank.

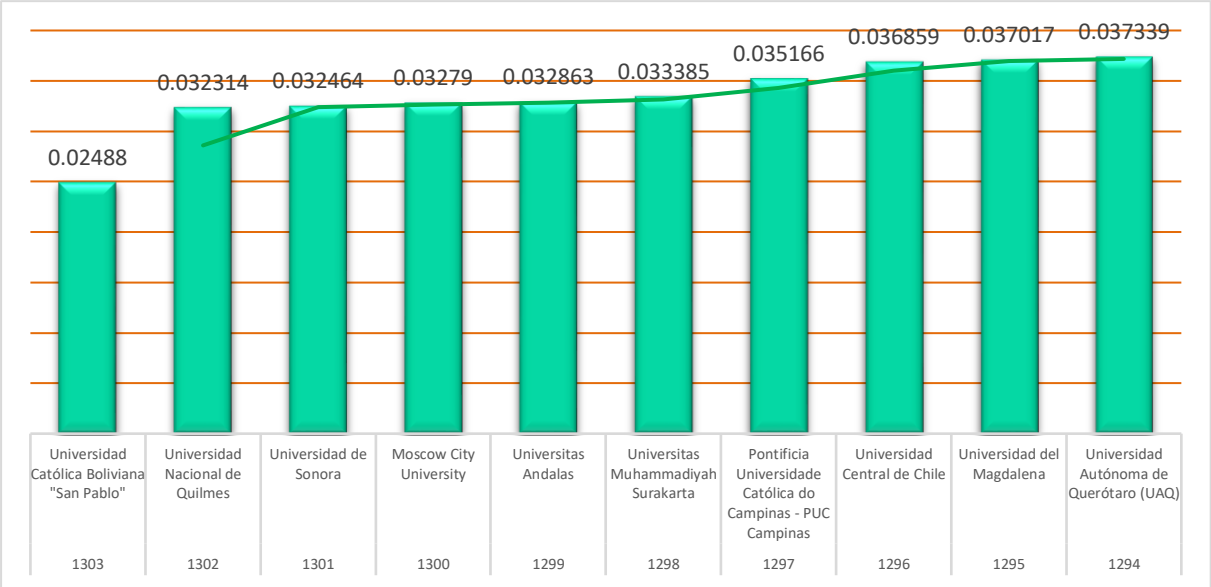

Figure 8. Universities in the Last 10 Rankings.

Figure 8 presents the last 10 universities in ranking. Universidad Católica Boliviana "San Pablo" is the lowest ranked university with a criterion weight of 0.024. It is followed by Universidad de Sonora, Moscow City University and Universitas Andalas.

CONCLUSION

In this study, publicly available dataset is obtained about World university ranking. In order to find the most highest values from the universites, we conducted TOPSIS model which is among the multi-criteria decision making methods. The findings from the data analysis, TOPSIS model orders the university rankings in parallel to QS Ranking model.

We presented the top 10, middle 10 and last 10 universities in the ranking. It is seen that the rankings made to determine the best for world universities have an important contribution in terms of revealing what the performances of universities mean at the international level, and also revealing the weaknesses and strengths of these universities. Despite the criticism of these ranking systems, most of the top universities in the world are related in taking the necessary actions to find these rankings significant and to find themselves in the top rankings. If a university wants to be at the top of the rankings, it should make the necessary arrangements based on the evaluation criteria of the mentioned ranking system and the weights of the relevant criteria. Thus, it can succeed in becoming a quality higher education institution and gain the prestige it deserves in the international arena as a product of its studies.

The study aims to help universities optimize their performance efficiently. The results of the study can be adapted as a reference in efforts to evaluate and improve the performance of universities and to formulate various policies.

In future studies, other multi-criteria decision making methods can be used instead of TOPSIS method. The cluster method can be applied to precisely group the locations of universities. In addition,

criteria that affect the selection criteria of universities can be found by conducting a questionnaire to university students. In addition, universities may combine self-evaluation reports to select robust data with new metrics in future research.

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