Ampirik Araştırma / Original Empirical Research

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Ranking Turkish Public Universities by Percentile Rank Based EWM–VIKOR Method

Yüzdelik Sıralama Tabanlı EWM – VIKOR Yöntemi ile Türkiye'deki Devlet Üniversitelerinin Sıralanması

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Abstract

The aim of this study is to evaluate and rank the performance of state universities in Türkiye based on the criteria provided in the 2023 Higher Education Council (YÖK) University Monitoring and Evaluation Report. To achieve this objective, a general ranking, as well as rankings for each of the four main categories ("Education and Training", "Research and Development, Projects, and Publications", "Internationalization", and "Social Responsibility"), were conducted. A total of the 56 criteria listed under these main categories are taken into account. We normalized the decision matrix using the percentile rank method, and then, applied the Entropy Weighting Method (EWM) to weigh the criteria. Later, we used the well-known VIKOR method for ranking. This study suggests to use of the percentile rank method for normalizing the decision matrix to overcome the limitations of EWM, which disregards ranking-based differences and only considers numerical differences, potentially leading to incorrect weighting or misinterpreting the importance of criteria when there are numerous zero values in the decision matrix. The study concluded that no single public university outclasses in all categories. Different universities demonstrated high performance in different categories. Hence, this study aims to serve as a guide in the evaluation and ranking of the performance of higher education institutions in terms of its methodology and results.

Keywords: Entropy Weighting Method, Higher Education Ranking, Multicriteria Decision Making, Percentile Rank, VIKOR

Özet

Bu çalışmada 2023 yılı YÖK (Yüksek Öğretim Kurulu) Üniversite İzleme ve Değerlendirme Raporu'nda yer alan kriterleri göz önüne alınarak Türkiye'deki devlet üniversitelerinin performansları değerlendirilmesi ve sıralanması amaçlanmıştır. Bu amacı gerçekleştirmek için raporda yer alan dört ana gösterge ("Eğitim ve Öğretim", "Araştırma-Geliştirme, Proje ve Yayın", "Uluslararasılaşma", "Topluma Hizmet ve Sosyal Sorumluluk") altında verilen 56 kriter esas alınarak genel bir sıralama ile birlikte, her bir ana gösterge için sıralama yapılarak toplam beş adet sıralama gerçekleştirilmiştir. Çalışmada karar matrisi oluşturulduktan sonra yüzde sıralaması (percentile rank) yöntemi ile normalleştirilerek kriterlerin ağırlıklandırılmasında Entropi Ağırlık Yöntemi (EWM), sıralama için ise VIKOR yöntemi uygulanmıştır. EWM sıralama tabanlı farklılıkları göz ardı edip nicel farklılıkları göz önüne aldığından dolayı ve karar matrisinde çok sayıda sıfır değeri yer aldığında kriterlerin önemlerini yanlış ağırlıklandırabildiği için bu sorunların üstesinden gelebilmek adına bu çalışmada yüzde sıralaması (percentile rank) yöntemi ile karar matrisinin normalleştirilmesi önerilmiştir. Çalışma sonucunda herhangi bir devlet üniversitesinin tüm alanlarda üstün olmadığı, farklı kategorilerde farklı üniversitelerin başarı performanslarının yüksek olduğu sonucuna varılmıştır. Bu çalışma, yöntemi ve sonuçları itibariyle yüksek öğretim kurumlarının performanslarının değerlendirilmesi ve sıralanmasında bir rehber olmayı gözetmektedir.

Anahtar Kelimeler: Entropi Ağırlık Yöntemi, Yükseköğretim Sıralaması, Çok Kriterli Karar Verme, Yüzde Sıralaması, VIKOR

Over the last two decades, universities in Türkiye have undergone significant transformation and growth. The number of universities has increased substantially, with the establishment of numerous new public and private universities across the country. This expansion has been accompanied by significant investments in infrastructure, research facilities, and academic resources, aimed at enhancing the overall quality of education. There has been also a notable increase in the variety of academic programs and disciplines offered that meet a broader range of student interests and industry needs. Efforts to internationalize higher education have also gained momentum, with many universities establishing partnerships with foreign institutions, and increasing student and faculty exchange programs. These developments have not only increased

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access to higher education for a larger segment of the population but have also improved the global standing and competitiveness of Turkish universities. Furthermore, the emphasis on research and innovation has led to a rise in scientific output, contributing to the country's socio-economic development and positioning Türkiye as a significant player in the global academic arena.

Between 2002 and 2024, the number of state universities in Türkiye has increased from 51 to 129, while the number of private universities has risen from 23 to 79 (four of which are vocational high schools). Number of bachelor students also increased from 1,46 million to 3,75 million. As the number of universities increased, the number of academicians also increased more than double from 74.134 to 184.021 (Yükseköğretim Kurulu, n.d.).

Despite these advancements, challenges such as ensuring consistent quality across institutions, fostering academic freedom, and enhancing the employability of graduates remain areas for continuous improvement. To identify areas needing enhancement and to support university operations while assessing their performance, The Council of Higher Education (YÖK) in Türkiye has been regularly conducting the "University Monitoring and Evaluation Report" study since 2019 (Yükseköğretim Kurulu, 2023). The "University Monitoring and Evaluation Report" focuses on key areas such as scientific production, academic performance, university-industry collaboration, R&D, internationalization, public service, sustainability, and social responsibility. Five major categories are used to organize these areas: "Education and training", "R&D, academic projects and publications", "internationalization", "social responsibility", and "sustainability". The sustainability category has been included for the first time as a main category as of 2023. In addition to the sustainability category, new indicators have also been added to other main categories as well, and some existing indicators have been removed or combined in 2023. Eventually, data are collected from universities according to 69 indicators under 5 main categories.

The YÖK underscores that the main goal of these annual reports is not to evaluate universities hierarchically but to identify and support the areas of the universities for improvement (Yükseköğretim Kurulu, 2023). Therefore, YÖK does not publish a higher education ranking based on multicriteria rather, they evaluate the best universities for every sub-criteria each year.

The YÖK collects mandatory data (if available) from universities for the report and evaluates them using this data and does not aim to rank them. This mandatory participation forces universities to measure their performances on various aspects, moreover, if there is a metric that they are unable to measure, they realize that this negatively impacts their overall performance, prompting them to ensure they measure it in the next period. Hence, the report produces valuable data not only to assess universities' performances through time but also to provide opportunity to rank them to compare their performances relatively.

Higher education rankings have become an indispensable tool in the landscape of higher education, serving multiple functions for a diverse array of stakeholders. These rankings offer a comparative evaluation of universities according to several factors, including employability, research output, academic prestige, and teaching quality. They provide accountability and openness in higher education, assist academic institutions in measuring their performance and strategic planning, and assist parents and prospective students in making well-informed judgments about which universities to attend. Rankings also influence policy and financing decisions, allow governments to observe whether their investments deliver world-class education, promote university competitiveness and quality enhancement, and support global recognition and reputation. This versatile tool emphasizes how crucial it is to comprehend and apply higher education rankings to promote a culture of quality and innovation in higher education (Johnes, 2018).

Various ranking systems are used to evaluate the performance and quality of universities. Three popular world rankings are The Times Higher Education (THE), The QS World University Rankings, and The Academic Ranking of World Universities (ARWU). The criteria used in these rankings include academic reputation, research outputs, teaching quality, international visibility, and industry income. Universities typically volunteer to participate in these rankings and provide data to the ranking organizations. Due to the voluntary participation of universities in these rankings, it is not possible to evaluate the performance of some institutions, externally.

There are also several ranking systems used to evaluate the performance of universities in Türkiye. One of these is the University Ranking by Academic Performance (URAP) system. URAP ranks universities solely based on academic performance, using criteria such as the number of articles, citations, and the quality of scientific publications. The URAP rankings aim to objectively assess the academic productivity of universities, particularly focusing on their scientific outputs.

In addition, the Entrepreneurial and Innovative University Index, prepared by TÜBİTAK, is another important ranking system in Türkiye. This index evaluates universities based on their entrepreneurship and innovation capacities, considering factors such as intellectual property rights, innovative projects, industry collaborations, and activities of incubation centers. The Entrepreneurial and Innovative University Index measures not only the academic productivity of universities but also their innovation and societal impact.

These rankings also align with the goal of the broader global rankings such as THE, QS World University Rankings, and the ARWU, to assess university performance.

Higher Education rankings are criticized for several reasons. The first argument is that metrics used in these rankings measure what is easily quantifiable rather than what is important, ignoring intangible qualities like creativity and resilience. This overemphasis on quantity encourages the academicians to prioritize quantity over quality, leading to a decline in educational quality, and undermining the importance of teaching (Jódar & De la Poza, 2020). Moreover, university administrations are willing to climb the league tables by altering their behaviors based on the ranking reports are worrying about where they should be developing social priorities (Johnes, 2018). Although higher education rankings encourage transparency so that a university can identify its strengths and weaknesses because the data are mostly provided by the universities themselves, they are also open to potential manipulation (Johnes, 2018).

Some argue that they are prone to bias and inconsistencies (Fauzi et al., 2020). They are also criticized for not being representative of the university's main goals for only focusing on teaching, and publication by neglecting other important aspects of universities such as social responsibility or sustainability (Gadd, 2021). There is also ongoing methodological dispute arguing which indicators to use or to neglect, how to determine the criteria weights, or which method to use for ranking (Bookstein et al., 2010), (Hou & Jacob, 2017), (Fauzi et al., 2020) At this point, we believe that the criteria used in the University Monitoring and Evaluation Report may serve as guidance to non-Turkish universities.

Therefore, it is essential to develop an effective performance evaluation mechanism that can offer accurate information for both universities and relevant educational institutions. Such a mechanism can significantly enhance the performance, decision-making processes, and adaptability of Turkish universities. Consequently, the objective of this study is to establish a comprehensive performance evaluation system and to create a robust mechanism that accurately assesses the performance of Turkish universities across multiple dimensions, including education, research, internationalization, social responsibility, and sustainability. Therefore, we aim to utilize the evaluation system to pinpoint specific areas where universities need enhancement, providing targeted insights and recommendations to help institutions improve their quality and performance.

The second objective of the study is to incorporate the percentile rank methodology into the entropy weighting method to assess the effectiveness of the percentile rank normalization technique in enhancing the reliability and interpretability of decision models within MCDM methods.

The structure of the article is organized as follows. Section 1 provides a comprehensive literature review on multicriteria decision-making methods employed in higher education rankings. In Section 2, we delve into the methodologies applied in our empirical study, offering a detailed explanation of each method. Section 3 is dedicated to presenting and elucidating the data and criteria utilized in the study, ensuring a clear understanding of the parameters involved. In Section 4, we showcase the findings from our empirical analysis, discussing the results and their implications. Finally, the last section concludes the article by summarizing the key findings and their significance, providing insights for future research and practical application.

MCDM Methods in Higher Education Rankings

Many higher education ranking studies have been conducted for various purposes. Some of these studies focus on certain aspects of university performance such as research, student preferences (Ayyildiz et al., 2023; Kabak & Dağdeviren, 2014), student satisfaction (Castro-Lopez et al., 2022; Polatgil & Güler, 2024; Thomas, 2024), sustainability (Alshuwaikhat & Abubakar, 2008; Arora et al., 2020; Burmann et al., 2021; López, 2023), entrepreneurship and innovation (Elevli & Elevli, 2024; Er & Yıldız, 2018; Kiani Mavi, 2014), while others aim to create an overall ranking by considering multiple disciplines (Aliyev et al., 2020; Gul & Yucesan, 2022; Wu et al., 2012).

Some multi-criteria decision-making (MCDM) studies on higher education rankings prefer subjective weighting (Ayyildiz et al., 2023; Castro-Lopez et al., 2022; Gul & Yucesan, 2022; Kabak & Dağdeviren, 2014), while others opt for objective weighting (Burmann et al., 2021; Elevli & Elevli, 2024; Wang et al., 2022), and also some adopt a combinative approach (Polatgil & Güler, 2024). The AHP method, which is a subjective weighting method, is the most frequently used method in higher education research (Yüksel et al., 2023).

In most studies, criteria are often determined based on the expert opinions of researchers. Weighting criteria based on expert opinions of researchers is very common in literature. This approach is subject to the subjective judgments of individuals (Singh & Pant, 2021). They are preferred because the data is easily accessible. This reliance on expert judgment introduces a certain level of bias into the ranking process. Additionally, some studies criticize the methodologies of prestigious rankings periodically published at national or international levels, such as THE, QS, ARWU, and GreenMetric, and propose alternative methods for criteria selection, weighting, or ranking (Billaut et al., 2010).

There have been other studies done based on the University Monitoring and Evaluation Report (Gul & Yucesan, 2022), (Keleş et al., 2020). Keleş et al. (2020) compared the performances of different methods (namely MAUT, EDAS, ROV, TOPSIS, MOORA, and MAIRCA) by

assigning equal weights to all criteria considered. On the other hand, Gul & Yucesan (2022) introduced a novel hybrid method combining the Bayesian BWM method to determine the criteria weights, which is a subjective weighting method based on expert opinion, and well-known TOPSIS to rank the universities. They identified the "R&D, Projects, and Publications" category as the most important criterion whereas "Social Responsibility" was deemed the least important category. Although these studies present comprehensive approaches to evaluating university performances by comparing different methods or bringing novel hybrid methods, they have some drawbacks. Because Keleş et al. (2020) investigates how different ranking methods influence the overall ranking of the universities, they assume that all the criteria have equal weights. This assumption is made because no specific weights were provided during the original reporting process. However, as it was mentioned in their reports, YÖK does not aim to evaluate the performances of universities and rank them based on multi-criteria approaches. Therefore, no specific weights were assigned to criteria but it does not necessarily mean that all criteria have equal importance.

On the other hand, in their study, Gul & Yucesan (2022) weighted criteria based on expert opinions. As it is well known that as the number of criteria increases it is hard to evaluate or compare them consistently to assign weights especially when they belong to different disciplines (Pamucar et al., 2018, p. 4; Zhu et al., 2015, p.409). Therefore, we find it more useful to assign criteria weights according to objective weighting methods.

A variety of MCDM tools have been used in the literature for the purpose of higher education rankings. Most of the studies prefer hybrid models. According to Yüksel et al. (2023), the Analytical Hierarchical Process by Saaty (2008) is the most frequently used method in MCDM studies in higher education. Table 1. displays a review of the literature regarding MCDM methods used for higher education rankings. These studies collectively demonstrate the value of multi-criteria decision methods in providing a more robust and tailored approach to evaluating university performances.

Methodology

This section explains the incorporated methodologies of the Entropy Weighting Method for criteria weighting and the well-known VIKOR for ranking. It also explains percentile rank methodology. The proposed methodology is conceptualized in the following subsections.

Percentile Rank

Normalization is essential in multicriteria decision-making (MCDM) methods to ensure fair and unbiased comparisons across diverse criteria. By transforming different units and scales into a common scale, normalization eliminates the influence of any single criterion dominating due to its numerical range. It facilitates meaningful aggregation of criteria scores and ensures that weights applied to criteria reflect their true importance. This process enhances the interpretability and consistency of decision models, making the evaluation and comparison of alternatives more reliable and understandable for decision-makers.

One method to overcome the aforementioned problem in a dataset is the percentile rank method. A percentile rank of a score is the percentage of the values that are lower than that particular score in its frequency distribution (Roscoe, 1969, p. 18). The main idea behind the percentile rank is that a score can be significantly enhanced by expressing it in units that reflect its relationship to other scores within the distribution. A score gains significance only through its comparison to other scores, highlighting the behavioral sciences' focus on individual differences (Roscoe, 1969, p. 17).

Percentile rank (PR) of a given score in a frequency distribution may be calculated by the formula:

$$PR = \frac{CF' + (0.5 \times F)}{N} \times 100 \qquad (Eq.\ 1)$$

Here, CF' is the count of all scores that are less than the given score, F is the frequency for the score of interest and N is the number of scores in the distribution. The percentile rank values obtained from each raw score using this formula range from greater than 0 to less than 100 ($0 < PR < 100$). Thus, in the new frequency distribution, all values will be positive. Therefore, the percentile rank is an ideal data transformation method for ranking and weighting methods that work exclusively with positive values such as MEREC (Keshavarz-Ghorabaee et al., 2021).

Although other normalization techniques such as min-max, z score, or log transformation reduce the data in a specified range they may not cope with outliers, remove the skewness in the data or they may equate some scores to zero. However, if there are several numbers of scores in the distribution, percentile rank produces a uniform distribution which eliminates the skewness. This is especially useful when calculating criteria weights objectively by the entropy weight method. When evaluating the criteria subjectively, one simply ignores the data and evaluates the in-between criteria importance based on their expert knowledge. However, the aforementioned frequent problems in the data directly impact the relative importance of criteria. Therefore, they must simply be removed.

Entropy Weight Method

Criteria weighing methods are categorized into three groups: subjective, objective, and combinative. The subjective approach is the most commonly used among MCDM studies (Singh & Pant, 2021). Subjective criteria weighing methods (e.g. Analytical Hierarchy Process, Best Worst Method, Delphi Method, Analytic Network Process,

etc.) ask decision-makers to take responsibility for assigning weights to the criteria. In contrast, objective methods (e.g. Entropy, CRITIC, MEREC, etc.) use mathematical algorithms, eliminating the need for decision makers' consultancy. The combinative approach, on the other hand, reconciles subjective and objective approaches (Ayan et al., 2023; Singh & Pant, 2021). Although subjective weighing methods are widely used, their efficiency decreases as the numbers of criteria increase because it becomes more difficult for decision-makers to be consistent when expressing their preferences (Keshavarz-Ghorabaee et al., 2021). This is the main motivation of this study to choose an objective weighing methodology because there are more than 50 criteria in "The University Monitoring and Evaluation Report".

The Entropy method is a widely used objective weighting technique in multi-criteria decision-making (MCDM) that assesses the relative importance of each criterion based on the diversity of information provided by the decision matrix. This method leverages the concept of entropy from information theory to determine the weights of criteria, ensuring an unbiased evaluation process (Shannon, 1948).

Although numerous studies have utilized entropy to calculate weights, this method has certain limitations. Zhu et al. (2020) identified two major issues regarding the entropy weight method (EWM). Firstly, the presence of many zero values in the data can lead to weighting less significant criteria disproportionately higher. To solve this problem, they suggested an alternative normalization method rather than the ordinary standard normalization technique used in EWM. Secondly, Zhu et al. (2020) underscored that EWM focuses on numerical differences, ignoring rank-based differences, which may misrepresent the true importance of criteria in certain decision-making contexts. They suggested a potential solution for this theoretical problem which is incorporating new variables that represent rank discrimination degree into the weighting process.

In order to overcome the aforementioned problems that are inherent in EWM we propose to incorporate percentile rank transformation into the normalization step of the decision matrix. This will provide all variables having positive values and incorporate rank-based distances into the weighting process.

The steps to apply the Entropy Weighting Method are as follows:

1. **Construct the Decision Matrix:** Given a set of m alternatives $(A_1, A_2, \dots, A_m)$ and n criteria $(C_1, C_2, \dots, C_n)$ a decision matrix wherein a_{ij} represents each element corresponding to the alternative A_i with respect to criterion C_j.
2. **Normalize the Decision Matrix:** Decision matrix is normalized according to percentile rank method where p_{ij} represents the **i**. alternative's performance with respect to criterion j:

$$p_{ij} = \frac{CF' + (0.5 \times F)}{N} \times 100 \qquad (Eq.\ 2)$$

3. **Calculation of the index's entropy:** The entropy for each criterion *j* is calculated using the normalized values where $k = 1/ln(m)$ is a constant that ensures ranges between 0 and 1.

$$e_j = -k \sum_{i=1}^{m} p_{ij}\, ln(p_{ij}) \qquad (Eq.\ 3)$$

4. **Degree of Diversification:** The degree of diversification for each criterion *j* is calculated as:

$$d_j = 1 - e_j \qquad (Eq.\ 4)$$

5. **Compute the Criteria Weights:** The weight for each criterion *j* is determined by normalizing the degree of diversification:

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \qquad (Eq.\ 5)$$

VIKOR

In this study, the VIKOR (Vise Kriterijumska Optimizacija I Kompromisno Resenje) methodology is employed to evaluate the overall performances of Turkish universities. Developed by Opricovic (1998), VIKOR is designed to identify a compromise solution that provides a balance between conflicting criteria, which is essential for practical decision-making. VIKOR is effective in situations where different alternatives need to be evaluated based on multiple criteria, and there is a need to balance conflicting goals. It especially aids decision-makers when they are not able to state their preferences coherently in the early stages of the system design (Opricovic & Tzeng, 2004). VIKOR is specifically preferred when there are conflicting goals in the context of decision-making meaning that improving one aspect of the performance may have a negative impact on another. In the case of higher education ranking this is also relevant because aiming to maximize social responsibility, for example, may have adverse effects on some other aspects such as research output or internationalization. VIKOR balances such conflicts and avoids favoring any criterion disproportionately at the expense of others. Therefore, VIKOR is considered a multi-criteria optimization for complex systems (Opricovic & Tzeng, 2007)(Nisel, 2014) (Mardani et al., 2016). Despite its ability to overcome the aforementioned problems, VIKOR has some disadvantages as well. It depends on the value of (weight of decision-making strategy) which may have a significant impact on the final rankings and there is little guidance for the selection of this parameter therefore this is typically set to 0.5 (Taherdoost & Madanchian, 2023).

VIKOR was applied several times for MCDM problems regarding university-related rankings. Nisel (2014) applied Extended VIKOR to rank online graduate programs from 20 U.S. universities based on 5 criteria and found that VIKOR

provides remarkably successful results. Ömürbek et al. (2014) applied TOPSIS and VIKOR to rank 10 universities in Türkiye (namely ADIM universities) based on 21 criteria. Ayyildiz et al. (2023) et al. proposed a novel hybrid MCDM approach by incorporating clustering methodology with VIKOR and evaluated Turkish universities according to students' perspectives based on teaching and research quality (Wu et al., 2012) also used the AHP-VIKOR approach to rank 12 Taiwanese private universities.

The VIKOR method follows a structured process consisting of several steps:

1. **Establishing the Decision Matrix:** Construct a decision matrix a_{ij} where each element represents the performance of alternative A_i with respect to criterion C_j.
2. **Determining the Best and Worst Values:** For each criterion j, identify the best (positive ideal solution) f_j and the worst (negative ideal solution) f_j^- values across all alternatives.
3. **Calculating the Utility and Regret Measures:**

a. Utility measure (S_i):

$$S_i = \sum_{j=1}^{n} w_j \frac{f^*_j - f_{ij}}{f^*_i - f_j} \qquad (Eq.\ 6)$$

Where w_j is the weight of criterion C_j, reflecting its relative importance (Opricovic & Tzeng, 2004).

b. Regret measure (R_i):

$$R_i = \max_j \left[w_j \frac{f^*_j - f_{ij}}{f^*_j - f_j} \right] \qquad (Eq.\ 7)$$

4. **Computing the VIKOR Index (Q_i):** Combine the utility and regret measures to calculate the value of benefit ratio (VIKOR index) for each alternative:

$$Q_i = v\left(\frac{S_i - S^*}{S^- - S^*}\right) + (1-v)\left(\frac{R_i - R^*}{R^- - R^*}\right) \qquad (Eq.\ 8)$$

Here, S^* and S^- are the best and worst values of S_i; and R are R^- the best and worst values of R_i. v is the weight of the decision-making strategy, typically set to 0.5 to represent a balanced approach (Opricovic, 1998).

5. **Ranking the Alternatives:** Based on the Q_i values, rank the alternatives from best to worst. The alternative with the lowest Q_i value is considered the most preferred.
6. **Determining the Compromise Solution:** The alternative with the smallest Q_i is proposed as the compromise solution. This solution must satisfy the following conditions:

a. **Condition 1 - Acceptable advantage:** The difference between the Q values of the first and second-ranked alternatives must be at least $\frac{1}{m-1}$, ensuring a significant lead of the best alternative.

b. **Condition 2 - Acceptable stability:** The solution should remain stable across different decision-making scenarios and parameter variations (Opricovic & Tzeng, 2004).

Empirical Study

University Monitoring and Evaluation Data

In the study, only public universities are considered as two different populations, hence, data is divided into two and analyzed accordingly. Firstly, we selected the criteria and sub-criteria from the report. There are five main categories: "Education and Training", "R&D, Projects and Publications", "Internationalization", "Sustainability", and "Social Responsibility". Each of these categories has sub-criteria which are displayed in Table 2.

Some of the sub-criteria are simply rankings and measured on an ordinal scale. Although universities performances have been measured since 2018, some universities still report missing values for certain sub-criteria. Most of these missing values are imputed based on basic imputation techniques (i.e. median, maximum, or minimum imputation), some variables included so many missing values. Because it is not possible to impute them efficiently, these variables are also ejected. See Table 3.

As one can see most of the sub-criteria under the sustainability category are disregarded. Most of the remaining sub-criteria also are not available for most of the universities because most of the state universities do not have investments in renewable energy sources, cycling, or efficiency investments. On the other hand, since sustainability sub-criteria are measured for the first time in 2023, most of the remaining data are skewed and have erroneous values. For these reasons, we decided to disregard sustainability criteria altogether. Eventually, 56 sub-criteria under four main categories are taken into consideration for the analysis.

Results

Multicriteria decision analysis is performed in five steps which are displayed in Figure 1.

1. Percentile rank normalization: We first normalized the data according to the percentile rank formula (see Eq.1).

2. Calculating the sum of percentile scores for every main category: Based on the computed percentile scores in step 1, percentile scores are summed up at a university level under each category. As a result, each university has four pillar scores for each main category (namely A, B, C, E).

3. Entropy weight calculation for the main categories: After calculating the total scores for the four main categories, the entropy weights for these four criteria were computed. The results are shown in Figure 2.

Figure 1
Steps of the empirical study

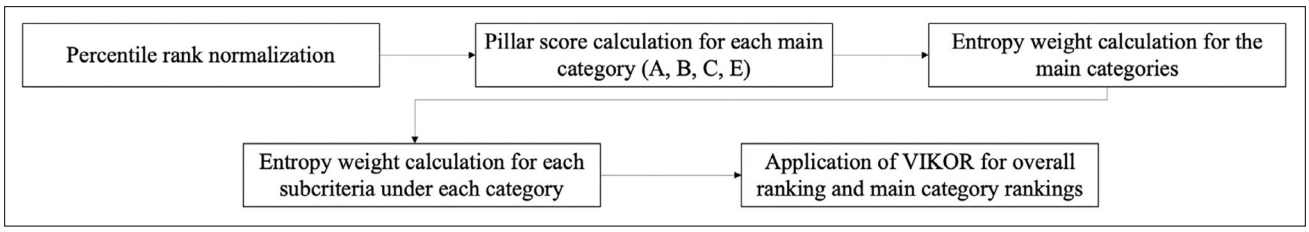
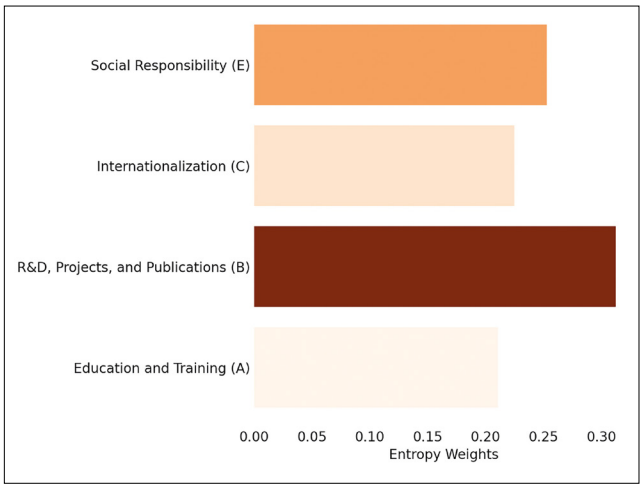


Figure 2
Entropy weights of main categories

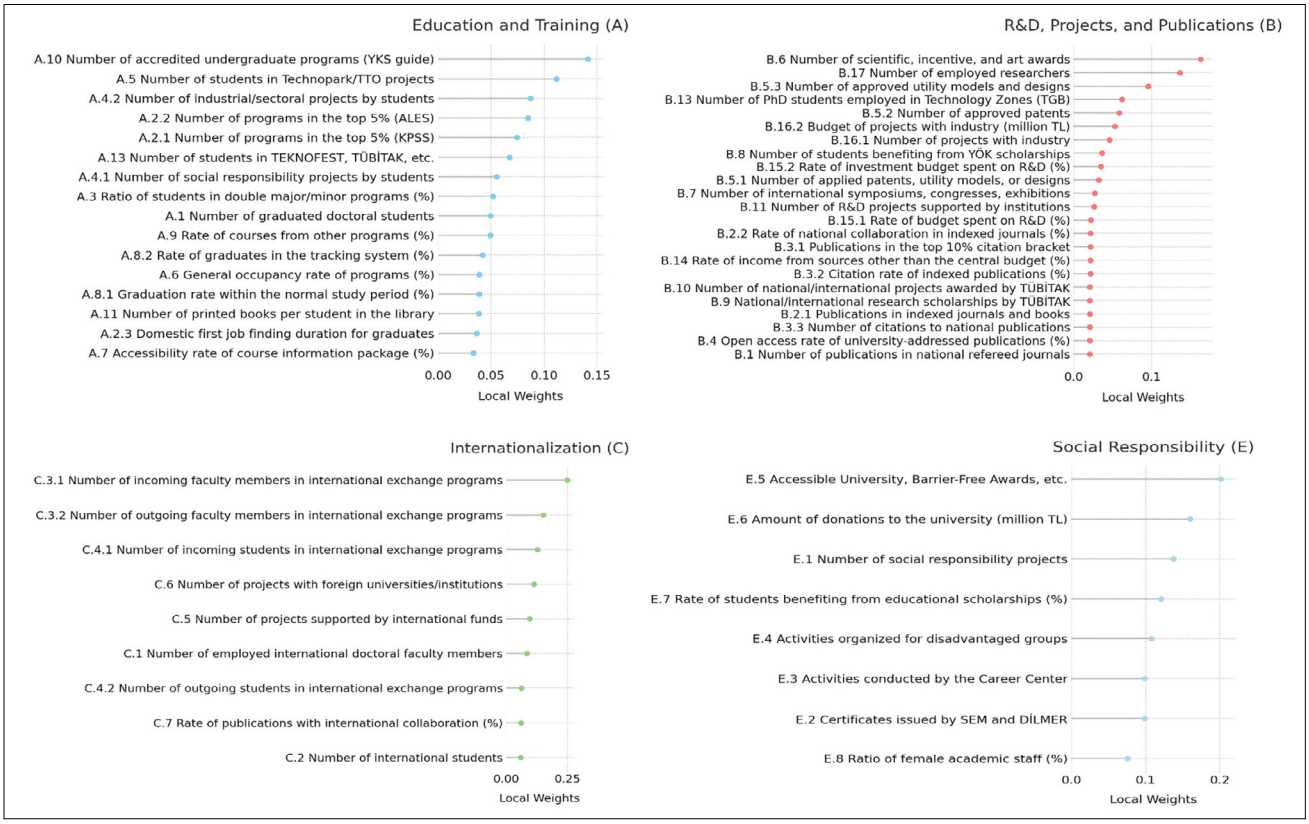


The most important category is "R&D, Projects and Publications" which is followed by "Social Responsibility", "Internationalization", and "Education and Training". Corresponding entropy weights are 0.3121, 0.2526, 0.2247, and 0.2105 respectively.

4. Entropy weight calculation for sub-criteria under each category: Based on the determined main criteria weights, and entropy weights of the sub-criteria were calculated separately for each main category so that the sum of the weights equals 1. Hence, local weights are calculated (see Figure 3).

The results indicate that the prominent sub-criteria for the "education and training (A)" category are "A.10 Number of accredited undergraduate programs", "A.5 Number of students participating in Technopark or Technology Transfer Office (TTO) projects" and "A.4.2 Number of industrial/sectoral projects carried out by students".

Figure 3
Entropy weights of sub-criteria



The significance of accreditation, hands-on training, and industry cooperation is emphasized by the high weight given to these features in the "Education and Training" category. The focus on accredited programs draws attention to the importance of an esteemed education. The university's emphasis on students participating in industrial/sectoral and Technopark/TTO projects shows its commitment to offering cutting-edge and relevant learning opportunities. These elements are crucial for developing a culture of innovation and entrepreneurship inside the university, improving employability, and preparing students for the workforce. These results also bring the polytechnic universities upfront because they highly encourage students to join the technology and innovation projects.

The most important criteria for the "R&D, Projects and Publications (B)" are "B.6 Number of scientific, incentive, and art awards", "B.17 Number of employed researchers" and "B.5.3 Number of approved utility models and designs". The high weights assigned to these criteria underscore the importance of recognition, research capacity, and practical innovation in the evaluation of university performance. These factors are crucial for the development of a research intensive environment that fosters innovation and academic excellence. The emphasis on awards and recognition encourages a culture of achievement and motivation, while the focus on employed researchers and approved utility models ensures the sustainability and practical relevance of research initiatives.

For the "Internationalization (C)" main category "C.3.1 Number of incoming faculty members within international exchange programs", "C.3.2 Number of outgoing faculty members within international exchange programs", and "C.4.1 Number of incoming students within international exchange programs" are the most important sub-criteria. The emphasis on these criteria indicates that international exchange programs for both faculty and students are pivotal in the internationalization efforts of universities. Bringing in faculty and students from abroad and sending local faculty to international institutions help in building a globally connected and culturally diverse academic environment. These exchanges foster international collaboration, enhance the educational experience, and elevate the university's global profile, making it a more dynamic and competitive institution.

In the "Social Responsibility (E)" category, "E.5 Number of Accessible University Awards, Barrier-Free Flag Awards, Barrier-Free Program Emblems, and Disabled-Friendly Awards", "E.6 Amount of donations to the university (million TL)", and "E.1 Number of social responsibility projects" are the most significant sub-criteria. The focus on these criteria underscores the importance of accessibility, community support, and active engagement in social issues for universities. Emphasizing awards for accessibility and inclusivity indicates a strong commitment to creating an equitable environment for all. The significance of donations highlights the importance of external support and financial stability, while the emphasis on social responsibility projects reflects the university's dedication to making a tangible difference in society. Together, these criteria illustrate a comprehensive approach to social responsibility, integrating inclusivity, community engagement, and proactive social initiatives.

5. Application of VIKOR: After identifying the criteria weights, we applied the VIKOR method to 126 universities and ranked the universities.

First, we performed the VIKOR method to determine the overall rankings by taking the entropy weights into consideration reported in Figure 2 and 3. Hence, we aim to evaluate the overall performance of universities. Later, we used local weights to evaluate the university performances by the main categories. The VIKOR results are displayed in Table 4.

Table 4 shows that İstanbul Technical University has the highest overall performance due to its superior performances in terms of "R&D, Projects, and Publications (B)" and "Internationalization (C)".

After ranking the alternatives from best to worst we need to identify a compromise solution. In VIKOR there are two conditions to be satisfied:

1. Acceptable advantage: The difference between the ***Q*** values of the first and second-ranked alternatives must be at least ***1/(m-1)***, ensuring a significant lead of the best alternative where m is the number of alternatives.

$$Q(A^2) - Q(A^1) \geq \frac{1}{m-1}$$

Acceptable advantage condition calculations $Q(A^2) - Q(A^1)$ are shown in Table 5. As one can see only acceptable advantage condition is satisfied only in the rankings for Category C and Category E. We conclude that we have compromised solutions for Overall, Category A, and Category B rankings for ***v=0.5*** because they did not satisfy the acceptable advantage condition for $1/(126-1) = 800$.

2. Acceptable stability: This condition suggests that the solution should remain stable across different decision-making scenarios and parameter variations. Accordingly, the uppermost alternative according to the Q_i value should also have the best (lowest) values for S_i and R_i. S_i and R_i values are demonstrated in Table 6.

For overall ranking first alternative İstanbul Technical University has the lowest S_i but it has the second lowest R_i. In the "Education and Training (A)" category, the uppermost alternative Yıldız Technical University has the second lowest S_i and third lowest R_i values. For the "R&D, Projects and Publications (B)" ranking, İstanbul Technical

University has the smallest S_i, R_i, and Q_i values. In the "Internationalization (C)" ranking, Middle East Technical University has the smallest S_i, R_i, and Q_i values. Lastly, Dokuz Eylül University is the best alternative for "Social Responsibility (E). However, it has the lowest S_i but second lowest R_i values.

In the overall ranking, İstanbul Technical University holds the top position with the lowest Q value, reflecting its proximity to the ideal solution across all criteria. Although it has the lowest S_i value, indicating superior performance overall, it has the second lowest R_i value, suggesting there is one criterion where it is not the absolute best but still performs exceptionally well.

In Category A (Education and Training), Yıldız Technical University ranks first despite having the second lowest S_i and third lowest R_i values, indicating consistent and robust performance across all criteria in this category, though not the most stable. For Category B (Research, Development, and Publications), İstanbul Technical University excels with the smallest S_i, R_i, and Q_i values, demonstrating absolute stability and robustness in its performance, being the best across all criteria, and minimizing both utility and regret measures. In Category C (Internationalization), Middle East Technical University leads with the smallest S_i, R_i, and Q_i values, indicating its comprehensive strength and top ranking in internationalization efforts. Lastly, in Category E (Social Responsibility), Dokuz Eylül University ranks first with the lowest S_i but the second lowest R_i values, suggesting that while it is the best overall in this category, there is one criterion where another university slightly outperforms it. Nonetheless, its overall performance remains robust and close to the ideal.

Discussion and Conclusion

This study adopted percentile rank normalization to EWM-VIKOR hybrid multicriteria decision-making method to rank public higher education institutions of Türkiye based on the data gathered from annually published The University Monitoring and Evaluation Report of YÖK. 56 sub-criteria categorized under 4 main categories (namely "Education and Training", "R&D, Projects, and Publications", "Internationalization", and "Social Responsibility") are taken into consideration for ranking.

Firstly, according to the weight results of EWM, "R&D, Projects, and Publications" was found the most important category that is followed by "Social Responsibility", "Internationalization" and "Education and Training". The most important criterion for the "R&D, Projects and Publications (B)" is "B.6 Number of scientific, incentive, and art awards" which emphasizes the importance of academic recognition. For "Social Responsibility" the most important criteria is "E.5 Number of Accessible University Awards, Barrier-Free Flag Awards, Barrier-Free Program Emblems, and Disabled-Friendly Awards" which points out the importance of accessibility, community support, and active engagement in social issues for universities. For the "Internationalization" category "C.3.1 Number of incoming faculty members within international exchange programs" is the most prominent criterion. It underscores the importance of international exchange programs. Lastly, "A.10 Number of accredited undergraduate programs" has the highest weight in the "Education and Training" category showing the importance of accessibility and community support.

The results show that alternatives like İstanbul Technical University and Middle East Technical University demonstrate high stability and robustness, as they have consistently low S_i and R_i values across multiple categories. The fact that İstanbul Technical University has the second lowest R_i overall but still ranks first highlights its overall strong performance, with only minor deviations from the ideal in certain criteria.

In "Education and Training (A)", Yıldız Technical University's high ranking despite not having the lowest S_i and R_i values suggests a balanced performance across multiple criteria rather than dominance in a single criterion. For "R&D, Projects, and Publications (B)", İstanbul Technical University's lowest S_i, R_i, and Q_i values indicate its clear leadership and stability, making it a model for excellence in this area. Middle East Technical University's top position in "Internationalization (C)" with the lowest S_i, R_i, and Q_i values showcases its exceptional performance in global engagement and partnerships. Dokuz Eylül University's performance in "Social Responsibility (E)" reflects its strong commitment to community and societal initiatives, even though it slightly trails another university in one criterion.

These results provide a nuanced understanding of the strengths and weaknesses of each university. Decision-makers can use this information to identify areas for improvement and strategic investment. The stability indicated by low S_i and R_i values ensures that the top-ranked universities are not just performing well under current conditions but are likely to maintain their performance across various scenarios and parameter changes.

The findings of the study have similarities and differences from previous studies. In their study, which stands out as one of the few conducted based on the data from the Council of Higher Education (YÖK) monitoring and evaluation report, Gul & Yucesan (2022), used a probabilistic approach to handle expert preferences in the weighting of the criteria. Their findings also indicated that "R&D, Projects, and Publications (B)" is the most important criterion. On the other hand, "Social Responsibility" comes forward as the second most important category in our study. In contrast, Gul & Yucesan (2022) concluded that social responsibility is one of the least important along with the "Budget and Finance" category which is no longer a main category in

the report since 2021. In 2021, YÖK distributed some sub-criteria under the "Budget and Finance" category to "R&D, Projects, and Publications" and "Social Responsibility" and excluded others. Hence, comparing the relative importance of all criteria between the two studies would not be meaningful.

Keleş et al. (2020) also studied on the same report but they aimed to compare the performances of different ranking methods for equal weighted criteria. They also found that Middle East Technical University, Boğaziçi University, Ankara University, and İstanbul University come forward across different rankings. However, it would not be appropriate to compare their findings with ours because two studies are conducted on separate data from different years. Keleş et al. aimed to compare various ranking methods while in some other studies, different weighting and ranking methods are combined to reach a final consensus. For example, Polatgil & Güler (2024) aimed to evaluate university performances in terms of student satisfaction by using Two-Layer Copeland. Their approach incorporated different weighting and ranking methodology results, aiming to achieve a final consensus rather than solely relying on one methodology. Yet, our study does not focus on aggregation, rather we investigated the stability and resilience of universities across multiple categories using VIKOR.

Our study has similar findings to other studies conducted on non-Turkish universities in terms of VIKOR methodology results. Wu et al. (2012) used a hybrid AHP-VIKOR method to rank 12 private universities in Taiwan. One of their main findings was that the VIKOR method showed stability across different criteria not only identifying top-ranked universities. Aliyev et al. (2020) applied fuzzy AHP and VIKOR methods to rank universities in the UK and concluded that universities with low Si and Ri values tend to maintain stability across different ranking scenarios.

In addition to comprehensive studies considering various categories, other studies focus on specific aspects of universities, such as research, education, sustainability, student satisfaction, and student preference.

For further studies, one may consider incorporating different normalization techniques other than percentile rank methodology into EWM to overcome the aforementioned methodological problems inherent to the well-known weighting method. Also, the EWM-VIKOR methodology can be applied to private universities in Türkiye. By all means different hybrid MCDM approaches can be applied to the higher education ranking for the same data. Lastly, assuming the University Monitoring and Evaluation Reports will continue to be published in the upcoming periods and hoping to have increased data quality by lessening missing and erroneous entries, we suggest ranking Turkish higher education institutions by sustainability criteria.

In conclusion, while the VIKOR method highlights the best alternatives based on overall $\boldsymbol{Q}$ values, examining $\boldsymbol{S_i}$ and $\boldsymbol{R_i}$ values provides deeper insights into the stability and resilience of these alternatives. This aids stakeholders in making more informed and strategic decisions. The findings of this study provide a valuable framework for evaluating university performance and offer actionable insights for policymakers and university administrators. The methodology's ability to balance different criteria while providing a compromise solution ensures that the rankings reflect a comprehensive and balanced view of each institution's strengths and areas for improvement. This ranking system could serve as a model for similar studies in other countries, particularly in terms of incorporating a wide range of criteria and addressing the methodological challenges of multi-criteria decision-making in higher education.

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Table 1
A summary of recent studies on MCDM methods in higher education rankings.

Authors	Methodology	Subject	Country of interest
Wu et al. (2012)	AHP-VIKOR	Overall performance	Taiwan
Zolfani & Ghadikolaei (2013)	Balanced scorecard, DEMATEL, ANP, VIKOR	Overall performance	Iran
Kabak & Dağdeviren (2014)	ANP-PROMETHEE	University selection	Türkiye
Ertuğrul et al. (2016)	Grey Relational Analysis	Academic performance	Türkiye
Er & Yıldız (2018)	ORESTE and Factor Analysis	Entrepreneurship and innovation	Türkiye
Quan & Zhou (2018)	TOPSIS	Entrepreneurship and innovation	China
Keleş et al. (2020)	Comparison of multiple MCDM methods	Overall performance	Türkiye
Arora et al. (2020)	Fuzzy AHP	Sustainability	India
Aliyev et al. (2020)	Fuzzy AHP	Overall performance	United Kingdom
Ishizaka et al. (2020)	PROMETHEE	Knowledge Transfer	United Kingdom
Burmann et al. (2021)	Goal Programming	Sustainability	International
Gul & Yucesan (2022)	Bayesian BWM-TOPSIS	Overall performance	Türkiye
Castro-Lopez et al. (2022)	Fuzzy AHP and Fuzzy Inference Systems	Student satisfaction	Spain
Wang et al. (2022)	Entropy-TOPSIS	Education quality	Vietnam
Ayyildiz et al. (2023)	IVN-AHP, VIKOR, Clustering	Overall performance	Türkiye
Akyol Özcan (2023)	TOPSIS	Sustainability	Türkiye
Polatgil & Güler (2024)	Two-layer Copeland	Student satisfaction	Türkiye
Elevli & Elevli (2024)	Entropy based Grey Relational Analysis and PROMETHEE	Entrepreneurship and innovation	Türkiye

Table 2
Sub-criteria and data source

Criteria	Data Source
Education and Training (A)	
A.1 Number of graduated doctoral students	YÖKSİS
A.2.1 Number of programs in the top 5% in the Public Personnel Selection Exam (KPSS)	ÖSYM
A.2.2 Number of programs in the top 5% in the Academic Personnel and Graduate Education Entrance Exam (ALES)	ÖSYM
A.2.3 Domestic first job finding duration for graduates	SGK ve YÖKSİS
A.3 Ratio of students doing double major or minor programs (%)	YÖKSİS
A.4.1 Number of social responsibility projects carried out by students	University
A.4.2 Number of industrial/sectoral projects carried out by students	University
A.5 Number of students participating in Technopark or Technology Transfer Office (TTO) projects	University
A.6 General occupancy rate of programs (%)	YÖKSİS
A.7 Accessibility rate of course information package (%)	University
A.8.1 Graduation rate within the normal study period (%)	YÖKSİS
A.8.2 Rate of graduates in the graduate tracking system (%)	University
A.9 Rate of courses that can be taken from programs other than the registered program (%)	University
A.10 Number of accredited undergraduate programs specified in the Higher Education Institutions Exam (YKS) guide	ÖSYM
A.11 Number of printed books per student in the university library	YÖKSİS
A.12 Satisfaction rate of the business world regarding the competencies of graduates	YÖKAK
A.13 Number of students participating in competitions organized by TEKNOFEST, TÜBİTAK, TÜBA, etc.	University
R&D, Projects and Publications (B)	
B.1 Number of publications per faculty member published in national refereed journals	TÜBİTAK ULAKBİM-TR
B.2.1 Number of publications published in indexed journals and books	Clarivate
B.2.2 Rate of publications published with national collaboration in indexed journals and books (%)	Clarivate
B.3.1 Number of publications in the top 10% citation bracket	Clarivate
B.3.2 Citation rate of indexed publications (%)	Clarivate
B.3.3 Number of citations to national publications	YÖKSİS
B.4 Open access rate of university-addressed scientific publications (%)	TÜBİTAK ULAKBİM-TR and InCites
B.5.1 Number of applied patents, utility models, or designs	University
B.5.2 Number of approved patents	University
B.5.3 Number of approved utility models and designs	University
B.6 Number of scientific, incentive, and art awards	Websites of the awarder institutions
B.7 Number of international symposiums, congresses, and artistic exhibitions	University
B.8 Number of students benefiting from YÖK scholarships	YÖK
B.9 Number of national and international research scholarships awarded by TÜBİTAK	TÜBİTAK
B.10 Number of national and international projects awarded by TÜBİTAK	TÜBİTAK
B.11 Number of R&D projects supported by national and international private or official institutions and organizations	University
B.13 Number of students enrolled in doctoral programs employed in Technology Development Zones (TGB)	Ministry of Industry and Technology
B.14 Rate of income from sources other than the central (private) budget (%)	University
B.15.1 Rate of budget spent on R&D (%)	University
B.15.2 Rate of investment budget spent on R&D (%)	University
B.16.1 Number of projects jointly conducted with industry	University
B.16.2 Budget of projects jointly conducted with industry (million TL)	University
B.17 Number of employed researchers	University

Internationalization (C)	
C.1 Number of employed international doctoral faculty members	YÖKSİS
C.2 Number of international students	YÖKSİS
C.3.1 Number of incoming faculty members within international exchange programs	University
C.3.2 Number of outgoing faculty members within international exchange programs	University
C.4.1 Number of incoming students within international exchange programs	University
C.4.2 Number of outgoing students within international exchange programs	University
C.5 Number of projects supported by international funds	University
C.6 Number of projects jointly conducted with foreign universities or institutions	University
C.7 Rate of publications published with international collaboration in indexed journals and books (%)	InCites
Social Responsibility (E)	
E.1 Number of social responsibility projects	University
E.2 Number of certificates issued by the Continuing Education Center (SEM) and Language Center (DILMER)	University
E.3 Number of activities conducted by the Career Center	University
E.4 Number of activities organized for disadvantaged groups	University
E.5 Number of Accessible University Awards, Barrier-Free Flag Awards, Barrier-Free Program Emblems, and Disabled-Friendly Awards	YÖK
E.6 Amount of donations to the university (million TL)	University
E.7 Rate of students benefiting from the university's educational scholarships (%)	University
E.8 Ratio of female academic staff (%)	YÖKSİS

* ÖSYM: Student Selection and Placement Center
** YÖKSİS: Council of Higher Education System
*** SGK: Social Security Institution
**** TÜBİTAK: Scientific and Technological Research Council of Türkiye
***** ULAKBİM: Turkish National Academic Network and Information Center

Table 3
Disregarded or ejected sub-criteria

Main Category	Disregarded Sub-criteria
A. Education and Training	A.12 Satisfaction rate of the business world regarding the qualifications of graduates
B. R&D, Projects, and Publications	B.12.1 University's world ranking according to THE B.12.2 University's regional (Asia) ranking according to THE B.12.3 University's national ranking according to THE B.12.4 University's world ranking according to QS B.12.5 University's regional (Asia) ranking according to QS B.12.6 University's national ranking according to QS B.12.7 University's world ranking according to ARWU B.12.8 University's national ranking according to ARWU

Table 4
The ranking results of overall and main category performances

University	Overall		Category A		Category B		Category C		Category E	
	Rank	Q	Rank	Q	Rank	Q	Rank	Q	Rank	Q
İstanbul Technical University	1	0.004	6	0.086	1	0.000	3	0.100	16	0.320
Hacettepe University	2	0.004	2	0.023	14	0.497	2	0.070	23	0.380
Ege University	3	0.046	7	0.094	23	0.666	6	0.136	7	0.138
Ankara University	4	0.055	13	0.148	5	0.095	9	0.158	24	0.390
Gazi University	5	0.072	4	0.033	7	0.104	7	0.153	8	0.143
Middle East Technical University	6	0.102	3	0.030	6	0.099	1	0.000	36	0.471
İstanbul University	7	0.106	34	0.406	4	0.093	28	0.403	5	0.124
Selçuk University	8	0.113	12	0.143	24	0.668	26	0.365	2	0.026
Sakarya University	9	0.121	10	0.124	17	0.565	5	0.136	3	0.058
Erciyes University	10	0.121	8	0.121	2	0.007	57	0.672	4	0.072
Yıldız Technical University	11	0.126	1	0.021	13	0.496	10	0.182	18	0.324
Dokuz Eylül University	12	0.132	5	0.041	33	0.723	59	0.735	1	0.008
Boğaziçi University	13	0.133	14	0.162	18	0.570	17	0.315	19	0.333
Bursa Uludağ University	14	0.153	9	0.121	20	0.620	37	0.451	10	0.222
Ondokuz Mayis University	15	0.185	15	0.173	36	0.737	23	0.340	9	0.185
Marmara University	16	0.187	16	0.182	15	0.505	58	0.733	30	0.423
İstanbul University-Cerrahpaşa	17	0.193	31	0.376	22	0.649	13	0.214	6	0.130
Necmettin Erbakan University	18	0.212	58	0.665	10	0.192	25	0.346	22	0.375
Akdeniz University	19	0.227	29	0.361	38	0.739	4	0.103	21	0.361
Çukurova University	20	0.233	11	0.126	9	0.137	61	0.756	82	0.726
Fırat University	21	0.249	17	0.196	3	0.073	30	0.415	37	0.473
Süleyman Demirel University	22	0.249	27	0.338	39	0.742	8	0.157	52	0.562
İzmir Institute of Technology	23	0.250	19	0.235	8	0.129	21	0.334	83	0.731
Anadolu University	24	0.252	51	0.564	41	0.746	62	0.760	12	0.250
Gaziantep University	25	0.272	20	0.253	45	0.753	27	0.393	15	0.316
Atatürk University	26	0.283	39	0.459	11	0.200	39	0.478	17	0.322
Karadeniz Technical University	27	0.300	26	0.337	37	0.738	19	0.323	28	0.411
Düzce University	28	0.305	43	0.497	50	0.781	60	0.751	75	0.672
Kocaeli University	29	0.309	24	0.264	35	0.732	20	0.324	26	0.394
Bartın University	30	0.329	40	0.466	21	0.625	74	0.834	11	0.246
Abdullah Gül University	31	0.333	60	0.688	12	0.430	18	0.318	41	0.500
Çanakkale Onsekiz Mart University	32	0.357	33	0.399	54	0.795	31	0.418	85	0.750
İzmir Katip Çelebi University	33	0.366	55	0.638	28	0.686	35	0.443	78	0.705
Pamukkale University	34	0.370	23	0.263	40	0.743	48	0.541	54	0.574
Eskişehir Osmangazi University	35	0.371	36	0.419	61	0.812	70	0.807	38	0.480
Sivas Cumhuriyet University	36	0.372	38	0.449	65	0.823	66	0.798	81	0.726
Inönü University	37	0.380	37	0.424	63	0.817	40	0.483	14	0.276
Eskişehir Technical University	38	0.388	22	0.260	34	0.726	78	0.856	35	0.467
Kastamonu University	39	0.395	44	0.504	47	0.771	44	0.518	84	0.745
Karabük University	40	0.403	76	0.810	46	0.766	67	0.798	29	0.415
Trakya University	41	0.435	32	0.390	53	0.791	69	0.806	97	0.819
Muğla Sıtkı Koçman University	42	0.435	21	0.259	75	0.851	16	0.293	25	0.391

Gebze Technical University	43	0.435	75	0.810	31	0.704	64	0.780	53	0.574
Dicle University	44	0.440	54	0.628	25	0.671	14	0.237	60	0.609
Bolu Abant İzzet Baysal University	45	0.446	79	0.822	57	0.796	15	0.288	46	0.521
Hitit University	46	0.456	77	0.814	60	0.808	53	0.575	91	0.782
Van Yüzüncü Yıl University	47	0.457	73	0.807	19	0.618	49	0.548	27	0.410
Burdur Mehmet Akif Ersoy University	48	0.461	30	0.364	29	0.692	24	0.345	96	0.816
Harran University	49	0.466	48	0.550	42	0.746	22	0.339	66	0.624
Zonguldak Bülent Ecevit University	50	0.467	25	0.286	72	0.846	77	0.850	48	0.534

Table 5
Acceptable advantage condition

Category		Acceptable Advantage Condition
Overall	0,00024	Satisfied
Education and Training (A)	0,00189	Not satisfied
R&D, Projects, and Publications (B)	0,00710	Satisfied
Internationalization (C)	0,07039	Not satisfied
Social Responsibility (E)	0,01718	Not satisfied

Table 6
Acceptable stability results

University	Overall		Category A		Category B		Category C		Category E	
	S_i	R_i	S_i	R_i	S_i	R_i	S_i	R_i	S_i	R_i
İstanbul Technical University	0.057	0.027	0.141	0.042	0.124	0.020	0.097	0.044	0.232	0.123
Hacettepe University	0.065	0.024	0.130	0.029	0.277	0.136	0.112	0.026	0.217	0.145
Ege University	0.096	0.039	0.205	0.034	0.407	0.163	0.142	0.049	0.123	0.087
Ankara University	0.101	0.042	0.190	0.049	0.164	0.040	0.144	0.059	0.296	0.133
Gazi University	0.093	0.054	0.121	0.033	0.182	0.040	0.191	0.045	0.176	0.078
Orta Doğu Technical University	0.086	0.074	0.104	0.034	0.171	0.040	0.031	0.013	0.372	0.145
İstanbul University	0.147	0.057	0.333	0.087	0.183	0.037	0.237	0.151	0.228	0.063
Selçuk University	0.133	0.065	0.214	0.044	0.411	0.163	0.336	0.108	0.137	0.049
Sakarya University	0.166	0.060	0.229	0.038	0.393	0.136	0.191	0.037	0.155	0.056
Erciyes University	0.155	0.063	0.233	0.036	0.135	0.020	0.354	0.248	0.239	0.045
Yıldız Technical University	0.155	0.066	0.127	0.029	0.276	0.136	0.212	0.053	0.336	0.106
Dokuz Eylül University	0.144	0.073	0.170	0.027	0.504	0.163	0.471	0.248	0.116	0.047
Boğaziçi University	0.192	0.058	0.238	0.045	0.402	0.136	0.285	0.097	0.333	0.109
Bursa Uludağ University	0.196	0.068	0.270	0.031	0.329	0.163	0.360	0.143	0.242	0.091
Ondokuz Mayis University	0.231	0.076	0.275	0.042	0.527	0.163	0.265	0.114	0.222	0.083
Marmara University	0.218	0.081	0.251	0.048	0.290	0.136	0.467	0.248	0.402	0.125
İstanbul University-Cerrahpaşa	0.235	0.079	0.371	0.075	0.377	0.163	0.234	0.063	0.256	0.060
Necmettin Erbakan University	0.278	0.077	0.364	0.141	0.329	0.040	0.350	0.096	0.326	0.123
Akdeniz University	0.267	0.089	0.383	0.070	0.531	0.163	0.146	0.033	0.382	0.109
Çukurova University	0.263	0.093	0.211	0.041	0.238	0.040	0.511	0.248	0.501	0.201
Fırat University	0.294	0.092	0.330	0.040	0.231	0.023	0.429	0.108	0.375	0.145
Süleyman Demirel University	0.299	0.091	0.346	0.070	0.536	0.163	0.216	0.041	0.444	0.160
İzmir Intitute of Technology	0.277	0.099	0.287	0.055	0.203	0.043	0.298	0.103	0.511	0.201
Anadolu University	0.306	0.090	0.412	0.112	0.542	0.163	0.518	0.248	0.317	0.086
Gaziantep University	0.324	0.096	0.338	0.052	0.555	0.163	0.364	0.114	0.381	0.095