

# Evaluation Of Technical Universities in Turkey in Accordance with Tübitak Entrepreneurial and Innovative University Index

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**Abstract:** Educational institutions compete with each other with entrepreneurial and innovative steps, just like production enterprises operating in different sectors. The Scientific and Technical Research Council of Turkey (TÜBİTAK) has been evaluating universities on a total of twenty-three sub-dimensions under four dimensions in line with the Entrepreneurial and Innovative University Index (GYÜE) every year since 2012. It shares the top fifty universities in the ranking with the public. These universities include both state universities and foundation universities. Eight of the top fifty universities in the ranking are Technical Universities. Since technical universities can integrate into more university-industry collaborations, they can undertake innovative and entrepreneurial projects and create value. In this context, the aim of the study is; It is the evaluation and ranking of Technical Universities in line with TÜBİTAK-GYÜE. Method of the research; The criterion weights of the technical universities included in the TÜBİTAK 2022 index were determined by the AHP method, and in this direction, the findings were obtained by using the PROMETHEE method. The study is also important in terms of determining the differences between technical universities and other universities in the context of the entrepreneurial and innovative university index and the reasons for these differences.

**Keywords:** Entrepreneurial and Innovative University, AHP, PROMETHEE, TÜBİTAK, GYÜE

## 1. Introduction

The simultaneous transformation of education and research activities offered in universities into economic output, that is, their commercialization, and the creation of more projects, patents and utility models contribute to the competitive structure of universities. With the university-industry cooperation to be established, it provides competence in giving way to the entrepreneurial ecosystem on both national and international scales, creating employment and transforming industrial design into products. According to Etzkowitz, who defends the Triple Helix thesis, the academic revolution in the university-industry-government trio; It is the step that integrates the economic and social development mission and transforms traditional teaching and research universities into entrepreneurial universities (Etzkowitz, 2004). Entrepreneurial universities are discussed from two different and interrelated perspectives. The mechanisms through which technology transfer processes can be implemented are both being investigated and policies and tools that encourage universities in this process are being evaluated (Feola et al., 2021).

The performance of universities in Turkey in the field of entrepreneurship and innovation is measured by the TÜBİTAK Entrepreneurial and Innovative University Index. This index evaluates universities based on criteria such as their commercialization of scientific research results, cooperation with industry, and support for entrepreneurial activities. The index consists of four core and 23 sub-components. These;

Scientific and Technological Research Competence (Number of Scientific Publications, Number of Citations, Number of Projects, Amount of Funds Obtained from Projects, Number of National and International Science Awards, Number of Doctorate Graduates), Intellectual Property Pool (Number of National Patent Documents, Number of National Utility Model Documents, International number of patent applications, number of international patent documents), Cooperation and Interaction (Number of projects carried out with industrial cooperation, amount of funds obtained from projects carried out with industrial cooperation, number of projects carried out with international cooperation, amount of funds obtained from projects carried out with international cooperation, faculty members/students in circulation number of students enrolled in industrial doctoral programs) and Economic and Social Contribution (Number of academic companies, Number of student/graduate companies, Net sales income of academic companies, Net sales income of student/graduate companies, Number of licensed patents/utility models/industrial designs, BIGG The number of companies is indexed as 4004-4005 number of projects) (TÜBİTAK, 2022). As a result of this index, the first fifty universities are shown in the ranking. This study, which evaluates the entrepreneurial and innovative performances of Technical Universities, consists of three parts: the literature section, which includes a section from past studies, the methodology of the study and the conclusion section.

## **2. Literature Review**

Elevli and Elevli (2024) stated in their study that multi-criteria decision-making methods with different criterion weights change university rankings. In this regard, they preferred Gray Relational Analysis (GRA) to rank the universities in Turkey according to the entrepreneurial and innovative university index (EIUI) and the Preference Ranking Organization Method (PROMETHEE) for the enrichment evaluation. They concluded that the ranking changes in each of the ranking approaches with varying weights.

In her study, Wu (2022) touched upon the development of talent training to increase the quality of postgraduate innovation and entrepreneurship education in universities. PROMETHEE I and PROMETHEE II methods were extended to create a reform scheme of this education mode in the big data environment and quantitative evaluation by making use of the Probability Linguistic Term Set (PLTS).

In their study in Turkey, Er and Yıldız (2018) examined the entrepreneurial and innovative university index results of 2016 and 2017 with ORESTE and Factor Analysis. By analyzing the ranking results evaluated by Tübitak, the ORESTE method and the factors of the criteria that need to be considered, the results are discussed and the discussion on the varying results is discussed.

Uslu et al. (2020) theoretically evaluated the Tübitak entrepreneurial and innovative university index (GYÜE) criteria within the scope of entrepreneurial university activity areas that stand out in higher education journals. In the study, it was determined that the five categories in TÜBİTAK-GYÜE included more than the prominent entrepreneurial activities for universities.

Ishizaka et al. (2020) created an index by examining knowledge transfer activities (KT) in their studies carried out at universities in England. In the study, which lists 162 higher education institutions in the United Kingdom, four different types of universities are defined according to the diversity and intensity of KT activities. These types of universities; It lists as ambidextrous, wide, focused and unreasoned.

Karahan and Peşmen (2021) tried to reveal the entrepreneurial and innovative change phases of universities and define third generation universities. In the study conducted using entrepreneurial and innovative university index data, the first ten universities ranked by the PROMETHEE Method were compared with regional universities.

In his study, Li (2022) created a design for the preliminary evaluation of the Performance Evaluation Index of Innovation and Entrepreneurship education for university students. By combining the features of innovation and entrepreneurship education implemented in universities, the design was carried out by using the Analytical Hierarchy Process (AHP), double generation environment, double input and a three-level evaluation performance of the index weights.

Wang et al. (2023) evaluated innovation and entrepreneurship education in applied universities in their study. It is stated that innovation and entrepreneurship teaching ability is tried to be measured with non-linear quantitative evaluation and biased qualitative evaluation. In order to overcome this; It is thought that this training will be overcome with a model based on Back Propagation (BP) neural network. The relevant model has been created.

In their study, Guerrero and Urbano (2019) investigated the changes that have occurred in the entrepreneurial and innovative university literature in the last 25 years. Articles written about the role of universities in entrepreneurship and innovation were examined in the Web of Science database. As a result of the study, it was found that articles from entrepreneurial and innovative universities have increasing interest and legitimacy.

Quan and Zhou (2018) created the entrepreneurship and innovation education capacity index system in their study at colleges and universities in China. As a result of the study conducted using entropy and TOPSIS methods, the main factors determining the capacity were revealed. These main factors are; It is expressed as the number of publications, the number of patents allowed, entrepreneurship plan competition and university science park.

In his study, Zuhail (2020) compared the determinants of national innovation capacity of developing countries with those of developed countries. The determinants of national innovation capacity have been determined as national technological capability and infrastructure factors, external factors and institutional factors. Panel data analysis was conducted for 18 developing countries and 31 developed countries. As a result of the study, a national innovation capacity scale was created.

In her study, Satici (2023) made a ranking using multi-criteria decision-making techniques according to the results of the 2021 entrepreneurial and innovative university index. Using the MEREC method in calculating the

criteria weights, it was determined that the most important criteria were cooperation and interaction. In the study, university rankings were carried out using the WASPAS method. As a result, the top three universities were Orta Doğa Technical University, Sabancı University and Istanbul Technical University.

Novikova et al. (2018) evaluated the start-up or spin-off projects of universities in their study conducted in Ukraine. In the study using SWOT analysis, comparison of world university rankings was used. The focus is on the scale of expenditures made on scientific research projects at universities and the level of results of the achievements made. As a result of the study, factors that hinder the development of innovative activities were discussed

### 3. Research methodology

This part of the study includes the purpose, population, sample, method and findings of the research.

#### 3.1 Purpose of the Study

Purpose of the study; It is the evaluation and ranking of Technical Universities in line with the TÜBİTAK Entrepreneurial and Innovative University Index (GYÜE). The entrepreneurial and innovative projects produced by the universities were measured again in the Technical Universities category in the context of industrial collaborations, patent numbers and all other criteria.

#### 3.2 Universe and Sample of the Study

The Scientific and Technical Research Council of Turkey (TÜBİTAK) has been evaluating universities on a total of twenty-three sub-dimensions under four dimensions in line with the Entrepreneurial and Innovative University Index (GYÜE) every year since 2012. It shares the top fifty universities in the ranking with the public. These universities include both state universities and foundation universities. In addition, universities are not categorized within themselves. All universities operating in higher education in Turkey are included in the evaluation. TÜBİTAK-GYÜE 2022 data was used in the study. In this study, which used secondary data, the last published data was taken as basis since the data for 2023 was not published. Among the top fifty universities in the ranking, eight are Technical Universities. These are in alphabetical order; Bursa Technical University, Eskişehir Technical University, Gebze Technical University, Istanbul Technical University, Karadeniz Technical University, Konya Technical University, Middle East Technical University, Yıldız Technical University constitute the study sample.

#### 3.3 Research Method, Analysis and Discussion

PROMETHEE Method, one of the Multi-Criteria Decision Making Techniques, was preferred as the research method. PROMETHEE Method is a multi-criteria decision-making method in which alternatives are evaluated by pairwise comparison with the appropriate alternative according to the determined criteria. In this method, alternatives are realized by combining their superiority according to the criteria (Genç, 2013). Many studies have been carried out in different fields in social sciences with the PROMETHEE Method. Studies carried out in the field of marketing; hedonic shopping (Zavadskas et al., 2019), green supplier selection (Abdullah et al., 2019), strategic marketing initiatives for cooperative enterprises (Yamagishi et al., 2021), studies in the field of tourism; destination selection (Ustasüleyman and Çelik, 2015), regional tourism competitiveness (Lopes et al., 2018), wine tourism (Maracajá et al., 2023), hotel selection (Sezgin and Yurtlu, 2021), studies in the field of entrepreneurship; entrepreneurship in rural areas (Faraji et al., 2011), ranking of business ideas (Nikoloudis et al., 2017), studies in the field of public administration; Sustainable development of cities (Ogrodnik, 2017) can be given as an example.

The steps of the PROMETHEE Method are as follows (Brans and Vincke, 1985):

**Step 1:** Creating the data matrix with options and criteria.

**Table 1: Data Matrix. Source: Brans and Vincke, 1985.**

Alternatives	$f_1$	$f_2$	.....	$f_n$
Alternative a	$f_1(a)$	$f_2(a)$	.....	$f_n(a)$
Alternative b	$f_1(b)$	$f_2(b)$	.....	$f_n(b)$
.....	.....	.....	.....	.....
Alternative m	$f_1(m)$	$f_2(m)$	.....	$f_n(m)$
Weight	$w_1$	$w_2$	.....	$w_n$

**m:** number of alternatives

**n:** number of criteria

**w:** weight value

**Step 2:** This is the stage of defining the preference functions of the criteria. This stage is determined according to the criteria and the qualities of the alternatives. There are six preference functions in the PROMETHEE Method to be used at this stage. These functions are Ordinary type, U-type, V-type, Level type, Linear type and Gaussian type. Preference functions are shown in Table 2.

**Table 2: Preference Functions**

Type	Parameters	Function
Ordinary type	-	$P_x = 0, x \leq 0$ $1, x > 0$
U-type	q	$P_x = 0, x \leq 0$ $1, x > 0$
V-type	p	$0, x \leq 0$ $P_x = x/m, 0 < x \leq m$ $1, x > m$
Level type	q, p	$0, x \leq q$ $P_x = 1/2, q < x \leq q+p$ $1, x > q+p$
Linear type	p, q	$0, x \leq 0$ $P_x = ((x-s)/r), s < x \leq s+r$ $1, x > m$
Gaussian type	s	$0, x \leq 0$ $P_x = \frac{x^2}{1 - e^{-2a^2}}, x > 0$

**q:** indifference value      **p:** absolute preference threshold      **s:** the intermediate value or standard deviation between p and q

**Source:** Brans and Vincke, 1985.

**Step 3:** Common preference functions are determined for the pairs of alternatives compared based on preference functions.

$$P(a, b) = \begin{cases} 0, & f(a) \leq f(b) \\ p[f(a) - f(b)], & f(a) > f(b) \end{cases}$$

**Step 4:** Preference indices are created for each alternative comparison pair for the common preference function determined in the third step.

$$\pi(a, b) = \frac{\sum_{i=1}^k w_i * P_i(a, b)}{\sum_{i=1}^k w_i}$$

**Step 5:** Identifying positive and negative advantages for all alternatives.

$$\phi^+ = \sum \pi(a, x) \quad x = (b, c, d \dots)$$

$$\phi^- = \sum \pi(a, x) \quad x = (b, c, d \dots)$$

**Step 6:** Partial ranking is determined with Promethee 1.

$$i = \Phi^+(a) > \Phi^+(b) \text{ and } \Phi^-(a) < \Phi^-(b)$$

**Step 7:** The final ranking is determined with Promethee 2.

$$\Phi(a) = \Phi^+(a) - \Phi^-(a)$$

#### 4. Results

The criteria and scores to be used in the study were analyzed with the PROMETHEE Method. Visual PROMETHEE Program was used for the method. The data entered into the program is shown in the figure.

	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<b>Scenario1</b>	Bilimsel ve te...	fikri mülkiyet ...	İşbirliği ve et...	Ekonomik ve ...
Unit	puan	puan	puan	puan
Cluster/Group	◆	◆	◆	◆
<b>Preferences</b>				
Min/Max	max	max	max	max
Weight	0,30	0,20	0,20	0,30
Preference Fn.	Linear	Linear	Linear	Linear
Thresholds	absolute	absolute	absolute	absolute
- Q: Indifference	1,84	3,05	2,53	6,82
- P: Preference	5,61	7,32	6,44	17,66
- S: Gaussian	n/a	n/a	n/a	n/a
<b>Statistics</b>				
Minimum	5,61	2,77	13,54	8,79
Maximum	12,25	14,80	22,17	34,40
Average	8,59	10,26	16,97	23,43
Standard Dev.	2,31	3,47	3,08	8,47
<b>Evaluations</b>				
<input checked="" type="checkbox"/> Orta Doğu Tekni...	12,25	14,80	22,17	34,40
<input checked="" type="checkbox"/> İstanbul Teknik Ü...	11,35	12,08	20,91	29,81
<input checked="" type="checkbox"/> Yıldız Teknik Üniv...	9,63	13,12	17,85	33,29
<input checked="" type="checkbox"/> Gebze Teknik Üni...	9,54	10,77	17,57	26,97
<input checked="" type="checkbox"/> Eskişehir Teknik Ü...	6,40	11,44	13,54	18,34
<input checked="" type="checkbox"/> Karadeniz Teknik...	7,67	8,06	13,93	18,86
<input checked="" type="checkbox"/> Konya Teknik Üni...	6,29	2,77	13,73	16,96
<input checked="" type="checkbox"/> Bursa Teknik Üni...	5,61	9,03	16,06	8,79

Source: These are the results obtained from the program, created by the author.

Figure 1: Data Matrix

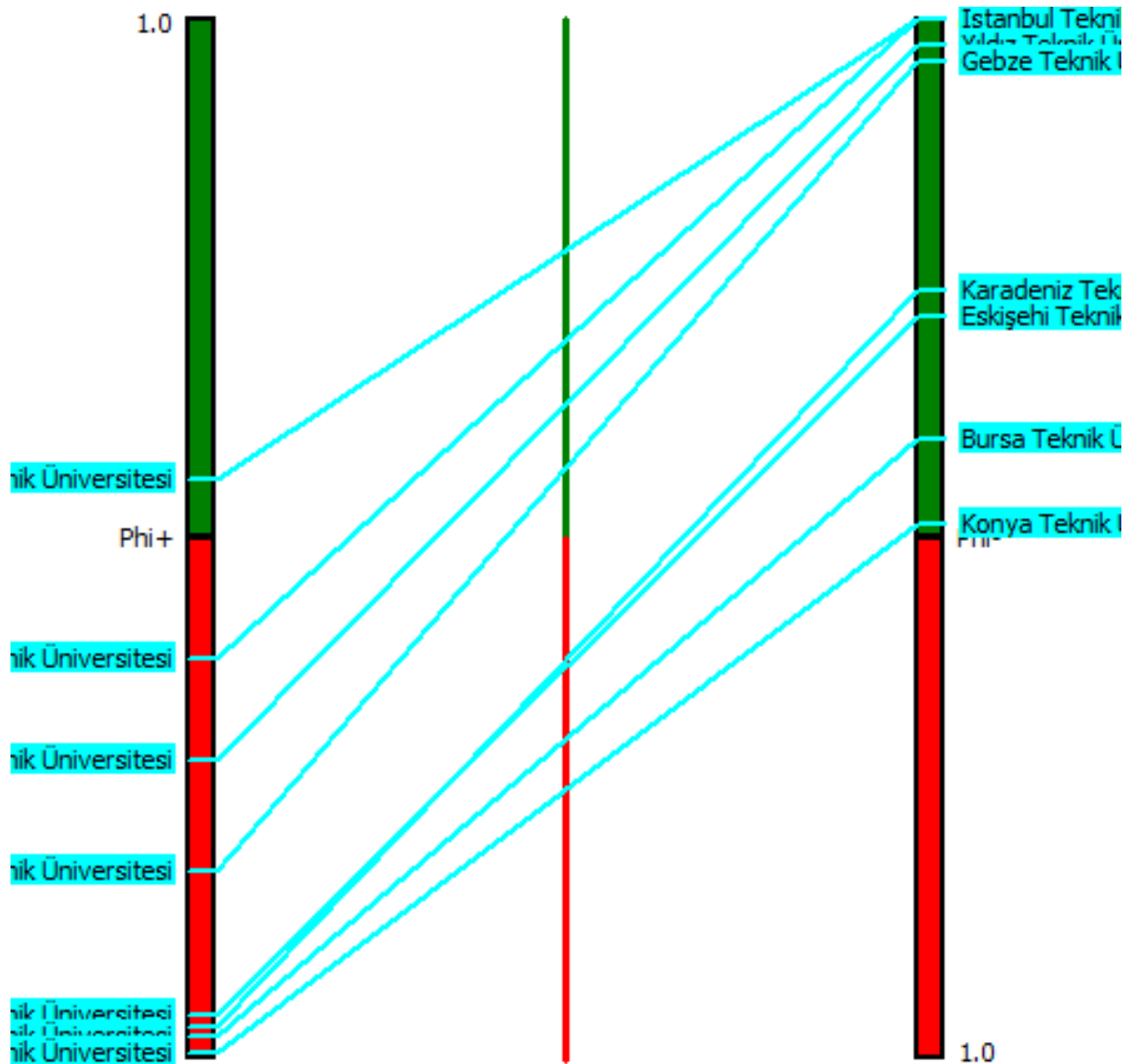
The criterion weight of Scientific and Technological Research Competence and Economic and Social Contribution, which are the criteria used in the study, was determined as 0.30, and the criterion weight of Intellectual Property Competence and Cooperation and Interaction was determined as 0.20. When the data matrix is examined, the unit part is determined as points. In the min-max section, max was chosen because it is advantageous for all of them to be high. Criterion weights obtained with AHP have been added to the Weight section. Linear was used in the preference function part. Since the decision matrix consists of numbers, absolute was preferred in the Threshold section, and the Q and P parameters were arranged according to the suggestions of the assistant. The positive and negative advantages of the Technical Universities in the list are shown in the table.

Table 3: Positive and Negative Advantages

	Phi+	Phi-
Middle East Technical University	0,5569	0,0000
Istanbul Technical University	0,3847	0,0000
Yıldız Technical University	0,2854	0,0258
Gebze Technical University	0,1798	0,0399
Eskişehir Technical University	0,0416	0,2862
Karadeniz Technical University	0,0303	0,2620
Konya Technical University	0,0053	0,4862
Bursa Technical University	0,0215	0,4054

Source: These are the results obtained from the program, created by the author.

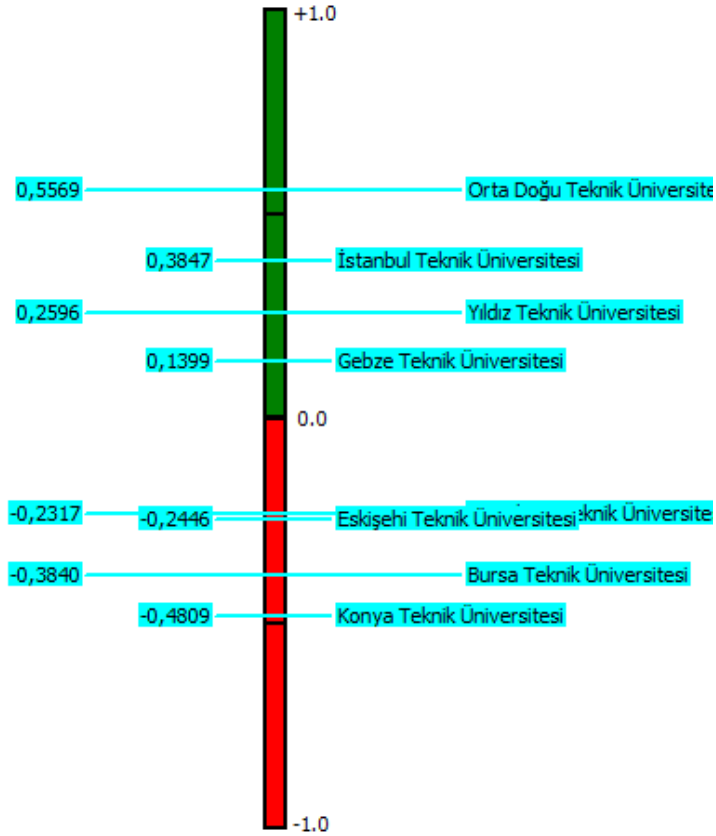
The partial ranking obtained with PROMETHEE 1 after determining the positive and negative superiorities is shown in the figure 2.



Source: These are the results obtained from the program, created by the author.

Figure 2: PROMETHEE 1 Partial Ranking Results

The figure showing the partial ranking shows the positive and negative values of technical universities. Positive advantages are shown on the left side of the figure, and negative advantages are shown on the right side. The final ranking obtained with PROMETHEE 2 is shown in the figure 3.



**Source:** These are the results obtained from the program, created by the author.

**Figure 3: PROMETHEE 2 Final Ranking Results**

The ranking results shown in the figure are shown in the table according to the ideality ranking.

**Table 4: Technical Universities Final Ranking**

Middle East Technical University	0,5569
Istanbul Technical University	0,3847
Yıldız Technical University	0,2596
Gebze Technical University	0,1399
Karadeniz Technical University	-0,2317
Eskişehir Technical University	-0,2446
Bursa Technical University	-0,3840
Konya Technical University	-0,4809

**Source:** These are the results obtained from the program, created by the author.

## 5. Conclusion

Due to the nature of technical universities, they can integrate into more university-industry collaborations, undertake innovative and entrepreneurial projects, create value, create useful models and increase the number of patents. In this study, which was carried out using the TÜBİTAK- Entrepreneurial and Innovative University Index, the Technical Universities in the ranking were discussed. Arrangement; The alternatives were discussed by making a pairwise comparison with the appropriate alternative according to the criteria determined by using the PROMETHEE method. Although the ranking made by the PROMETHEE method is compatible with the TÜBİTAK ranking, it is seen that Bursa Technical University, Eskişehir Technical University, Karadeniz Technical University and Konya Technical University are in different places in the ranking according to PROMETHEE. This is due to the method used.

As a result of the study, it can be recommended that technical universities in Turkey follow the following steps in order to be evaluated in line with the TÜBİTAK Entrepreneurial and Innovative University Index;

1. **Examination of Index Criteria:** Examine the index criteria announced by TÜBİTAK in detail. These criteria may include factors such as academic publications, number of patents, technology transfer activities, industrial collaborations, and entrepreneurial activities.
2. **Analysis of the Performance of Technical Universities:** Analyze the performance of technical universities in Turkey according to the criteria included in the index. Determine which universities stand out in which areas and in which areas they need improvement.
3. **Entrepreneurship and Innovation Supports:** Evaluate technical universities' methods and policies to support entrepreneurship and innovation activities. Investigate how these activities contribute to students, academics and local industry.
4. **Collaboration and Networking:** Evaluate efforts of technical universities to collaborate with industry and create international networks. These collaborations and networks show how universities contribute to the innovation ecosystem.
5. **Case Study Analyzes:** Examine some of the technical universities that stand out in the index with case studies. The success stories of these universities can reveal practices and strategies that can serve as examples for other universities.

As a result, evaluating technical universities in Turkey in line with the TUBITAK Entrepreneurial and Innovative University Index is important in terms of universities commercializing their scientific research and contributing to the innovation ecosystem.

This evaluation provides an opportunity to highlight universities' strengths and identify areas for improvement.

## References

- Abdullah, L., Chan, W., & Afshari, A. (2019). Application of PROMETHEE method for green supplier selection: a comparative result based on preference functions. *Journal of Industrial Engineering International*, 15, 271-285.
- Etzkowitz, H. (2004). The evolution of the entrepreneurial university. *International Journal of technology and globalisation*, 1(1), 64-77.
- Elevli, S., & Elevli, B. (2024). A study of entrepreneur and innovative university index by entropy-based grey relational analysis and PROMETHEE. *Scientometrics*, 1-31.
- Er, F., & Yıldız, E. (2018). Türkiye Girişimci ve Yenilikçi Üniversite Endeksi 2016 ve 2017 sonuçlarının ORESTE ve faktör analizi ile incelenmesi. *Alphanumeric Journal*, 6(2), 293-310.
- Faraji Sabokbar, H., Badri, S. A., Sojasi Qidari, H., Sadeghloo, T., & Shahdadi Khaje Asgar, A. (2011). Entrepreneurship development ranking (gradation) in rural area by using of PROMETEE technique. *Human Geography Research*, 43(1), 53-68.
- Feola, R., Parente, R., & Cucino, V. (2021). The entrepreneurial university: How to develop the entrepreneurial orientation of academia. *Journal of the Knowledge Economy*, 12, 1787-1808.
- Genç, T. (2013). PROMETHEE Yöntemi ve GAIA Düzlemi. *Afyon Kocatepe Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 15(1), 133-154.
- Guerrero, M., & Urbano, D. (2019). A research agenda for entrepreneurship and innovation: the role of entrepreneurial universities. *A research agenda for entrepreneurship and innovation*, 107-133.
- Ishizaka, A., Pickernell, D., Huang, S., & Senyard, J. M. (2020). Examining knowledge transfer activities in UK universities: Advocating a PROMETHEE-based approach. *International Journal of Entrepreneurial Behavior & Research*, 26(6), 1389-1409.
- Karahan, M., & Peşmen, S. (2021). Some universities performance evaluation of entrepreneurship and innovation in turkey with multiple criteria decision making methods. In *Digital Conversion on the Way to Industry 4.0: Selected Papers from ISPR2020, September 24-26, 2020 Online-Turkey* (pp. 569-583). Springer International Publishing.
- Li, J. (2022). Design of Performance Evaluation System of College Students' Innovation and Entrepreneurship Education Based on AHP Method. *Advances in Education, Humanities and Social Science Research*, 1(1), 144-144.
- Lopes, A. P. F., Muñoz, M. M., & Alarcón-Urbistondo, P. (2018). Regional Tourism Competitiveness Using the PROMETHEE Approach. *Annals of Tourism Research*, 73, 1-13.
- Maracajá, K. F. B., Schramm, V. B., Schramm, F., Valduga, V., & Trindade, J. R. (2023). Application of MCDM Using PROMETHEE II for Evaluation of Wine Tourism Services. *International Journal of Wine Business Research*, (ahead-of-print).
- Nikoloudis, C., Strantzali, E., & Aravossis, K. (2017, June). Applying the multi-criteria method Promethee II for the startup ranking during a business ideas competition. In *Proceedings of the 6th international symposium and 28th national conference on operational research "OR in the digital era—ICT challenges"* Thessaloniki, Greece.
- Novikova, I. E., Osetskiy, V. L., & Alekseieva, K. A. (2018). Startups and spinoffs as factors of the academic business development: the foreign experience and the ukrainian prospects. *Наука та інновації*, (14, № 5), 77-89.
- Ogrodnik, K. (2017). The application of the PROMETHEE method in evaluation of sustainable development of the selected cities in Poland. *Ekonomia i Środowisko*, (3 [62]).

- Quan, L., & Zhou, H. (2018). Evaluation of innovation and entrepreneurship education capability in colleges and universities based on entropy TOPSIS-A case study. *Educational Sciences-Theory & Practice*, 18(5).
- Satıcı, S. (2023). MEREC temelli WASPAS yöntemiyle üniversitelerin girişimci ve yenilikçi performanslarının değerlendirilmesi. *Girişimcilik ve Kalkınma Dergisi*, 17(2), 106-128.
- Sezgin, M., & Yurtlu, M. (2021). Dijital Pazarlama Yöneticilerinin Bakış Açısıyla En Uygun Otel Seçimi: Analitik Hiyerarşi Prosesi (AHP) ve PROMETHEE Yaklaşımı. *Türk Turizm Araştırmaları Dergisi*, 5(3), 1756-1784.
- Uslu, B., Çalikoğlu, A., Seggie, F. N., & Seggie, S. H. (2020). TÜBİTAK girişimci ve yenilikçi üniversite endeksi kriterlerinin girişimci üniversitelerde öne çıkan faaliyetler açısından değerlendirilmesi. *Yükseköğretim Dergisi*, 10(1), 1-11.
- Ustasüleyman, T., & Çelik, P. (2015). Ahp ve Bulanık Promethee Yöntemleriyle Destinasyon Seçimini Etkileyen Faktörlerin Önem Derecesinin Belirlenmesi ve En Uygun Destinasyon Seçimi. *Uluslararası İktisadi ve İdari İncelemeler Dergisi*, (14).85-102.
- Wang, W., Qiu, D., Chen, X., & Yu, Z. (2023). An empirical study on the evaluation system of innovation and entrepreneurship education in applied universities. *Computer Applications in Engineering Education*, 31(1), 100-116.
- Wu, W. (2022). Probabilistic linguistic promethee i and ii methods for evaluation of the reform scheme of postgraduate innovation and entrepreneurship education talent training mode under the big data environment. *Mathematical Problems in Engineering*, 2022(1), 8341052.
- Yamagishi, K., Sañosa, A. R., de Ocampo, M., & Ocampo, L. (2021). Strategic marketing initiatives for small co-operative enterprises generated from SWOT-TOWS analysis and evaluated with PROMETHEE-GAIA. *Journal of Co-operative Organization and Management*, 9(2), 100149.
- Zavadskas, E. K., Bausys, R., Kaklauskas, A., & Raslanas, S. (2019). Hedonic shopping rent valuation by one-to-one neuromarketing and neutrosophic PROMETHEE method. *Applied Soft Computing*, 85, 105832.
- Zuhal, M. (2020). Determinants of national innovation capacity in developing countries: An empirical survey. *Turkish Economic Review*, 7(3), 184-192. [https://tubitak.gov.tr/sites/default/files/gostergebazliveri\\_tablo.pdf](https://tubitak.gov.tr/sites/default/files/gostergebazliveri_tablo.pdf)