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Comparison of relationship between global innovation index achievements and university achievements in terms of Countries

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Abstract

In this study, analyses were conducted to determine the relationship between the countries' achievements in the Global Innovation Index and the international achievements of the universities in the relevant countries. For university achievements, the data from HEEACT and ARWU rankings that measure the achievements of the universities worldwide were used. In the study, first, using the Global Innovation Index data of the countries and their respective data in HEEACT and ARWU rankings, Chi-square tests were performed and as a result, a significant relationship was detected. To determine the direction and degree of this relationship, Correlation tests were performed and it was concluded that there was a strong linear correlation between the innovation environment in the countries and the achievements of their universities. Finally, considering the continents and economic-political groups (G7, G20, BRICS) the countries were in, the data was classified using k-Means Cluster Analysis. It was found that GII, HEEACT, and ARWU achievements varied depending on the continent and economic-political groups the countries are in.

Keywords: Global innovation Index, University Achievement Ranking, Development of Countries, Innovation Environment.

Introduction

Universities are mechanisms that ensure the social and scientific development of countries. The significance of this has only been understood in the age of information. Today where technology is developing rapidly, the contribution of universities, which are especially the birthplace of certain technologies, to the national and global economy is big. Thus, today, the number of newly established universities increase proportionally to the awareness of this significance. The universities generate new technological knowledge and this is recognized as a wellspring of knowledge for firms[1]. While universities were only centers of education in the recent past, today, they can transform knowledge into economic benefits thanks to the technology transfer and research-development centers they contain.Those who can manage this mechanism the fastest become pioneers. Another important factor in the development of universities is, obviously, the responsibilities the nations take in this direction and the contribution they offer. The participation of universities, which are the leverage to the national economy, in the global economy is determined by many factors such as region, culture, trade, technological infrastructure, etc.

Identification of the Problem: The abundance of universities naturally evokes competition. As universities start to behave like companies steered according to the economic income and market share in education, it becomes difficult for the students to decide where and which education to take more economically and risk-free[2].

This can put the students in a dilemma between their choice of university and their choice of profession. Many factors, from the personal ones such as age, sex, area of interest to those such as the popular professions of today and the universities' performances, play a role in the choice of university and profession. The success of the university can be determined by the perceived quality of the university. However, the level of perceived quality is different for every university. Thus, some universities are famous nationally and worldwide. National and international organizations that measure the achievement levels of universities conduct periodical studies to shed light on this issue and determine the performance measures. According to Lukman, R., Krajnc, D., & Glavic, P.[3], higher education brings an extra financial burden for students, parents and organizations that provide scholarship, the students can get a quality higher education and other complementary services if they have a scholarship and this affects their future employment opportunities.

The Aim and Importance of the Study: A very commonly utilized perception of quality is innovation. The innovation level of universities comes across as a distinctive feature. The innovativeness of a university creates the perception that the said university is a successful one. Many organizations have

collaborated to measure the level of innovativeness. For instance, Global Innovation Index (GII) is one of the popular organizations which measure this innovativeness. Fundamentally, this organization aims to provide the vision to the institutions and government directors to measure their own performances by measuring innovation. GII comprises three sub-indices that are overall GII, the Innovation Input Sub-Index, and the Innovation Output Sub-Index. GII score is calculated by taking the calculating the mean of Input and Output indices and these two sub-indices are calculated using their own sub-indices. Input index is constituted by *Institutions*, *Human Capital and Research*, *Infrastructure*, *Market Sophistication*, and *Business Sophistication* elements, which are the main pillars of the national economy that comprises innovative actions. Output sub-index is constituted by two foundations, which are*Knowledge and Technology Outputs* and *Creative Outputs*.

Since 2007, GII has been very effective on three fronts. The first one of these is that since the politicians regularly use innovation to evaluate their economies and to identify strategies and consider their innovation ranking as a measurement tool, they adjust themselves according to this index. The second one is that with GII, the institutions measure their own innovation performances and thereby bring together the intellectual capital and the most suitable resource design, and make investments to required areas. The third one is that innovation measures are brought together to stimulate economies and continue to prioritize them. It aims at giving a new shape to the innovation measurement agenda by trying and evaluating innovation measures with new data[4]. It covers 126 economies representing 90.8% of the world population and 96.3% of the global gross domestic product as of 2018 and provides an important tool for detailed measurements for economies and a rich database[5].

While GII measures the innovation performance of the countries, some institutions measure the achievement of universities. However, based on the analysis of previous studies on GII and university achievements, the impact of the innovation environment in countries on university achievement is still unclear. Therefore, the aim of this study was to investigate the relationship between the GII achievements of countries and the international achievements of universities and to determine the effect of the approach to innovation on the perception of university quality.

From an university point of view, with such university qualities, GII creates an innovation environment for the development of universities. GII provides the potential that can have a positive influence on the university achievements through the innovative country environment. In such an environment, it becomes possible to develop more creative and productive research and technologies, which is important for both the university and the global economy. Creating this environment will only make sense with the presence of an interaction here. In terms of demonstrating the relationship between universities and creative, productive, innovative environments, this study adds uniqueness to the literature. This study will form the basis for studies that will be carried out for more successful and innovative universities.

As there is GII that measures the achievement ranking of countries around the world, there are many institutions that measure the achievement ranking of universities. The criteria taken into account by these institutions in achievement ranking may differ from one another.

Studies on GII: The GII index has been the subject of many studies in the literature. For example, in their study, Hu, J. L., Yang, C. H., & Chen, C. P.[6] presents a new method to evaluate national R&D (Research and Development) productivity by comparing R&D productivities of 24 countries between 1998 and 2005. The study applies the distance function approach to estimate national R&D productivity by adding multiple R&D outputs to the stochastic frontier approach. Technological cooperation in business world, and knowledge transfer between higher education institutions and business world are positively associated with national R&D productivity.

Self Organizing Map (SOM), a self-organizing artificial neural network technique, to evaluate potential relationships between regional innovation system components as well as to investigate potential relationships between regional innovation system components and economic growth[7]. As a result, it was found that there is a similar diversity in the components of individual regional innovation systems due to their strong interrelationships. Thus, the positive effects of knowledge-intensive regions on innovation were revealed and it was determined that the economic growth of European regions is associated with country innovation and entrepreneurial activity level.

Using the canonical analysis method in their study Hancıoğlu, Y.[8] was found that there was a significant relationship between both sets of variables. They propose that private sector R&D investments should be encouraged by creating effective policies with new economic and legal regulations. The share of R&D expenditures should be increased, and thus, it will be possible to create a learning and developing society that can go beyond the traditional structure of education and training reforms.

Yıldız, G.[9] was investigated the effect of technological innovation performance of Turkey and EU-15 countries on economic growth levels between 1998-2013. Instead of a single indicator that measures technological performance, Technological Innovation Index (TIE) values were calculated by using the Technology Achievement Index (TAI) and Archibugi-CoCo (Ar-Co) indices, which are widely used in the literature. As a result, it was revealed that Turkey's technological innovation performance does not have a statistically significant effect on the level of economic growth, and it was argued that this result is due to the low level of investment in science and technology in Turkey.

University Performance Ranking Institutions: The objectives of university achievement rankings can be listed as directing the entrance to higher education programs, evaluating the phenomena of the international higher education market, promoting market directions for international universities, and creating positive competition for university founders, educators, and students, and making their voices heard[3].

Achievement performances of universities are measured based on the criteria considered by the institutions measuring this performance. However, there are many controversies on ranking methods. For instance, the emergence of scientific databases such as the Science Citation Index (SCI) and Social Science Citation Index (SSCI), which are one of the criteria in the innovativeness achievement of universities, in 1960, has made it possible to use quantitative scales in ranking the academic and program output[2]. However, evaluation of the studies that have these indices can be biased. Research evaluation studies performed by independent assessors in England found a relationship between three quantitative indicators (business and management, economics and econometrics, and accounting and finance) and the three components of research (research output, value, and research environment). In a study, the assessment was found biased. This issue demonstrates that other bibliometric indicators must also be used in the assessment[10].

Saka, Y., & Yaman, S. study[11], the most followed up university ranking systems in the world were analyzed and the criteria and weighting they used in ranking were compared. According to this, the differences encountered between the ranking results of the four biggest ranking systems Webometrics, ARWU, HEEACT, THES-QS are attributed to the differences between the criteria they ranked. In Turkey, it was found that the basic measure in the reports prepared by Council of Higher Education (YÖK) is the criterion of publication.

In summary, it would be suitable to briefly introduce these institutions that are known by their names. The references used in this study are the institutions that measure the achievements of the universities around the world.

ARWU (Academic Ranking of World Universities): Since 2003, Shanghai Jiao Tong University has been using ARWU system to compare the universities around the world. The criteria used to rank the first 500 universities of the world are the number of alumni (10%) and staff (20%) awarded with Nobel or Fields Medal prize, the number of staff (20%) who are in the list of highly cited researchers, the number of papers published in Nature and Science (20%), the number of papers indexed in SCI[1] and SSCI[2] (20%), and the per capita academic performance of the institution (10%)[12].

HEEACT (Higher Education Evaluation and Accreditation Council of Taiwan): Higher Education Evaluation and Accreditation Council of Taiwanhas ranked since 2007. The criteria of the institution to determine the first 500 universities are the research productivity (25%) based on the number of papers in the last 11 years (10%) and last year (15%), research impact (35%) based on the number of citations in the last 11 years (15%) and the last 2 years (10%) and the average number of citations in the last 11 years (10%), and the research excellence based on the H-index in the last 2 years (10%), the number of highly cited papers (15%) and the number of papers in high impact journals (15%)[13].

THE (Times Higher Education): Times magazine published in the UK provides data that measures the performances of different units (students and their parents, university academics, university leaders, governments, and universities for the industry) since 2004. Unlike other ranking systems, it also utilizes survey data. The following criteria are taken into account in the ranking: The learning environment criteria obtained from the surveys (30%), research criteria based on the data obtained from the surveys and universities (30%), average number of citations per standardized publication (30%), industry-funded projects based on the data obtained from the surveys and the universities (2.5%), international staff, students, and research (7.5%)[14].

Webometrics: Since 2004, universities worldwide are ranked by the Cybermetics Laboratory in Spain based on the following criteria. Size criteria based on 4 search engines (20%), visibility criteria based on the number of links to the webpage of the relevant university (50%), file richness criteria based on the number of academic files in the webpage of the relevant university (15%), and Google Scholar browsing criteria that determine the number of references to the relevant university regarding these files (15%)[15].

Leiden: Since 2008, it is the ranking system used by The Centre for Science and Technology Studies in Leiden University, Netherlands. Unlike other systems, this system ranks for each criterion separately. When determining the evaluation criteria, it takes into account the number of publications browsed by SCI and SSCI in the last 5 years (P), the number of citations per publication (MCS), standardized number of citations per publication (MNCS), the number and proportion of publications that belong to the top 10% most frequently cited (pptop 10%), and the number and the proportion of publications that have been co-authored by other universities (ppcollab)[15].

SCIMAGO: This research institution in Spain began ranking in 2009 and instead of a list that includes all criteria, each criterion is ranked separately. Using the Scopus database, it uses criteria such as the number of publications in the last 5 years (O), International Collaboration (IC), standardized number of citations per publication (IN), the number of papers in the top 25% high-impact journals (Q1), specialization/influence criteria (SI), the number of papers in the top 10% most-cited in their field (ER)[15].

QS: Since ending its collaboration with TIMES magazine in 2010, QS (Quacquarelli Symonds) of the UK has ranked

universities in the world. In the ranking based on surveys, criteria such as academic reputation (40%), employee opinion (10%), number of citations per staff (20%), number of students per staff (20%), rate of foreign students (5%), number of foreign staff (5%)are used[15].

URAP (University Ranking by Academic Performance): URAP Research Laboratory in METU, Turkey, which is known to rank since 2010, takes into account the number of articles browsed via SCI, SSCI and AHCI in the last 1 year (21%), the number of citations given in the last year to articles published in the last 5 years (21%), the sum of the number of articles multiplied by the impact factors of the journals in which they were published (18%), the sum of the number of citations in the last year multiplied by the impact factors of the citing articles (15%), and the number of joint publications between countries (15%) in the last 5 years[15].

Studies on University Performance: It was shown by Aguillo, I. F., Bar-Ilan, J., Levene, M., & Ortega, J. L.[16] that different indices used to compare university rankings can produce different results. While ARWU and HEEACT ranked close to each other, institutions such as THE, QS, Webometrics produced different results as they took other criteria into account in the evaluation. It is thought that indices such as THE and QS do not provide an adequate and representative sample size and evaluate institutions in a specific field (biomedicine), and CWTS does not rank universities with low publication performance, the obtained results are different.

Huang, M. H.[17] was compared the results of the 2009 HEEACT (Higher Education Evaluation and Accreditation Council in Taiwan) and ARWU as well as THE-QS rankings for the world's top three universities. The research revealed that HEEACT ranks fairer as it includes universities that date back a long time and focuses on research performance. In conclusion, it was understood that the performance criteria and indicators in the ranking systems should be well defined in order to interpret the rankings of universities' success correctly.

Aghion, P. studied[18] the ownership structures of the American and European universities and the investment rates from Gross National Product to these universities. The research was based on the Nelson-Phelps model. The study revealed the differences between the ownership structure and management of American and European universities. As a result of this study, it was revealed that as the performance of European universities increases, more investments should be made in higher education.

Akkucuk, U.[19] determined the competitive position of the world economy by using cluster analysis and multidimensional scaling based on the data published by the WEF (World Economic Forum). He suggested analytical methods obtained as a result of different clustering, and recommended investigating locations with more variables.

Goodall, A. H.[20], investigated the effect of the characteristics of department heads in 58 US universities on the research efficiency of the university department based on 15 years of data. In the study, they explained the statistical relationship between the personal characteristics of university administrators and the scientific productivity of university departments using the Granger causality test. As a result, it was shown that there is a concave relationship between university administrators' citations and subsequent department performance.

As can be seen, there are many systems that evaluate university performance and their criteria differ.Based on this, the research question posed is "In order to determine the potential relationship between the success rankings of universities and the GII success rankings, hypotheses were created by using the data of the HEEACT and ARWU success rankings, which measure the success of GII and world universities. The hypotheses created are as follows: i. H_1: There is no relationship between the universities' HEEACT success rankings and the GII success rankings of their countries. ii. H_2: There is no relationship between the ARWU success rankings of the universities and the GII success rankings of their countries. iii. H_3: The distribution of GII achievements of countries does not differ according to their continents. iv. H_4: The distribution of university achievements of countries does not differ according to their continents. v. H_5: The distribution of GII achievements of countries does not differ according to the economic-political groups they are in. vi. H_6: The distribution of university achievements of countries does not differ according to the economic-political groups they are in.

Methodology

In this study, HEEACT and ARWU institutions were chosen because they have complete and appropriate data for the tests and analyses to be used in the evaluation of university achievements. For this, 10 years of data between 2009-2018 were used.Countries without 10-year data or have missing data during this 10-year period were excluded in the study. The ARWU and HEEACT rankings corresponding to the GII values of the countries were taken into account. The number of universities in the top 20, top 100, top 200, top 300, top 400 and top 500 universities according to their GII score in ARWU and HEEACT rankings were used.

In data analysis and hypothesis testing, the Chi-Square Independence test was used. Correlation analysis and Clustering Method were used to investigate whether there is a significant relationship between GII achievements and university achievements. IBM SPSS Statistics 23 software was used to analyze data.

In this study, Chi-Square Independence tests were performed separately between the Global Innovation Index rankings and HEEACT rankings, and between the Global Innovation Index rankings and ARWU rankings.

K-means, one of the oldest clustering algorithm, was developed by J. B. Mac Queen in 1967 [21]. It ensures that each data belongs to only one cluster when grouping data. Therefore, it can be counted as a strident clustering method. The assignment mechanism of K-means, one of the most widely used unsupervised learning methods, allows each data to belong to only one cluster.

In this study, K-Means Clustering Analysis was applied by using the countries' continents, G7, G20 and BRICS memberships, KIE rankings, ARWU rankings and HEEACT rankings.

Results and discussion

GII Classification groups are grouped into three classes. The top 10 countries in the GII were classified as the Top 10, the top 20 countries were classified as the Top 20, and the "other" category was created for the rest. Similarly, the same method was used for ARWU and HEEACT. Accordingly, the Top 100 classification was made for the countries whose universities were in the top 100, and the Top 200 classification was made for the countries that were in the top 200, and the "other" category was used for the groups other than these. Table-1 below shows the ARWU ranking of the universities according to the GII score of their countries.

Based on the values in Table-1, it was found that the universities of the countries that are in the top 10 in the GII ranking were mostly in the top 100 in the ARWU ranking. Although the countries in the top 20 in the GII ranking had a greater number of universities in top 100 in ARWU ranking, the number of universities in top 100 decreased while the number of universities in top 200 and "other" rankings increased significantly. The countries that remained outside the top 20 in GII ranking mostly had their universities outside the top 200 in ARWU ranking.

Based on the values in Table-2, it was found that the universities of the countries that are in the top 10 in the GII ranking were mostly in the top 100 in the HEEACT ranking. Although the countries in the top 20 in the GII ranking had a greater number of universities in top 100 in HEEACT ranking, the number of universities in top 100 decreased while the number of universities in top 200 and "other" rankings increased significantly. The countries that remained outside the top 20 in GII ranking mostly had their universities outside the top 200 in HEEACT ranking.

Results of the Chi-Square Analysis: The hypothesis test results for the GII "Top 10-20" and ARWU "Top 100-200" classifications were given in Table-3. It can be seen that the significance value at the top of the Assymp. Sig. column in Table-3 is p=0.00. Since this value meets the condition $p<0.05$, the relationship between GII top 10-20 achievement level and ARWU and HEEACT top 100-200 achievement level is significant.

Table-1: The GII scores of the countries in which the universities in ARWU top 100, top 200, and "other" rankings.

Countries			ARWU Ranking			Total
			Top 100	Top 200	More 200	
GII	Top 10	Number	31	7	5	43
		% in ARWU	72.1%	16.3%	11.6%	100.0%
		% GII	20.3%	6.5%	0.4%	2.8%
	Top 20	Number	25	10	8	43
		% in ARWU	58.1%	23.3%	18.6%	100.0%
		% GII	16.3%	9.3%	0.6%	2.8%
	More 20	Number	97	91	1246	1434
		% in ARWU	6.8%	6.3%	86.9%	100.0%
		% GII	63.4%	84.3%	99.0%	94.3%
Total		Number	153	108	1259	1520
		% in ARWU	10.1%	7.1%	82.8%	100.0%
		% GII	100.0%	100.0%	100.0%	100.0%

Table-2: The GII scores of the countries in which the universities in HEEACT top 100, the top 200, and "other" rankings.

Countries			HEEACT Ranking			Total
			Top 100	Top 200	more 200	
GII	Top 10	Number	35	3	5	43
		% in HEEACT	81.4%	7.0%	11.6%	100.0%
		% GII	18.5%	5.5%	0.4%	2.8%
	Top20	Number	25	7	11	43
		% in HEEACT	58.1%	16.3%	25.6%	100.0%
		% GII	13.2%	12.7%	0.9%	2.8%
	More 200	Number	129	45	1260	1434
		% in HEEACT	9.0%	3.1%	87.9%	100.0%
		% GII	68.3%	81.8%	98.7%	94.3%
Total		Number	189	55	1276	1520
		% in HEEACT	12.4%	3.6%	83.9%	100.0%
		% GII	353	100.0%	100.0%	100.0%

Table-3: Chi-Square Test between GII "Top 10-20" and ARWU "Top 100-200" Classifications.

Chi-Square Test	ARWU*GII			HEEACT*GII		
	Value	df	Asymptotic Significance (2-sided)	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	351.241[a]	4	.000	318.501[b]	4	.000
Likelihood Ratio	223.137	4	.000	206.364	4	.000
N of Valid Cases	1520			1520		
a. 4 cells (44.4%) have expected count less than 5. b. The minimum expected count is 3.06.				b. 2 cells (22.2%) have expected count less than 5. b. The minimum expected count is 1.56.		

With the correlation analysis, it was shown that the universities in the countries that were successful in GII were mostly successful in ARWU and HEEACT.

Based on this, it can be concluded that there is a medium positive relationship between the GII achievements of the countries and HEEACT and ARWU achievements at 1% significance level, and that the universities in the countries that were successful in GII were mostly successful in HEEACT and ARWU.

Results of the K-means Clustering Analysis: The K-Means Algorithm divided the data into 3 groups as Cluster 0, Cluster 1 and Cluster 2. In the first group (Cluster 0), it was seen that they were not G7, G20 and BRICS countries, they were in the top 10 in GII and in the top 200 in HEEACT.It was observed that those in the second group (Cluster 1) were G7 and G20, but were notBRICS countries, and they were in the top 20 in the GII and the top 100 in the HEEACT. It was revealed that the countries in the third group (Cluster 2) were not G7, G20, and BRICS countries and could not make it to the top 20 in the GII and the top 200 in the HEEACT.

Table-4: Correlation coefficient between GII country scores and ARWU and HEAACT university rankings.

	Correlation coefficient	GII Rank	HEEACT Rank		GII Rank	ARWU Rank
GII Rank	Pearson Correlation	1	.646**	GII Rank	1	.650**
	Sig.(2-tailed)		.000			.000
	N	398	398		417	417
**. Correlation is significant at the 0.01 level (2-tailed).						

Table-5: Clustering analysis results of the universities' achievement rankings and the countries they are in.

Test No	Incorrectly Assigned Instances (%)	Seed Number	Cluster no	Region	G7	G20	BRICS	GII	ARWU	HEEACT	Assigned Instance	Assigned Instances (%)
1	11.6447	9	0	-	No	No	No	Top10	-	Top200	133	9
1	11.6447	9	1	-	Yes	Yes	No	Top20	-	Top100	85	6
1	11.6447	9	2	-	No	No	No	Top20+	-	Top200+	1302	86
2	12.4342	6	0	-	No	No	No	Top20+	Top200+	-	1337	88
2	12.4342	6	1	-	No	Yes	Yes	Top20	Top200	-	84	6
2	12.4342	6	2	-	No	No	No	Top10	Top100	-	99	7
3	20.3289	14	0	North America	-	-	-	Top10	Top100	-	274	18
3	20.3289	14	1	Africa	-	-	-	Top20+	Top200+	-	1144	75
3	20.3289	14	2	Asia	-	-	-	Top20	Top200	-	102	7
4	11.9079	8	0	Africa	-	-	-	Top20+	Top200+	-	1320	87
4	11.9079	8	1	Europe	-	-	-	Top10	Top100	-	151	10
4	11.9079	8	2	Asia	-	-	-	Top20	Top200	-	49	3
5	11.1184	8	0	Africa	-	-	-	Top20+	-	Top200+	1320	87
5	11.1184	8	1	Europe	-	-	-	Top10	-	Top100	151	10
5	11.1184	8	2	Asia	-	-	-	Top20	-	Top200	49	3
6	15.9211	14	0	Europe	No	Yes	No	Top10	Top100	-	227	15
6	15.9211	14	1	Africa	No	No	No	Top20+	Top200+	-	1206	79
6	15.9211	14	2	Asia	No	No	No	Top20	Top200	-	87	6
7	15.8553	50	0	Africa	No	No	No	Top20+	Top200+	-	1216	80
7	15.8553	50	1	Europe	No	No	No	Top10	Top100	-	164	11

7	15.8553	50	2	Asia	No	Yes	No	Top20	Top200	-	140	9
8	12.3026	8	0	Africa	No	No	No	Top20+	Top200+	-	1226	81
8	12.3026	8	1	Europe	No	No	No	Top10	Top100	-	149	10
8	12.3026	8	2	Asia	No	Yes	No	Top20+	Top200	-	145	10
9	15.5921	29	0	Europe	No	No	No	Top20+	Top200+	-	1374	90
9	15.5921	29	1	Asia	No	No	No	Top20	Top200	-	76	5
9	15.5921	29	2	America	No	Yes	No	Top10	Top200	-	70	5
10	15.5921	14	0	America	Yes	Yes	No	Top20	Top100	-	113	7
10	15.5921	14	1	Africa	No	No	No	Top20+	Top200+	-	1320	87
10	15.5921	14	2	Asia	No	No	No	Top10	Top200	-	87	6
11	15.4605	8	0	Africa	No	No	No	Top20+	-	Top200+	1226	81
11	15.4605	8	1	Europe	No	No	No	Top10	-	Top100	149	10
11	15.4605	8	2	Asia	No	Yes	No	Top20+	-	Top200	145	10
12	12.0395	14	0	Europe	Yes	Yes	No	Top20	-	Top100	85	6
12	12.0395	14	1	Africa	No	No	No	Top20+	-	Top200+	1320	87
12	12.0395	14	2	Europe	No	No	No	Top10	-	Top200	115	8
13	17.0395	8	0	Europe	No	Yes	No	Top10	-	Top100	245	16
13	17.0395	8	1	Africa	No	No	No	Top20+	-	Top200+	1210	80
13	17.0395	8	2	Asia	No	No	No	Top20	-	Top200	65	4

Regarding the continents, it was noted that, according to tests 4, 7, and 8, Europe had a country in GII top 10, and there were both GII top 10 countries and countries with universities in HEEACT top 100. Asia was found to have countries in GII top 10 and universities in ARWU top 200 according to test 11 Cluster 2 alone. While Asian continent with countries in GII top 20 had universities in ARWU top 200 according to tests 3, 4, 6, 7, 8, 9, and 10, it only had universities in HEEACT top 200 according to tests 11 and 12.

American continent had countries in GII top 10 and universities ARWU top 200 according to test 9, it was found that there were countries in GII top 20 and universities in ARWU top 100 according to test 10.

Rankings regarding G7 countries are found in Test 1, 10, and 12 clusters. GII top 20 countries and these countries have universities in ARWU and HEEACT top 100 rankings, respectively.

In rankings regarding G20 countries, it can be seen that the countries are in GII top 20 and top 20+ group and although the majority have universities in ARWU and HEEACT top 200 rankings, according to test 10, it was found that they are in both GII top 10 and ARWU top 100. Moreover, according to test 13, GII top 10 and HEEACT top 100 groups gave striking results.

Rankings regarding BRICS countries demonstrated that, according to test 2, there were GII top 20 countries and ARWU top 200 universities.

In short, the results of the hypotheses proposed in this study were summarized in the Table-6.

Table-6: Results of the hypothesis test.

Hypotheses	Methods	Results
H_1: There is no relationship between the universities' ARWU and HEEACT success rankings and the GII success rankings of their countries.	Chi-Square Test	Reject
H_2: There is no positive relationship between the ARWU and HEEACT success rankings of the universities and the GII success rankings of their countries.	Correlation Analysis	Reject
H_3: The distribution of GII achievements of countries does not differ according to their continents.	Clustering(K-Means)	Reject
H_4: The distribution of university achievements of countries does not differ according to their continents.	Clustering(K-Means)	Reject
H_5: The distribution of GII achievements of countries does not differ according to the economic-political groups they are in.	Clustering(K-Means)	Reject
H_6: The distribution of university achievements of countries does not differ according to the economic-political groups they are in.	Clustering(K-Means)	Reject

According to the Table-6, it was concluded that there were not enough data available to accept the proposed hypotheses, therefore, the hypotheses were rejected. The results were discussed in the next section.

Discussion and recommendations: In this study, in order to analyze the relationship between the countries' GII achievements and the achievements of their universities, Chi-square, correlation tests, and K-Means cluster analysis were performed. The results obtained from these tests and analyses were discussed in this section.

As a result of the two-way Chi-Square tests, it was concluded that there is a significant relationship between the GII-HEACT achievements and the GII-ARWU achievements of the countries. Additionally, the universities in the countries that are successful in GII are generally successful in the rankings of HEEACT and ARWU institutions that measure the achievements of universities worldwide.

The results of the correlation tests showed that there is a strong positive linear relationship between the GII rankings and ARWU and HEEACT rankings.Based on these findings, it can be said that countries that are successful in GII provide a suitable innovation environment for their universities and this environment has a positive effect on the increase in universities'achievement. This result is in line with the result of the study by Özerbaş, M. A.[22], in which the academic achievement of students who learn in a creative thinking learning environment was greater than that of the students who learn in a teacher-centered learning environment.

Based on the K-Means Analysis which included the continents, it was concluded that the distribution of GII achievements and university achievements of countries differ according to the continents they are located in. It was observed that while European and American countries are at the top, Asian countries follow them one step behind, while Africa falls behind.

It was observed that the countries in the European continent are mostly clustered in GII top 10, and the universities in these countries are clustered in ARWU and HEEACT top 100. This result is in line with the conclusion of the study[23] that "There is a high correlation between economic development, competitiveness and innovation in European Union member countries".

According to the result of the K-Means analysis, which also included the economic-political groups the countries were in, the distribution of GII and university achievements of the countries varies according to the economic-political groups these countries are in.

It was seen that the G7 and G20 countries ranked as succesful in these rankings, while the BRICS countries were successful but were behind the G7 and G20 countries. It has been revealed that countries in the G20, which is authorized to harmonize economic policy positions and take collective decisions[24] mostly make it to the GII top 20. However, considering that all 3 economic-political groups achieved successful results, it can be said that countries with high economic levels have high innovation environment and university achievement.

Based on the results, it can be said that countries can lead the formation of a research society and increase university achievement by providing the necessary environmental conditions for innovation. On the other hand, the financial income of universities ranked as the best universities in the world by ARWU and THE may directly depend on the fees paid by foreign students. In addition, if the university receives extra funding from foreign states, then it may be more sensitive toward academic studies depending on this issue[25].

Conclusion

Based on the results of this study, it was found that there is a relationship between the countries' GII achievements and their university achievements. This finding is also a preliminary idea for new studies; Does GII achievement affect university achievement, or does university achievement bring the country higher up in the GII rankings? This question should be answered by taking the two-way relationship into account. Innovation inputs can be shaped by the policies of countries. However, innovation outputs can only be shaped by the success of these policies. The innovation environment created by improvements in innovation inputs will support the success of universities, while more successful universities will increase the innovation output of countries with the outputs they generate. This question was not numerically answered in the study and remains open for future studies. Researchers can engage in detailed research on this subject.

In the research, it has been determined that university culture is effective both in the development of innovative universities and in knowledge sharing[26].

In summary, in order to compete with the world's leading universities, it is necessary to create an innovation culture that will increase and support productivity in universities and countries.

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