

# UNIVERSITY QUALITY MEASURES BASED ON GLOBAL RANKING SYSTEMS

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## ABSTRACT

This paper generated an index that marries the Times Higher Education (THE) World University ranking and the Reuters Innovative University ranking through principal component analysis (PCA). This study utilized the descriptive-correlation design to generate an index of university rankings based on the composite of the indicators used in the THE World University and the Reuters Innovative University ranking systems. The PCA also created an index of university rankings based on the composite of the indicators used in the two university ranking systems. The regression analyses showed that the THE World University ranking system has a 100% fit, while the Reuters Innovative University ranking system has an  $r^2$  of 36.54%. Additionally, universities in the United States dominate the rankings in both, with 19 universities included in the top 35 of both ranking systems. After marrying the two ranking systems through the PCA, four principal components were identified. These components include academic competence, returns on innovations, commercial impact, and international outlook. The new or unified ranking system shows that quality tertiary education is a function of academic competence, returns to innovation, commercial impact, and international outlook. The unified university ranking system encompasses the ability to innovate and the ability to produce breakthrough knowledge. Hence, the unified ranking system shows that the universities included in the rankings are resilient universities that can adapt to disruptive changes in society.

**Keywords:** *quality education; higher education; university ranking*



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## INTRODUCTION

Quality is an elusive yet essential consideration in higher education. The Higher Education Funding Council of the United Kingdom published a book enumerating over 3,600 quality indicators. In any event, the global trend in higher education funding, which is to link funding with quality via access to higher education is meaningless unless such education is imbued with globally-accepted quality measures. People generally know when quality is present, however, it is tough to define the term in a precise and readily observable manner.

The Times Higher Education (THE) is the leading data provider underpinning excellence in every continent across the world (World University Rankings, 2017). The data and benchmarking tools produced by THE are utilized by many of the world's most prestigious universities to assist them to achieve their strategic goals. The THE World University rankings are adopted as a geopolitical indicator as well as an aid to a vital measurement of institutions and a crucial factor in the study choices of millions of students around the world. The insights derived allow leadership teams to set reasonable goals and enhance their education and research environment. The data provided by THE enables comparison across more than 1,300 universities (World University Rankings, 2017).

Other data providers for university rankings include the THE's closest collaborator, Quacquarelli Symonds (QS, n.d.) which provides the QS World University Rankings in collaboration with THE. It uses almost the same metrics as THE for ranking universities. A third influential university ranking system is the Academic Ranking of World Universities (Shanghai Ranking, n.d.). These top three prominent ranking systems put heavy emphasis on research and citations which account for more than 50% of the total weight for the universities.

As a consequence, universities in developing and underdeveloped nations have little chance of being listed in the top 100 universities in the world. The general tradition of universities in these countries is teaching/instruction with little or no regard for research. Since the year 2000 developing or underdeveloped nations have taken significant reforms to be included in the list.

Meanwhile, other higher education sectors have taken a different track altogether by revisiting the definition of higher education quality in light of a very competitive environment and disruptive changes in the landscape. For this sector, quality is equated with innovation. In the belief that a university is of quality if it can adapt to changes through innovations, the founders of the idea have shifted from predominantly research-based metrics of THE, QS, and Academic Ranking of World Universities, to innovation metrics such as patents, discoveries, and commercialization.

Universities across the globe are now presented with a plethora of options: (a) use traditional quality metrics based on research and citations, or (b) align themselves with the innovation-based parameters of the 21<sup>st</sup> century. Reuters averred that the world's most innovative universities identify and rank the educational institutions doing the most to advance science, invent new technologies, and power new markets and industries.

This paper attempted to generate an index that marries the traditional and new concepts of quality in higher education through PCA.

## Conceptual Framework

Charles Darwin's evolution theory (*Darwin's Theory Of Evolution*, n.d.) explains that natural selection acts to preserve and accumulate minor advantageous genetic mutations. In this process, members of a species developed a functional advantage where their offspring would inherit that advantage and pass it on to their offspring (*Darwin's Theory Of Evolution*, n.d.; *British Library*, n.d.). Moreover, "natural selection is the preservation of a functional advantage that enables a species to compete better in the wild; it is the same as domestic breeding." Over the centuries, domestic breeding has produced dramatic changes in local animal populations by selecting individuals to breed. Breeders eliminate undesirable traits gradually over time. Similarly, natural selection eliminates inferior species slowly over time (Than, Taylor, & Garner, 2021).

In the context of the present study, the standard set in predominantly research-based metrics of THE, QS, and Academic Ranking of World Universities, and the innovation metrics such as patents, discoveries, and commercialization in Reuters Innovative Universities are paired. In this pairing, the dominant qualities or characteristics of universities in research-based parameters as well as those in innovation universities are identified to come up with a new set of standards that will characterize a university that is most fit to survive the competition.

Meanwhile, Darwin's theory of evolution is applied to characterize a higher social type by social competition between "fit" and "unfit" groups and individuals, whose "fitness" or "value" to society is defined in some ways (Claeys, 2000). A university needs to equip itself with the qualities of a competitive higher learning institution so that it will become fit to compete with other universities in the world. As a result, some governments and universities in Asia, for instance, are confronted with increasing pressure for global university ranking; and have tried to adopt different strategies in terms of special funding schemes, and various forms of measures in shaping teaching, learning, and research activities to enhance their global ranking (Mok, 2015). Nonetheless, a university can become fit by being academically competitive through research; another is by being adaptive to disruptive changes (innovation), and for some reason, some have thrived through the years.

Once a university has found its niche and developed in itself the qualities of both the research and innovative institutions, it becomes resilient. Resilience according to Allen and Angeler (2016) is the amount of disturbance that a system can

withstand before it shifts into an alternative stable state. It is a positive adaptation in the face of adversity (Clifford, & Lemery-Chalfant, 2015). Resilience has gained popularity among both academicians and laypeople, as a term meant to describe a system's ability to withstand disturbance and with uncanny ability to improvise (Glass, 2017). This developed resilient character of a university is comparable to genetic influence on the human person. In twin studies conducted, it was indicated that genetic and environmental factors contribute to both psychological resilience and coping style (Navrady, et al., 2018). Clifford and Lemery-Chalfant (2015) added that genetic influences on protective or promotive factors might have a direct effect or interact with environmental factors. At the neurobiological level, genes may influence the functioning of systems and mechanisms promoting resilience. Apropos to this, the concept of genetics explains that several biological traits can be combined and can make an individual more resilient than others. The same concept can be applied to a university. So that if a university combines all the positive characteristics of top-ranking universities in the world, then that university will become more resilient and fit compared to others.

## METHODOLOGY

This study utilized the descriptive-correlation design to generate an index of university rankings based on the composite of the indicators used in the THE World University and the Reuters Innovative University ranking systems. The PCA merged the indices of the two and created a new ranking system which is referred to throughout this paper as the 'unified ranking system'.

The university scores in the indicators of the two ranking systems served as the raw data in the analysis of this study. The THE World University ranking system has 13 calibrated performance indicators, which are grouped into five and include teaching, research, international outlook, and industry income (World University Rankings, 2017). Meanwhile, the Reuters Innovative University ranking system has 10 indicators. The composite score where the final score is based is composed of the total patents filed, patents granted, and commercial impact (*Top 100 World Innovative Universities – Compare*, n.d.).

The scree plot and the Eigenanalysis of the PCA identified the number of principal components from the raw data. The identified principal components served as the indicators of the unified ranking system.

The sum of the factor loading of each indicator under a principal component multiplied by the score of the university in the mentioned indicator is computed to determine the rank of the universities under the unified ranking system. Finally, the square root of the sum of the squared coefficients of the principal components served as the score of the universities. The ranking of the universities was according to the scores.

Moreover, this paper utilized the concept of material science on resilience to compare the three ranking systems. In particular, the idea of  $\sigma_y$  or the yield strength is adopted in this paper as the variance of the ranking system. The

variance of the ranking system means the ability of the ranking system to accommodate disruptive changes. The higher the variance, the higher the number of uncertainties accommodated by the ranking system, thus the higher its power to rank universities based on their resilience. The variances of the THE World University ranking, the Reuters Innovative Ranking, and the unified ranking system were compared to determine which ranking system has the highest ability to accommodate disruptive changes.

## RESULTS AND DISCUSSION

### Definition of Quality Higher Education

The regression analyses showed that the THE World University ranking system has a 100% fit. The  $r^2$  coefficient means that all the indicators of quality tertiary education used in the THE ranking explain all the variability of the university ranks. The regression model also showed that quality tertiary education is composed of 30% teaching, 30% research, 30% citation, 2.49% industry income, and 7.51% international outlook.

It is apparent that quality tertiary education of the THE World University ranking system is focused on research as 60% of the criteria in ranking the universities is on research and citation. Teaching is given a weight of only 30% in the ranking. Industry income and international outlook have the least influence. A tertiary education focused on research has many benefits. As Gupta (n.d.) enumerated, a tertiary education focused on research will improve teaching, make the students learn more, and enhance professional practice.

Prince, Felder, and Brent (2007) pointed out the potential synergies between research and teaching. However, they are not integrated fully into the undergraduate courses and reach only a limited number of students. Colbeck (1998) suggested combining teaching and research, while Lewis, Perry, and Murata (2006) proposed the use of lesson study, a Japanese form of professional development that centers on the collaborative research of live classroom lessons.

Wayment and Dickson (2008) at Northern Arizona University implemented programs to enhance student participation in research. The results included increased student opportunity to participate in university-wide research conferences, increased student engagement in research activities, increased student satisfaction with the program, faculty, and life skill preparations, and an increase in the number of students who took graduate courses.

On the other hand, the Reuters Innovative University ranking system has an  $r^2$  of 36.54%, which means that the indicators explain only 36.54% of the variability of the university rankings. It also showed that the percentage of patents granted has no significant relationship with the university rank.

The model shows that being innovative represented by the number of patents and the commercial impact score has the most influence on the rank of the universities.

The ranking system shows that teaching and research play minor roles in measuring quality tertiary education. This ranking system measures quality tertiary education in terms of being able to adapt to the fast-changing demands of society. Just like business firms that must continually transform through innovation to meet the needs of society (Mohd Zawawi, et al., 2016), the universities’ innovation rate will also make them more competitive. The critical term is to continually be relevant in society through effects on job generation by way of innovation (*The Impact of Universities on the UK Economy, n.d.*).

**Table 1**  
*Regression analysis of the two leading world university ranking systems*

Ranking System	Indicators	Regression results		
		R <sup>2</sup>	p-value	model
THE World University Ranking	Teaching	100%	0.000	Rank = -0.0196 + 0.299959 Teaching + 0.299943 Research + 0.300037 Citations + 0.025268 Industry Income + 0.075072 International Outlook
	Research		0.000	
	Citations		0.000	
	Industry Income		0.000	
	International Outlook		0.000	
Reuters Innovative University Ranking	Patents Filed	36.54%	0.001	Rank = 18.5 + 0.028 Patents Filed - 15.8 Patents Granted + 0.743 Commercial Impact Score
	Patents Granted		0.340	
	Commercial Impact Score		0.000	

Universities in the United States dominate the rankings in both the Reuters Innovative University and the THE World University rankings with 19 universities included in the top 35 of both ranking systems. The other countries represented by one or more universities in both ranking systems include the United Kingdom, Canada, Netherlands, Germany, and Belgium. Meanwhile, four countries in Asia made it to the top 35 of the rankings showing that some Asian universities are on par with the universities of the world.

The results of the correlation between the two ranking systems showed a significant positive relationship. However, the correlation coefficient indicates that there is only a 44.1% chance that the university’s rank in the Reuters system is the same in the THE system. Since the focus of the two systems is different (Reuters on innovation, while THE on research), a university’s rank in one system is only 44.1% the same in the other system. However, studies particularly by Usher and Savino (2007) and Buela-Casal, et al. (2007) have shown that research is consistently taking the most substantial weight in the ranking.

Gaining a slot in the THE ranking is very difficult for the majority of universities. Meanwhile, becoming an innovative university may not be that acceptable since it would entail undermining instruction and focusing on inventions, and acquiring patents. The alternative route to achieving quality is to marry the two most

prominent world university ranking systems to come up with a hybrid method of measuring quality tertiary education.

**Table 2**

*Comparison of university rankings under the two prominent ranking systems*

University	Country	Reuters Innovative University Ranking	THE World University Ranking
Boston University	USA	70	70
California Institute of Technology	USA	21	3
Columbia University	USA	33	14
Cornell University	USA	16	19
Delft University of Technology	Netherlands	62	63
Duke University	USA	17	17
Emory University	USA	58	98
Free University of Berlin	Germany	100	88
Georgia Institute of Technology	USA	29	33
Harvard University	USA	3	6
Imperial College London	UK	8	8
Johns Hopkins University	USA	19	13
Korea Advanced Institute of Science & Technology	South Korea	11	95
KU Leuven	Belgium	7	47
Kyoto University	Japan	26	74
Leiden University	Netherlands	77	67
Massachusetts Institute of Technology (MIT)	USA	2	5
National University of Singapore	Singapore	63	22
Northwestern University	USA	24	20
Princeton University	USA	64	7
Purdue University System	USA	50	60
Seoul National University	South Korea	34	74
Stanford University	USA	1	3
Tsinghua University	China	44	30
University of British Columbia	Canada	61	34
University of Cambridge	UK	18	2
University of Chicago	USA	51	9
University of Freiburg	Germany	81	82
University of Manchester	UK	53	54

**Table 2** (continuation)

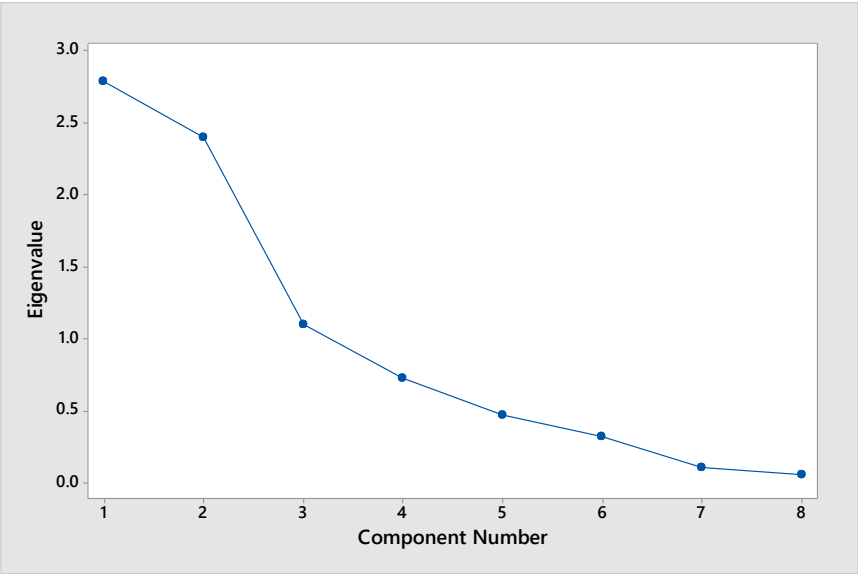
University	Country	Reuters Innovative University Ranking	THE World University Ranking
University of North Carolina Chapel Hill	USA	9	56
University of Oxford	UK	40	1
University of Pennsylvania	USA	4	10
University of Southern California	USA	15	66
University of Toronto	Canada	35	22
Yale University	USA	38	12

Spearman rho correlation for World Innovative University Ranking and THE University Ranking = 0.441  
P-Value = 0.008

**Marrying the Two Prominent Ranking Systems**

This paper employed the PCA to combine the two ranking systems into a unified ranking system. The scree plot showed the four principal components that explain the variability of the consolidated university ranking. Also, the Eigenanalysis showed that the four principal components explain 87.9% of the variability of the unified ranking system.

**Figure 1**  
*Scree plot of the components of the Reuters Innovative University ranking and the THE World University ranking*





**Table 3***Eigenanalysis of the correlation matrix*

<b>Eigenvalue</b>	0.7935	0.4006	0.1066	0.7323	0.4705	0.3290	0.1085	0.0591
<b>Proportion</b>	0.349	0.300	0.138	0.092	0.059	0.041	0.014	0.007
<b>Cumulative</b>	<b>0.349</b>	<b>0.649</b>	<b>0.788</b>	<b>0.879</b>	0.938	0.979	0.993	0.000

Based on the results of the PCA, four principal components were identified, which explain the 87.9% variance of the university rankings. The identified principal components (Table 4) include academic competence, returns on innovations, commercial impact, and international outlook. The academic competence index is composed of teaching, research, and citations. Meanwhile, the returns on innovations index is composed of the number of patents filed, the percentage of the patents granted, and the industry income. Both the commercial impact and international outlook have one variable, which is commercial impact and international outlook, respectively.

**Table 4***Factor loadings of the principal components*

<b>Variable</b>	<b>PC1</b>	<b>PC2</b>	<b>PC3</b>	<b>PC4</b>
Teaching	<b>0.482</b>	-0.220	0.345	0.315
Research	<b>0.459</b>	-0.236	0.467	0.053
Citations	<b>0.438</b>	0.205	-0.244	-0.035
Industry Income	-0.183	<b>-0.460</b>	0.222	-0.435
International Outlook	0.353	0.239	0.141	<b>-0.764</b>
Patents Filed	0.172	<b>-0.543</b>	-0.314	0.167
Patents Granted	-0.339	<b>-0.406</b>	0.215	-0.183
Commercial Impact	0.250	-0.355	<b>-0.624</b>	-0.247

In Table 5, the four indicators or indices, namely academic competence, returns on innovations, commercial impact, and international outlook are used to gauge the status of universities around the world. At a glance, it can be observed that only one university scored high in all the indicators, the rest of the universities scored high in just three, two, or one indicator, while some scored low in all the indices.

The Korea Advanced Institute of Science and Technology (KAIST) has high scores in the four indices which means that the institute has superb performance in all the indicators. Both Kyoto University and the University of Cambridge scored high in three indices. While Kyoto University scored high in returns on innovations, commercial impact, and international outlook, the University of Cambridge scored high in academic competence, commercial impact, and international outlook.

The following universities scored high in both academic competence and returns on innovations: California Institute of Technology, Delft University of Technology, and the Free University of Berlin. Table 5 also shows that the University of British Columbia scored high in both commercial impact and international outlook, while

the Massachusetts Institute of Technology and the University of Manchester had high scores in both returns on innovations and commercial impact. The Seoul National University and Tsinghua University scored high in both returns on innovations and international outlook, while the University of Oxford had high scores in academic competence and international outlook.

Meanwhile, Emory University, Leiden University, and the University of Freiburg scored high in academic competence. Harvard University, Princeton University, and the University of Toronto scored high in commercial impact. International outlook figured high among the Imperial College London, the National University of Singapore, and the University of North Carolina at Chapel Hill, while Boston University scored high in returns on innovations.

In the study by Tabassum, et al. (2017), they analyzed the country-wise influence of all the performance indicators in the last two years and found that the variation of scores in teaching, research, citations, and international outlook mostly influenced the ranking of universities. In this case, however, it can be observed that the distribution is equal among the four indices with 10 universities having a high score in each index. Nevertheless, they acknowledged that ranking is a transitional and ever-changing process which is why a university's ranking varies every year. Meanwhile, the Academic Ranking of World Universities sought to rank research universities in the world by their academic or research performance based on internationally comparable third-party data that everyone can check (Liu, 2015).

Using the THE World University Ranking for 2014, Hazelkorn (2011 in Marginson, 2012) observed that the US had 46% of its universities in the top 100, while Europe had only 35%. However, if the scope is widened to include the top 400 (equivalent to the top 2% of the world's higher education institutions), the US share would drop to 27%, while Europe's would increase to 41%. It is noteworthy, however, that some Asian universities can penetrate the ranking, and in this case, an Asian university can get high scores in all the indices.

**Table 5**  
*University scores according to the identified indices*

University	Academic Competence Index	Returns on Innovations Index	Commercial Impact Index	International Outlook Index
Boston University	1.1583	1.4266	0.2501	0.3956
California Institute of Technology	1.5301	1.249	0.1019	0.4083
Columbia University	0.8226	0.5748	0.1894	0.3077
Cornell University	0.6811	0.4276	0.1692	0.0058
Delft University of Technology	1.4397	1.3265	0.175	0.8119

**Table 5** (continuation)

University	Academic Competence Index	Returns on Innovations Index	Commercial Impact Index	International Outlook Index
Duke University	0.6776	0.2551	0.0128	0.2897
Emory University	<b>1.6229</b>	<b>1.1042</b>	0.0914	<b>0.6795</b>
Free University of Berlin	<b>1.6783</b>	<b>1.329</b>	0.148	0.1044
Georgia Institute of Technology	0.199	0.2877	0.0971	0.2399
Harvard University	<b>1.36</b>	0.2099	<b>1.0718</b>	<b>0.4391</b>
Imperial College London	0.8965	0.3713	<b>0.2597</b>	<b>1.1551</b>
Johns Hopkins University	0.7474	<b>1.0609</b>	0.144	0.0535
Korea Advanced Institute of Science and Technology (KAIST)	<b>1.6569</b>	<b>2.6639</b>	<b>0.4245</b>	<b>1.4295</b>
KU Leuven	0.7961	0.3698	0.145	0.0439
Kyoto University	<b>1.2002</b>	<b>1.251</b>	<b>0.4541</b>	<b>1.7176</b>
Leiden University	<b>1.3696</b>	0.1256	0.1519	0.0493
Massachusetts Institute of Technology	<b>1.2825</b>	<b>2.288</b>	<b>2.9711</b>	<b>0.7738</b>
National University of Singapore	0.244	0.2905	0.105	<b>1.1212</b>
Northwestern University	0.5418	0.1073	0.0759	<b>0.4295</b>
Princeton University	<b>1.275</b>	0.5342	<b>0.6962</b>	<b>0.3967</b>
Purdue University	<b>1.077</b>	0.3282	<b>0.2973</b>	0.0238
Seoul National University	<b>1.1883</b>	<b>1.9101</b>	<b>0.2615</b>	<b>1.493</b>
Stanford University	<b>1.4796</b>	0.3091	<b>0.8117</b>	0.3501
Tsinghua University	0.1653	<b>1.8393</b>	<b>0.3357</b>	<b>1.2007</b>
University of British Columbia	0.3543	<b>1.0627</b>	<b>0.3832</b>	<b>0.9687</b>
University of Cambridge	<b>1.3915</b>	<b>0.7085</b>	<b>0.385</b>	<b>1.0026</b>
University of Chicago	<b>1.144</b>	<b>1.0483</b>	<b>0.2579</b>	0.0111
University of Freiburg	<b>1.6981</b>	0.3817	<b>0.2074</b>	0.0906
University of Manchester	1.0316	<b>1.2901</b>	<b>0.6027</b>	<b>0.8204</b>
University of North Carolina at Chapel Hill	0.6823	<b>0.8169</b>	0.0254	<b>1.1795</b>
University of Oxford	<b>1.4561</b>	0.4299	<b>0.2357</b>	<b>1.0874</b>
University of Pennsylvania	1.0619	0.274	<b>0.3305</b>	0.3405
University of Southern California	<b>1.0866</b>	<b>0.9456</b>	0.0113	0.2685
University of Toronto	0.4145	<b>0.8991</b>	<b>0.3808</b>	<b>0.456</b>
Yale University	<b>1.0677</b>	<b>0.9467</b>	0.1666	0.2007

The return to innovation index is given slightly higher importance in the unified ranking system. Meanwhile, the other three indices have almost equal weight with academic competence - 1.40%, commercial impact - 24.61%, and international outlook - 23.46%.

The unified ranking system shows that quality tertiary education is a function of academic competence, returns to innovation, commercial impact, and international outlook. For a university to survive in the competitive world of university rankings, it must excel in these four categories.

**Table 6**  
*Weights of the indices*

Index	Weight
Academic Competence	21.40%
Returns on Innovation	30.53%
Commercial Impact	24.61%
International Outlook	23.46%
<b>Total</b>	<b>100.00%</b>

**Table 7**  
*University rankings based on the unified index*

University	Unified university index	Rank
Massachusetts Institute of Technology	4.0381	1
Korea Advanced Institute of Science and Technology (KAIST)	3.4735	2
Seoul National University	2.7126	3
Kyoto University	2.4823	4
Tsinghua University	2.2282	5
Free University of Berlin	2.1485	6
Delft University of Technology	2.1265	7
Emory University	2.0792	8
California Institute of Technology	2.0195	9
University of Manchester	1.9403	10
Boston University	1.8963	11
University of Cambridge	1.8952	12
University of Oxford	1.8822	13
Harvard University	1.7987	14
University of Freiburg	1.7551	15
Stanford University	1.7511	16
Princeton University	1.5978	17
The University of North Carolina at Chapel Hill	1.5889	18
University of Chicago	1.5730	19

**Table 7** (continuation)

University	Unified university index	Rank
Imperial College London	1.5308	20
University of British Columbia	1.5297	21
University of Southern California	1.4653	22
Yale University	1.4506	23
Leiden University	1.3846	24
Johns Hopkins University	1.3068	25
University of Pennsylvania	1.1949	26
National University of Singapore	1.1883	27
Purdue University	1.1647	28
University of Toronto	1.1547	29
Columbia University	1.0666	30
KU Leuven	0.8908	31
Cornell University	0.8219	32
Duke University	0.7799	33
Northwestern University	0.7038	34
Georgia Institute of Technology	0.4352	35

Spearman rho for World Innovative University Ranking and Unified University Index

Ranking = -0.123

P-Value = 0.483

The results of the correlation suggest that the created index is unrelated to the THE World University ranking and the Reuters Innovative University ranking. The index is a new index that depicts an entirely new way of evaluating quality tertiary education by ranking the universities.

The main criterion for the THE World University ranking is research, which depicts the universities' robustness as pillars of academic excellence. The universities with the highest performance in research and citations are regarded as the sturdiest universities. Meanwhile, the Reuters Innovative University ranking is focused on innovation, which depicts the ability to adapt to abrupt and violent changes in society. The universities which can adjust to sudden changes are the ones that are most likely to survive in competition. The unified ranking system, which is the result of the combination of the THE and the Reuters ranking systems depicts sturdiness and adaptability.

## Resilience

The key to providing quality higher education is the resilience of universities. Common in the definitions of organizational resilience (Kantur, 2015; Tengblad & Oudhuis, 2018) is reliability, the capacity to change, and integrity. Organizational resilience means "the ability of an organization to anticipate, prepare for, respond, and adapt to incremental change and sudden disruptions to survive and prosper." (*Organizational Resilience: A summary of academic evidence, business insights and*

*new thinking*, n.d.) In material science, resilience is the ability of a material to absorb energy when it is deformed elastically, and release that energy upon unloading (Campbell, 2008). The formula is

$$U_r = \frac{\sigma_y^2}{2E} = \frac{\sigma_y * \epsilon_y}{2}$$

Where  $U_r$  is the modulus of resilience,  $\sigma_y$  is the yield strength or the variance of  $y$ ,  $\epsilon_y$  is the yield strain, and  $E$  is Young's modulus (Campbell, 2008). The concept of  $\sigma_y$  or the yield strength is adopted in this paper as the variance of the ranking system. The variance of the ranking system means the ability of the ranking system to accommodate disruptive changes. The higher the variance, the higher the number of uncertainties accommodated by the ranking system, thus the higher its power to rank universities based on their resilience.

Table 8 shows the relative variances of the three ranking systems. The data indicate that the unified university ranking system has the most substantial variance of 0.731, followed by the THE World University ranking system with 0.0986, and the Reuters Innovative University ranking system with 0.0206. Since the unified university ranking system encompasses the ability to innovate and the ability to produce breakthrough knowledge, it has the highest variance of the three systems. However, that statement does not undermine the strength of the THE and the Reuters ranking systems to rank universities to the real standing of universities in the world quality higher education competition. What the unified ranking system shows is that a university, which is innovative to adapt to disruptive changes in the world and at the same time is reliable in producing breakthrough knowledge will stand out in the rankings.

**Table 8**  
*Comparative variances of the three ranking systems*

Ranking System	Variance
Times World university ranking system	0.0986
Reuters innovative university ranking	0.0206
Unified ranking system	0.731

**CONCLUSION**

This paper generated an index that marries the traditional and new concepts of quality in higher education through PCA. The unified ranking system shows that quality tertiary education is a function of academic competence, returns to innovation, commercial impact, and international outlook. The unified university ranking system encompasses more than the ability to innovate and the ability to produce breakthrough knowledge. Hence, the unified ranking system has the highest variance of the three methods and shows that the universities included in the ranking are resilient universities that can adapt to disruptive changes in society.

Universities should develop and strengthen not only teaching but more critical research and innovations to become resilient. Moreover, the same universities must establish their commercial impact and advance their international outlook through research, scholarships, and other types of collaborations.

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