Evaluating Research Performance of Leading Pakistani Universities: A Grey Relational Analysis

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ABSTRACT

Universities play a crucial role to educate societies. Students select high-quality educational institutes by vetting their ranking criteria for advancement in career and growth. Aim of this study is to evaluate research performance of nineteen major universities of Pakistan. The overall design of the study consists of reviewing relevant literature, elicitation of secondary data and quantitative analysis. This study uses Grey Relational Analysis (GRA) as a technique of investigation. The study has shown that Quaid-e-Azam University occupies top position whereas the University of Lahore comes on the nineteenth position. The ranking has been developed on the basis of selected criteria such as published research articles, the total number of citations, total documents counts (i.e. conference papers, reviews, letters, discussions, scripts in addition to journal articles published), citation impact total, article impact total and international collaborations. This study provides expedient cognizance to regulators, management, students, parents and other stakeholders at large. It could evaluate only nineteen universities on the basis of the limited number of selected criteria, future studies may consider a large number of institutions with a multitude of different criteria.

Keywords: *research performance, ranking, grey system theory, GRA, universities, Pakistan*

Introduction

Education is a leading indicator of increased economic growth and economic stability of nations (Ozturk, 2008). In the last few decades, higher education has moved from the edge to the centre of governmental agendas worldwide. Universities are now playing a vital role in the education system both at national and international levels. They are instrumental in reshaping policy priorities, intellectual capital and innovative thinking (Sánchez, & Elena, 2006). They have become hubs of international resources, novelty, and business incubations (HEC, 2019). They play a pivotal role in articulating agendas of social justice, mobility, socio-cultural development, public health and well-being. Universities perform a vital role in educational systems by way of helping societies to embark on the arena of skills and knowledge (Gunasekara, 2006). They are contributory to transform peoples' lives through the wider influence of education and research (Ertugrul, et al. 2016). Performance of universities is gauged by stakeholders on a multitude of criteria values to them (Angiola, Bianchi, & Damato, 2018). There is the number of systems prevailing to rank or evaluate academic institutions some of which are subjective and others objective (Ertugrul, et al. 2016). Policymakers, scientists, media, students, parents, society at large are widely concerned about a ranking of universities. Performance measurement of universities is defined as a process of quantifying the actions to evaluate efficiency and effectiveness in disseminating education (Neely, et al. 1995; Alach, 2017).

University administration and management apply a wide variety of methods and tools for measurement of performance of universities (Kim et al., 2010; Chen, Wang, & Yang, 2009). Popular measures focus on output or outcome that, in fact, do not to catch the process of academic activities completely. The world is divided into different blocks viz OECD, European Union, Asian Pacific Rim, Gulf, South African Countries, SAARC, D-8, G-10 etc. some of the blocs are technologically and educationally advance, some are on road to educational development and rather some are lagging behind. Pakistan is one of the countries that are on the road to educational development. In the last decade, Pakistan has made remarkable development in degree-awarding institutions. The score of which has reached to almost 250 degree awarding institutions (HEC, 2019). The Pakistani government has also taken many initiatives to enhance the frontiers of education. It is striving to keep the pace with at least Asian countries. A number of public sector universities were also established in less-developed areas in order to provide equal opportunities to students of disadvantaged backgrounds (Ali, Tariq, & Topping, 2013: Khan, Khan, & Turi, 2017). With the influx of the institutions and a multitude of criteria to evaluate the potential of these institutions, it has become a confusing and complex issue particularly for students and their parents to make a rational decision. Regulators have developed some performance indicators to deliver valuable information about the credibility of educational institutions but still, there is room for further research. The Higher Education Commission (HEC), a government-controlled regulatory body, is accountable to control the affairs of the public sector universities in Pakistan. The government is making rigorous efforts to address the issue linked with quality education since the reforms of HEC has been launched i.e. promoting excellence in learning and developing universities' faculties across the country (Ali et al., 2013). In this context higher education commission of Pakistan (the regulatory body of degree-awarding institutions) and international agencies are continuously ranking educational institutions against multiple criteria in different ways. However, the techniques of ranking, particularly that of HEC, are based on certain individual criteria which do not represent the composite ranking grades of institutions. It is important to rank the institutions through such a technique that accounts for a multitude of institutions with a wide variety of criteria for assessment. Performance ranking plays such a big role in shaping the opinions of current and potential stakeholders about the quality of higher educational institutions. Rankings are significant as a basis for comparisons and as references. The rating is mostly an arbitrary arrangement of indicators that marks what it has in the pre-defined status as a "good" educational institution. Those, who are in favour of ranking, may claim that lack of sound and comparable information, ranking is the best option for determining the quality of universities and higher education institutions. Therefore, this study has considered the multi-criteria assessment technique to rank universities. The main objective of this study is to evaluate the research performance of nineteen major universities of Pakistan based on Grey Relational Grades using secondary data in order to present a rather clearer picture of universities. Rest of the paper is organized as a literature review, methodology, GRA, and conclusion.

Literature Review

Carmona and Sieh (2004) asserted that higher education faced a lot of problems regarding budgets and resource allocation to improve academic performance, education quality effectiveness or efficiency and competitiveness. Efficiency is generally described as the ratio of output to input. The debate on efficiency and effectiveness must be related to different measurements such as inputs and outputs/outcomes (Carmona and Sieh, 2004). The measurements of effectiveness and efficiency vary in accordance with the organizational perspective and goals. Efficiency is a result of multi-dimensional efforts in achieving organizational objectives with the slightest cost. Performance measurement and educational quality issues are high on the agenda of higher education institutions. Performance measurement, effectiveness and efficiency are not simply a fixed format but it is a broad perspective (Alach, 2017). The effectiveness of organizational actions are wants of customers (Neely, 1998). Performance measurement indicators are imperative to be established for ensuring high-quality education in universities (Alach, 2017). They give path and direction to university competitiveness and quality. Alach, (2017) also argued that the degree of maturity in universities is one of the indicators of relatively high performance. It linked performance with organizational culture particularly in New Zealand universities for the period 2008-2013. This study used seventh-element maturity model (Alach, 2017). Importance Performance Analysis (IPA) Model is also a tool to assess performance (Sever, 2015; McLeay, Robson, & Yusoff, 2017). Annamdevula, & Bellamkonda (2016) asserted that periodical evaluation of universities depict student's satisfaction and expectations and they help to find improvement in the allocation of resources in the relevant area. It is also a tool for operative output control and it is an instrumental meet real mission. Evaluation measurement and building performance by the allocation of resources provide a rationale for defect management (Olanrewaju, 2012). UK quasi-market based system approach focused on total quality movement, performance measurement, organizational structure, resource management and educational structure is used for evaluating the performance of universities (Oliver, 1993). Ertugrul, et al. (2016) evaluated ten Turkish universities by using Grey Relational Analyses (GRA) and gave a different insight into rankings. They juxtaposed the results with one of the other rankings of same universities. They asserted that GRA is one of the best methods to evaluate universities and to rank them rational bases. GRA method is a cohesive approach to assess multi-criteria decisions in complex real-life problems (Wu, et al. 2010; Wu, et al. 2012).

Wu, et al. (2011) and Wu, et al. (2012) asserted that many researchers also set performance evaluation catalogues through Balanced Scorecard to expand better education in universities. The performance evaluation of institutions is entailed to utilize multiple criteria decision making because people need to have a spirit of lifelong learning to come across the expanding steps of globalization. Kaplan, (1992) developed balanced scorecard as a model which was aimed to transform vision, mission, strategy, objectives to outcomes. Cullen et al., (2003) considered balanced scorecard useful for managing quality and monitoring performance. Cavicchi and Vagnoni (2018) asserted that the sustainable

development approach helps in quality education and best decision making for universities. It presented an exploratory case study of North Italian University by which was aimed to examine the process of implementation of a sustainability performance measurement (SPM) among stakeholders and indicators and to track the shift toward sustainable development (SD). Beamon (1999) argued that because of uncertainty and ambiguity, quantitative performance measures are preferred over that of qualitative. This argument was based on a survey of university students in India. The purpose of this survey was to test the relationships among quality of service, satisfaction, motivation and loyalty by using structural equation modelling, that showed the direct positive effect of perceived service quality of students on satisfaction, loyalty and motivation (Annamdevula, & Bellamkonda, 2016). Further, Annamdevula, & Bellamkonda, (2016). investigates the relationship between service quality, student satisfaction and student loyalty in Andhra Pradesh India. The satisfaction of students depends on the quality of services provided by the universities. Nizamani, et al. (2019) evaluated the websites of 10 top Pakistani universities from the viewpoint of website designs, whereas, Nouman, & Umer, (2019) investigated navigation systems of websites. Islam, Ali, & Niazi, (2018) investigated the role of entrepreneurial education in the context of Pakistan. Channar, et al., (2018) investigated the problems faced by female researchers in Jamshoro, Pakistan. Ali, & Hussain, (2018) investigated document-based teaching practices and concluded that there is a lack of proper guidelines and it developed a policy framework for regulatory bodies. From the above representation of literature, it is pretty clear that their overall scanty literature regarding performance evaluation of universities in general and there is virtually little research in the context of Pakistan. Research in Pakistan itself is a recent phenomenon therefore research on the issue in hand is too nascent. Worldwide it is hot to rank universities on the basis of research activities therefore it is imperative to evaluate Pakistani degree-awarding institutions on the immaculate basis.

Methodology

This study follows a deductive approach with positive philosophy. Secondary data is obtained from the Middle East Technical University Ranking by Performance Research Laboratory (URAP). It is a cross-sectional study with mono method statistics approach. In present-day, authors use a number of Multi-Criteria Decision Making Techniques (MCDMT) to evaluate and compare the performance of institutions or firms. It is a system for order of predilection by correspondence to the idyllic solution or analytical hierarchical process, depending on the nature of phenomena under study. Since this research is objected to comparing the universities performance based on various variables compositely, therefore, GRA (also an MCDMT) found appropriate method to evaluate performance (Ho, Dey, & Higson, 2006). Universities are compared on the basis of research productivity as their total impact factor publications, articles, citations or international collaborations.

Grey Relational Analysis: Dr. Deng in 1989 introduced the world of research with a revolutionary theory known as a grey relational theory with its various analytical techniques. In grey analysis multitude of variables are analyzed and the best variables among alternatives are obtained in Multi-criteria decision making. The central goal of the analysis is to collect grey relational coefficient and generate a grey relational

grade. Firstly this theory was introduced to scientific research but after a few years, this approach came out as a link between management and natural sciences. Know it is an interdisciplinary approach. Hung & Chin (2008) defined that grey theory is that based on two system approach, white system and black system. The white system refers to information needed is available and black system refers to information required but not available. A unique relation is established between variables of interest to Grey system includes discerning values that are poorly stated or vague. Grey system technique consists of five components counting grey decisions, grey predictions, grey control, grey programming and GRA. GRA is a well-known technique to discrete data set (Tosun, 2006). Mathematical formulas are used in decision making of multi-attribute case. GRA method is one of the most reliable methods of decision making in management sciences with real data set and mathematical calculations. In a vibrant way, quantitative variables are compared and on the basis of correspondence and discrepancy, a relation is established among variables. In an actual system when experiments cannot be carried out properly, GREY analysis helps to reimburse the deficiencies in statistical regression. In various past studies, this technique is used to analyze impure and incomplete information to construct relation among variables. Various other statistical techniques as correlation or regression can also be used to rank universities but these techniques have certain limitations as requiring a large amount of data to generate the unsatisfied level of results (Chang, Tsai, & Chen, 2003). Grey analysis is an appendage to all such emblematic statistical techniques. To employ the GRA firstly, all variable of interest are arranged into a matrix known as a decision matrix. In the second step from the data matrix, the reference series is generated to find the most suitable value (ideal target) for each variable. In the third step normalization of data set is performed and transformed values in 0-1 interval. In the fourth step, the deviation sequence is generated from the normalized values of the data set. In the fifth step, the grey relational coefficient is calculated. In the sixth step, the grey relational grade is calculated and after getting grade universities are ranked according to the grade they got in the analysis. The highest Grey Relational grade among the alternatives will be the best choice (Huanget al., 2008; Wei, 2011; Lin, Lin & Ko, 2002).

Research Performance Indicators of Universities: Following is the detail of research performance indicators of universities:

1. ***Articles*** are the measures of current scientific productivity. To the research world, scientific activities are introduced with reference to articles carried out in universities. Research articles findings add to the existing knowledge and construct new theories of research. In this paper data of universities articles used from 2012 to 2016.

2. ***Citation:*** is a measure of research impact. How valuable and innovative a study to other researchers is straightly related to the citations they receive. As a paper written by Deng in 1982 on grey analysis introduction received 3116 citations according to Google scholar. That's why; the number of citations of articles defines the performance of universities. In this research, we used a total number of citations received by these universities from 2012 to 2016.

3. ***Total Document:*** is the measure of sustainability and continuity of

scientific productivity. As scientific activities carried out by universities are not limited to articles but also includes papers, conferences, reviews, discussions and journals. These documents are also an indicator of universities scholarly performance. In this study, we took documents for the period of 2012 to 2016. The weight of this indicator is 10%.

4. ***Article Impact Total (AIT):*** Definition and criteria adopted from Ertugrul, et al. (2016) formula is given below:

$$AIT = \sum_{i=1}^{23} \left(\frac{CPP_i}{CPP_{world}}\right) * Articles_i$$

This indicator aims to balance the institution's scientific productivity with the field normalized impact generated by those publications in each field. The weight of this indicator is 18%.

5. ***Citation Impact Total (CIT):*** Definition and criteria adopted from Ertugrul, et al. (2016) formula is given below:

$$CIT = \sum_{i=1}^{23} \left(\frac{CPP_i}{CPP_{world}}\right) * Citations_i$$

The contribution of this indicator to the overall ranking is 15%.

6. ***International Collaboration:*** is a measure of global acceptance of a university. International collaboration data, which is based on the total number of articles published in collaboration with foreign universities, is obtained from Incites for the years 2012-2016. The weight of this indicator is 15% in the overall ranking.

Applying Grey Relational Analysis:

Step 1: Created a data set and established a decision matrix of data set using the following formula and prepared Table 1.

$$x_i(k) = \begin{bmatrix} x_1(1)x_1(2) & \cdots & x_1(m) \\ \vdots & \ddots & \vdots \\ x_n(1)x_n(2) & \cdots & x_n(m) \end{bmatrix}$$

Where i=1, 2, 3............n   k = 1, 2, 3 ....m

Table 1: *Decision Matrix of Data Set*

Sr#	University	Article	Citation	Total Doc	AIT	CIT	Collaboration	Total
1	QU	66.39	64.3	30.97	57.29	46.63	47.3	312.88
2	PU	64	63.53	30.41	54.34	45.07	45.74	303.09
3	NUST	63.75	63.11	30.48	54.27	45.04	45.67	302.32
4	UAF	64.42	63.22	30.48	54.11	36.68	45.83	294.74
5	UOK	55.46	45.45	30.1	37.71	18.38	45.4	232.5
6	BZU	54.61	42.98	24.85	38.67	24.62	45.14	230.87
7	GCUF	52.05	37.47	21.13	35.27	25.07	45.04	216.03
8	UOP	63.2	36.53	20.97	30.33	17.04	45.23	213.3
9	UOS	32.71	23.53	14.01	22.11	14.71	39.38	146.45
10	LUMS	15.08	23.13	7.29	19.26	16.58	33.17	114.51
11	GCUL	20.48	17.95	15.45	17	7.45	34.07	112.4
12	UETL	26.74	14.27	8.88	14.82	9.45	29.68	103.84
13	AAU	11.1	20.76	11.11	18.73	14.47	23.02	99.19
14	UOF	13.66	16.15	5.25	11.42	7.88	22.12	76.48

15	KUST	9.96	10.05	3.89	9.92	6.83	21.67	62.32
16	HU	11.95	10.99	4.31	10.08	6.55	18.17	62.05
17	AWKU	11.1	10.43	3.62	7.98	5.85	19.52	58.5
18	UVAS	8.54	8.64	10.77	6.13	2.38	19.07	55.53
19	UOL	9.11	5.33	4.02	4.14	1.83	15.24	39.67

Legends: Universities: Quaid-i-Azam University (**QU**), University of Punjab (**PU**), National University of Sciences & Technology (**NUST**), University of Agriculture Faisalabad (**UAF**), University of Karachi (**UOK**), Bahauddin Zakariya University (**BZU**), University of Peshawar (**UOP**), Government College University Faisalabad (**GCUF**), University of Sargodha (**UOS**), Kohat University of Science & Technology (**KUST**), University of Veterinary & Animal Science (**UVAS**), Hazara University (**HU**), Abdul Wali Khan University (**AWKU**) and University of Lahore (**UOL**). **Criteria:** Published Research Articles (**PRA**), total number of citations (**TNA**), total documents count (**TDC**), citation impact total (**CIT**), article impact total (**AIT**) and international collaborations (**IC**)

In Pakistan, there are many methods which are being used for the ranking of universities in which different standards and criteria are used such as institutional resources, finances, and faculty. Here in table 1, second, third and fourth university shows very close performance in Article generation and Citation of their articles but these universities differ in total scores and establishment years. Therefore, to measure the correlation among comparable sequence and reference sequence a unique approach is adopted in Table 2 to compare universities.

Step 2: Creation of reference series and comparison sequence with the following formula to identify the best alternative for the normalization process and to make a comparison.

$$x_{o=}[x_o(k),\dots\dots\dots x_o(n)] \text{ where } k = 1,2,\dots\dots,n$$

Table 2: *Reference Series and Comparison Matrix*

University	Article	Citation	Total Doc	AIT	CIT	Collaboration
Ref. Series	66.39	64.30	30.97	57.29	46.63	47.3
QU	66.39	64.30	30.97	57.29	46.63	47.3
PU	64.00	63.53	30.41	54.34	45.07	45.74
NUST	63.75	63.11	30.48	54.27	45.04	45.67
UAF	64.42	63.22	30.48	54.11	36.68	45.83
UOK	55.46	45.45	30.10	37.71	18.38	45.4
BZU	54.61	42.98	24.85	38.67	24.62	45.14
GCUF	52.05	37.47	21.13	35.27	25.07	45.04
UOP	63.20	36.53	20.97	30.33	17.04	45.23
UOS	32.71	23.53	14.01	22.11	14.71	39.38
LUMS	15.08	23.13	7.29	19.26	16.58	33.17
GCUL	20.48	17.95	15.45	17.00	7.45	34.07
UETL	26.74	14.27	8.88	14.82	9.45	29.68
AAU	11.10	20.76	11.11	18.73	14.47	23.02
UOF	13.66	16.15	5.25	11.42	7.88	22.12
KUST	9.96	10.05	3.89	9.92	6.83	21.67
HU	11.95	10.99	4.31	10.08	6.55	18.17
AWKU	11.10	10.43	3.62	7.98	5.85	19.52
UVAS	8.54	8.64	10.77	6.13	2.38	19.07
UOL	9.11	5.33	4.02	4.14	1.83	15.24

There is no set standard for creating reference sequence values. In table 2 we used original values to calculate the reference sequence. All indicators are referred on the basis of "Larger the Better" value and the reference series is consist of

the maximum value of the column. To compare universities we need to convert data set into normalize values ranging from 0 to 1. The normalization process is performed in Table 3. **Step 3:** Create a normalize matrix. Data with bigger value effect positively. Eq. 3 is used to normalize data set for larger values.

$$\text{Larger the better } x_{i(k)} = \frac{x_i(k) - \min x_i(k)}{\max x_i(k) - \min x_i(k)},$$

$$\text{S}maller \text{ the better } x_i(k) = \frac{\max x_i(k) - x_i(k)}{\max x_i(y) - \min x_i(k)}$$

$$\text{Ideal the better } x_i(k) = \frac{x_i(k) - x_i b(k)}{\max x_i(k) - x_i \, b(k)}$$

Table 3: *Normalized comparable sequences*

University	Article	Citation	Total Doc	AIT	CIT	Collaboration
QU	1	1	1	1	1	1
PU	0.958686	0.986943	0.979525	0.944497	0.965179	0.9513412
NUST	0.954365	0.97982	0.982084	0.94318	0.964509	0.9491578
UAF	0.965946	0.981686	0.982084	0.940169	0.777902	0.9541485
UOK	0.811063	0.680346	0.96819	0.631609	0.36942	0.9407361
BZU	0.79637	0.63846	0.776234	0.649671	0.508705	0.9326263
GCUF	0.752118	0.545023	0.640219	0.585701	0.51875	0.9295072
UOP	0.944857	0.529083	0.634369	0.492756	0.339509	0.9354336
UOS	0.417805	0.308632	0.37989	0.3381	0.2875	0.7529632
LUMS	0.113051	0.301848	0.134186	0.284478	0.329241	0.5592639
GCUL	0.206396	0.214007	0.432541	0.241957	0.125446	0.5873362
UETL	0.314607	0.151603	0.192322	0.200941	0.170089	0.4504055
AAU	0.044252	0.261658	0.273857	0.274506	0.282143	0.24267
UOF	0.088505	0.183483	0.059598	0.136971	0.135045	0.2145976
KUST	0.024546	0.080041	0.009872	0.108749	0.111607	0.2005614
HU	0.058946	0.095981	0.025229	0.111759	0.105357	0.0913911
AWKU	0.044252	0.086485	0	0.072248	0.089732	0.1334997
UVAS	0	0.05613	0.261426	0.037441	0.012277	0.1194635
UOL	0.009853	0	0.014625	0	0	0

In Table 2 we only have "larger the better" criteria, that's why we used equation 3. For example, the value of Article for UAF is calculated as follows:

$$x_{i(\gamma)} = \frac{x_i(\gamma) - \min x_i(\gamma)}{\max x_i(\gamma) - \min x_i(\gamma)}$$

$$x_{4(1)} = \frac{x_4(1) - \min x_4(1)}{\max x_4(1) - \min x_4(1)}$$

$$x_{4(1)} = \frac{64.42 - 8.54}{66.39 - 8.54}$$

$$x_{4(1)} = 0.96595$$

All the values are normalized. After obtaining normalized valued a deviation sequence is generated between comparable sequence and reference sequence to measure grey co-efficient in Table 4.

Step 4: Obtaining absolute values by calculating Deviation sequence from desires value.

$$\Delta_{0(\gamma)=}|x_0 * (\gamma) - x_1 * (\gamma)|$$

Table 4: *Deviation Sequence*

University	Article	Citation	Total Doc	AIT	CIT	Collaboration
QU	0	0	0	0	0	0
PU	0.041314	0.013057	0.0204753	0.055503	0.034821	0.048659
NUST	0.045635	0.02018	0.0179159	0.05682	0.035491	0.050842
UAF	0.034054	0.018314	0.0179159	0.059831	0.222098	0.045852
UOK	0.188937	0.319654	0.0318099	0.368391	0.63058	0.059264
BZU	0.20363	0.36154	0.223766	0.350329	0.491295	0.067374
GCUF	0.247882	0.454977	0.3597806	0.414299	0.48125	0.070493
UOP	0.055143	0.470917	0.3656307	0.507244	0.660491	0.064566
UOS	0.582195	0.691368	0.6201097	0.6619	0.7125	0.247037
LUMS	0.886949	0.698152	0.8658135	0.715522	0.670759	0.440736
GCUL	0.793604	0.785993	0.5674589	0.758043	0.874554	0.412664
UETL	0.685393	0.848397	0.8076782	0.799059	0.829911	0.549595
AAU	0.955748	0.738342	0.7261426	0.725494	0.717857	0.75733
UOF	0.911495	0.816517	0.9404022	0.863029	0.864955	0.785402
KUST	0.975454	0.919959	0.990128	0.891251	0.888393	0.799439
HU	0.941054	0.904019	0.9747715	0.888241	0.894643	0.908609
AWKU	0.955748	0.913515	1	0.927752	0.910268	0.8665
UVAS	1	0.94387	0.738574	0.962559	0.987723	0.880536
UOL	0.990147	1	0.9853748	1	1	1

Deviation sequence measures how much the values of comparable sequence differ from the reference sequence. If the value of deviation sequence is close to 1, it shows that comparable sequence is distant to the reference sequence and if the value is close to 0, it describes that they are non-distant to each other. For example, deviation sequence of PU for CIT is as follows where 1 is reference sequence and 0.96518 is a comparable sequence.

$$\Delta_{0(\gamma)=}|x_0 * (\gamma) - x_i * (\gamma)|$$
$$\Delta_{2(5)=}|x_0(5) - x_2(5)|$$
$$\Delta_0 = |1 - 0.96518| = 0.03482$$

Step 5: Establish a co-efficient matrix of grey relation system using the following formula.

$$\gamma_{\Delta o} = \frac{\Delta_{\min} + \xi\Delta_{max}}{\Delta_0 (\gamma)_{+ \xi\Delta_{max}}}$$

Table 5: *Grey Relational Coefficients*

University	Article	Citation	Total Doc	AIT	CIT	Collaboration
QU	1	1	1	1	1	1
PU	0.923679	0.97455	0.9606603	0.900085	0.934891	0.911313
NUST	0.916363	0.961206	0.9654077	0.897956	0.933722	0.907701
UAF	0.936236	0.964665	0.9654077	0.893127	0.692427	0.916
UOK	0.725756	0.610013	0.9401856	0.575777	0.442251	0.894032
BZU	0.710601	0.580356	0.690831	0.588008	0.504391	0.881253
GCUF	0.668554	0.523573	0.5815437	0.546867	0.509554	0.876435
UOP	0.900669	0.514977	0.5776135	0.496404	0.430852	0.885635
UOS	0.462024	0.419685	0.4463849	0.43033	0.412371	0.669311
LUMS	0.360504	0.417309	0.3660822	0.411346	0.427073	0.531499
GCUL	0.386517	0.388805	0.4684021	0.397443	0.363754	0.547847

UETL	0.421801	0.370811	0.3823571	0.384894	0.375965	0.476374
AAU	0.343466	0.403766	0.4077829	0.407999	0.410557	0.397668
UOF	0.354234	0.37979	0.3471253	0.36683	0.366312	0.388983
KUST	0.338879	0.352123	0.3355417	0.359389	0.360129	0.384782
HU	0.346968	0.356121	0.3390356	0.360168	0.358515	0.35496
AWKU	0.343466	0.353728	0.3333333	0.350201	0.354543	0.365898
UVAS	0.333333	0.346292	0.40369	0.341867	0.336084	0.362178
UOL	0.335537	0.333333	0.3366154	0.333333	0.333333	0.333333

Values of Table 5 shows the Grey relational coefficients and these are calculated after the deviation sequence where ξ is distinguishing coefficient and its value is taken as 0.5, [0,1]. In literature ξ coefficient also has 0.5 value because of its' a distinguishing value and offers good stability. (Özçelik and Öztürk, 2014). For example,

$$\gamma_{\Delta o} = \frac{\Delta_{\min} + \xi\Delta_{max}}{\Delta_0(\gamma)_{+\xi\Delta_{max}}}$$

$$\Delta_0 = \frac{0.00 + (0.5) \times 1}{0.02018 + (0.5) \times 1} = 0.96121$$

Step 6: Calculate GRA grade. Gray relational grade is calculated after coefficient obtained.

$$\gamma(x_0, x_1) = \sum_{k=1}^{n} \beta_k \gamma[(x_0(1), x_1(\gamma)]$$

Table 6: *Grey Relational Grade*

Sr No.	University Name	Grey Relational Grade
1	Quaid-i-Azam University(QU)	6.000000000
2	University of Punjab(PU)	5.605178160
3	National University of Sciences & Technology (NUST)	5.582356089
4	University of Agriculture Faisalabad (UAF)	5.367862589
5	University of Karachi (UOK)	4.188015304
6	Bahauddin Zakariya University (BZU)	3.955439807
7	University of Peshawar (UOP)	3.706527027
8	Government College University Faisalabad (GCUF)	3.806151511
9	University of Sargodha (UOS)	2.840105812
10	Government College University Lahore (GCUL)	2.513813115
11	Lahore University of Management Sciences (LUMS)	2.552767733
12	University of Engineering & Technology Lahore (UETL)	2.412201981
13	Arid Agriculture University (AAU)	2.371238904
14	University of Sindh (UOS)	2.203275203
15	Kohat University of Science & Technology (KUST)	2.130842137
16	University of Veterinary & Animal Science (UVAS)	2.115767190
17	Hazara University (HU)	2.101169228
18	Abdul Wali Khan University (AWKU)	2.123443648
19	University of Lahore (UOL)	2.005486100

Grey relational grades are equal to the weighted sum of the values and these grades indicate the correlation between the reference sequence and comparable sequence. Grey Relational Grade is computed by obtaining the average of the Grey Relational coefficient. And the criteria weight equal to each other. As the calculation Grey Relation Grade for UAF is following.

$$\gamma(x_0, x_1) = \sum_{k=1}^{n} \beta_k \, \gamma[(x_0\,(1), x_1(\gamma)]$$

$$\gamma(x_0, x_1) + 1.667 \times$$
$$(0.93624 + 0.96467 + 0.96541$$
$$+0.89313 + 0.69243 + 0.91600)$$
$$= 0.89466$$

Here (k) indicates the weight of the kth criterion. β_k is determined by 1.667 as $\frac{1}{6}$.

Step 7: After obtaining Grey relational grade all universities are arranged in ascending order.

Table 7: Proposed Ranking using GRA and Original Ranking

	Proposed Ranking		Original Ranking
1	Quaid I Azam University	1	Quaid I Azam University
2	University of Punjab	2	University of Punjab
3	National University of Sciences & Technology	3	National University of Sciences & Technology
4	University of Agriculture Faisalabad	4	University of Agriculture Faisalabad
5	University of Karachi	5	University of Karachi
6	Bahauddin Zakariya University	6	Bahauddin Zakariya University
7	Government College University Faisalabad	7	University of Peshawar
8	University of Peshawar	8	Government College University Faisalabad
9	University of Sargodha	9	University of Sargodha
10	Lahore University of Management Sciences	10	Government College University Lahore
11	Government College University Lahore	11	Lahore University of Management Sciences
12	University of Engineering & Technology Lahore	12	University of Engineering & Technology Lahore
13	Arid Agriculture University	13	Arid Agriculture University
14	University of Sindh	14	University of Sindh
15	Kohat University of Science & Technology	15	Kohat University of Science & Technology
16	Hazara University	16	University of Veterinary & Animal Science
17	Abdul Wali Khan University	17	Hazara University
18	University of Veterinary & Animal Science	18	Abdul Wali Khan University
19	University of Lahore	19	University of Lahore

An alternative with larger the grade identified the best alternative. Grey Relational Grade is ranked in ascending order. Table7. Represent the comparison of the university according to the Grey Relational Grade. According to the Grey Relational ranking of 3, 4universities and furthermore changed. GRA measures the correlation with the ideal values; it measures the relative performance of another. Therefore, the results evaluated the reasonable.
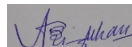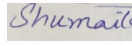
Discussion & Conclusion

To bring social change, educational institutions shape our attitudes, transmit the updated knowledge and cultural values to the next generation. Aim of this study is to evaluate research performance of nineteen

major universities of Pakistan. It is important to rank the institutions through such a technique that accounts for a multitude of institutions with a wide variety of criteria for assessment. Ranking plays a crucial role in shaping opinions of current and potential stakeholders about the quality of education and research being imparted by universities. There are multiple methods to rank but GRA is one of the reliable scientific methods resolve the issue in hand. GRA is a well-known technique to handle discrete data set using incomplete/insufficient information. It is one of the most reliable methods of decision making in management sciences since it uses mathematical calculations having parental authority over statistical techniques of data analysis. Statistical techniques like correlation or regression can also be used to rank universities but these techniques suffer certain limitations and they also require a lot of data, hence, GRA is an appendage to all such emblematic statistical techniques. Therefore, the study used GRA for ranking that provides valuable insights into the phenomenon. The ranking has been developed on the basis of selected criteria such as published research articles, a total number of citations, total documents count (i.e. conference papers, reviews, letters, discussions, scripts in addition to journal articles published), citation impact total, article impact total and international collaborations. Results of the study divulge that Quaid-e-Azam University occupies top position whereas the University of Lahore comes on the nineteenth position which is similar to that of University Ranking by Academic Performance (URAP) Research Laboratory. The analysis further showed that some of the ranks are similar and some different. The study avowed most of the

ranks of URAP but a bit diverged e.g.: i) Government College University Faisalabad and University of Peshawar, ii) Lahore University of Management Sciences and Government College University Lahore, and iii) Hazara University, Abdul Wali Khan University and University of Veterinary & Animal Science. The ranks of these universities are swapped due to changing technique of ranking. This study provides expedient cognizance to regulators, management, students, parents and other stakeholders at large. It could evaluate only nineteen universities on the basis of a limited number of selected criteria, future studies may consider a large number of institutions with a multitude of different criteria.

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