

What Contributes More to the Ranking of HEIs?: Comparative Analysis of Ranking Parameters of India Rankings 2021 in Overall Category using Pearson's Correlation Coefficient

Anil Kumar Nassa¹, Jagdish Arora^{1,*}, Priyanka Singh¹, Hiteshkumar Solanki²

¹National Board of Accreditation, New Delhi, INDIA.

²Information and Library Network Centre (INFLIBNET), Gandhinagar, Gujarat, INDIA.

ABSTRACT

This study conducts correlation amongst five broad categories of parameters of top 100 ranked institutions in the Overall category of India Rankings 2021 to identify their relative significance. This includes i) inter-correlation; ii) intra-correlation; and iii) year-to-year correlation between ranks and scores of institutions as well as long-term correlation at intervals of five years, i.e. 2017 and 2021. The correlation analysis reveals that while RP (Pearson $r = 0.9098$), PR (Pearson $r = 0.8941$), TLR (Pearson $r = 0.7118$) and GO (Pearson $r = 0.5330$) are four major categories of parameters that have good to strong correlation with the total overall score as well as with each other, parameters under O & I correlate strongly with each other but neither total score of O & I nor score of its parameters correlate with total Overall score. Year-to-year correlation between ranking of institutions as well as correlation at intervals of five years is near perfect, which reaffirms consistency and reliability of ranking methodology. Based on intra- and inter-correlation analysis conducted on raw data (rather than on its weighted score), the study identifies 12 parameters that have the highest number of correlations with total TLR, RP, GO, PR as well as total overall score with value of Pearson's r ranging between 0.2500 to 0.9900. These 12 parameters can potentially constitute a compact and coherent set of ranking indicators on which HEIs can focus and ranking agencies may consider regrouping and redistributing weightage to these 12 indicators.

Keywords: Ranking parameters, Ranking indicators, India Rankings, National Institutional Ranking Framework, University ranking, Correlation Analysis, Correlation Coefficient.

Correspondence

Jagdish Arora

National Board of Accreditation,
New Delhi, INDIA.

Email id: prof.jarora@gmail.com

ORCID ID: 0000-0002-4809-7361

Received: 21-09-2022

Revised: 27-10-2022

Accepted: 10-11-2022

DOI: 10.5530/jscires.11.3.33

INTRODUCTION

The National Institutional Ranking Framework (NIRF), released in September 2015 by the Ministry of Education, Government of India provides a broad framework of parameters and their weightage for various categories and subject domains for rankings institutions of higher education in India. The NIRF was first implemented for the maiden edition of India Rankings in April 2016 in four categories and subject domains, namely Universities, Engineering, Management and Pharmacy. From 2017 to 2021, over a period of six years, new categories and subject domains were added including three categories, namely Overall, Colleges and Research Institutions and four subject domains, namely Law, Medical, Architecture and Dental.

India Rankings deploys multidimensional performance parameters, identified and defined in NIRF, that are judged to be true surrogate of quality of teaching, learning and research in institutions of higher education to assess performance of the academic institutions in India in the higher education space. Performance parameters identified and defined in NIRF are grouped in five broad generic groups of parameters, i.e. i) Teaching, Learning and Resources (TLR); ii) Research and Professional Practice (RP); iii) Graduation Outcomes (GO); iv) Outreach and Inclusivity (O & I); and v) Perception (PR). Total score obtained by a participating institution is calculated by adding its score on each sub-parameter under each of the five broad categories of parameters as per methodology for various categories and subject domains available on the NIRF website.^[1] Ranks are assigned based on total weighted sum of marks assigned for each of these five broad groups of parameters. Table 1 lists parameters and their weightage under each of the five generic groups of ranking parameters.

This study conducts three aspects of correlation between top 100 ranked institutions in the Overall category of India

Copyright

© The Author(s). 2022 This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made.

Table 1: Generic Group Parameters used by the India Rankings.

Teaching, Learning and Resources	Research and Professional Practice	Graduation Outcomes	Outreach and Inclusivity	Perception
(0.30)	(0.30)	(0.20)	(0.10)	(0.10)
Student Strength (20)	Publications (35)	Placement & Higher Studies (40)	Regional Diversity (30)	Employers Perception
Faculty Student Ratio (30)	Citations (35)	University Exams (15)	Women Diversity (30)	Academic Peers
Faculty with Ph.D. (25)	Research Projects (15)	Median Salary (25)	Economically and Socially Challenged Students (20)	Perception (100)
Financial Resources & its Utilization (25)		Ph.D. Students (20)	Physically Challenged Students (20)	

Rankings 2021 to identify relative significance of ranking parameters used for ranking of HIEs by the India Rankings. These three correlations include: i) inter-correlation between five broad categories of ranking parameters; ii) intra-correlation between parameters within each of the five broad categories of parameters; and iii) inter-statistical year-to-year correlation between ranking of institutions as well as long-term correlation at interval of five years, i.e. 2017 and 2021. Based on intra- and inter-correlation analysis using raw values of data instead of its weighted score, that have the highest number of correlations with total TLR, RP, GO, PR as well as total overall score with value of Pearson's r ranging between 0.2500 to 0.9900.

Statistical Correlation in Rankings of HEIs: A Literature Review

Studies have been unable to demonstrate convincingly that there is a positive correlation between teaching ability and research productivity.^[2] As such, ranking based on only research parameters can be a futile exercise since teaching and research are more or less independent activities considering weak correlation between research productivity and undergraduate instruction.^[3] Astin,^[4] further explored the nature of the relationship between research and teaching in the US and concluded that a department that has a strong research orientation in terms of publication of books and articles and research activities has a negative correlation with teaching, hours spent on teaching and advising, commitment to student development, use of active learning techniques in the classroom, and the percentage of faculty engaged in teaching general education courses.

The value of correlation coefficients between the total score and the score of each indicator used in ARWU was above 0.80 for all the top 500 institutions for the year 2003^[5]. Moreover, the scores of different indicators also correlated well among themselves with value of correlation coefficients higher than

0.50, indicating that the set of indicators is a compact and coherent one. Moreover, Saisana, *et al.*^[6] examined correlation between the indicators that are used for ranking of HEIs by ARWU and THES and concluded that the correlation between the ARWU scores and its underlying indicators are stronger than that of THES, indicating that ARWU framework has more overlap of information than in the THES.

Van Raan^[7] observed lack of correlation between the judgement of the experts (opinion / survey) and the citation-analysis based results in THES ranking with value of coefficient of determination, i.e. $R^2 = 0.005$. However, it was observed that HEIs are adopting strategies to improve their position considering close correlation between rankings and reputation.^[8,9]

Chen and Liao^[10] conducted i) inter-correlation among different ranking systems; ii) intra-correlation within ranking systems; iii) correlation of indicators across ranking systems; and iv) impact of different citation indexes on rankings and concluded that 55 % of top 200 universities are covered in all ranking systems. The study revealed significantly stronger correlation and intra-correlation amongst indicators used by ARWU and PRSPWU for ranking which can essentially be a pointer to ranking indicator(s) with high degree of discriminativeness or representativeness. The authors concluded that there is no significant impact of using different citation indexes on the ranking results for top 200 universities.

Cakir *et al.*^[11] conducted rank similarity analysis between national rankings and global rankings filtered for each country and suggested that except for a few instances global rankings do not strongly predict the national rankings. Except in cases of national ranking systems where there is a strong correlation between educational/institutional indicators and size-dependent research output measures.

Moed^[12] conducted an elaborate statistical correlation between identical and semi-identical indicators of 5 ranking systems, namely ARWU, Leiden, THE, QS and U-Multirank using Spearman Rank Correlation method and delve into direction and strength of rank correlation.

Nassa, *et al.*^[13] conducted elaborate statistical inter-correlation amongst nine world university ranking systems as well as intra-correlation within various world university ranking systems at interval of five years (2011–2015; and 2016–2020) and 10 years (2011–2020) and established lack of correlation amongst these nine global university ranking systems for the year 2020. However, intra-correlation within each ranking system is positive and very strong in most of the cases.

MATERIALS AND METHODS

The data for study was taken from the Data Capturing System (DCS) of India Rankings for 100 top-ranked HEIs in overall category for the year 2021. The data on perception of peers and employers was sourced from online perception capturing system of India Rankings in Overall category for the year 2021. Moreover, data on publications, citations, highly cited papers, patent granted, and patent published, etc. are retrieved from third party sources, namely Web of Science, Scopus and Derwent Innovations for the three years, i.e. 2017, 2018 and 2019 applicable for ranking of institutions in the year 2021.

The data thus collected was analysed using Excel (Microsoft 365). Spearman's Rank Correlation Coefficient (Spearman's r) as well as Pearson's Correlation Coefficient (Pearson's r) was computed to determine strength of correlation between various parameters. However, Pearson's r was preferred over Spearman's r since value of Pearson's r was invariably higher than the value of Spearman's r presumably because Pearson's r uses actual data rather than ranks assigned based on the data. For multi-year correlation analysis, top 100 HEIs in overall category were compared for their corresponding ranks in different years of India Rankings in the entire range of ranked institutions to find intra-correlation across years as well as at an interval of five years. For example, 100 institutions ranked in 2021 in Overall category were compared for their corresponding rank in 250 institutions ranked in 2017, 2018, 2019 and 2020 respectively. Moreover, institutions ranked in rank bands were assigned its exact rank in that particular band as available in Data Capturing System to facilitate calculation of correlation coefficient.

Moreover, actual data used for ranking was used instead of its normalized value or weighted score to obtain correlation on raw values of data instead of its weighted score. This essentially means that all 33 parameters or sub-parameters considered in this study are treated equal irrespective of weightage assigned to them under NIRF. Furthermore, in addition to data for broad categories of parameters and parameters within each broad categories, data was also taken for sub-parameters under a parameter. For example, data for expenditure on library, laboratory, operational expenditure and capital expenditure was taken separately under the parameter "Financial Resources and its Utilization" grouped under "Teaching, Learning and Resources". Likewise, data on citations and highly cited publications was taken under the parameter "Quality of Publications" grouped under "Research and Professional Practices".

Correlation Analysis

The correlation analysis is used in this study to measure the strength of association between parameters used for India Rankings as defined in the National Institutional Ranking

Framework (NIRF) for Overall Category. Both statistical methods to conduct correlation analysis, namely Pearson's Product Moment Co-efficient of Correlation (Pearson's r) and Spearman's Ranks Order Coefficient Correlation (Spearman's r) have been used in this study.

The value of correlation coefficient ranges from -1 to +1. When there is a perfect positive correlation, the value of correlation coefficient is equal to +1 and it is -1 in case of perfect negative correlation which is rare in real-life situation. As such, correlation coefficient is considered i) "very high" or "very strong" when its value ranges from 0.75 to 1.00; ii) "high" or "strong" when its value ranges from 0.50 to 0.74; iii) "Moderate" when its value ranges from 0.25 to 0.49; and iv) "Low" or "weak" when its value is below 0.25.

Ranking Parameters

This study investigates 33 parameters across five major categories of parameters. As such, definition, scope and applications of parameters are not elaborated in this article for the sake of brevity. Detailed definition and scope of parameters used for ranking of HEIs in Overall category is given in the document entitled "Methodology for Ranking of Academic Institutions in India- Ranking metrics for Overall category" available on the NIRF website.^[14] The NIRF ranking is based on the weighted sum of the score of five broad categories of parameters given on Table 2 along with their total weighted score and maximum, minimum mean, median and standard deviation obtained by HEIs amongst top 100 ranked institutions in Overall category. It can be observed that O & I, GO and TLR have the lowest standard deviation of 0.75, 1.88 and 2.83 respectively which means that scores of most HEIs is concentrated around mean values for these parameters, i.e. 5.87 (out of 10) in case of O & I, 14.24 (out of 20) in case of GO, and 17.72 (out of 30) in case of TLR. Whereas Perception and RP have the highest standard deviation of 2.18 and 5.21, which means values of these two parameters are dispersed randomly in relation to the mean, i.e. 10.94 (out of 30) (RP) and 2.39 (out of 10) (PR). TLR has the highest mean score of 17.72 and its minimum score (11.98) is

Table 2: Broad Category of Parameters, Total Weighted Score and Actual Maximum and Minimum Scores by HEIs in Overall Category of India Rankings 2021.

Broad Category of Parameters	TLR	RPC	GO	O & I	PR	Total (Overall)
Total Weighted Score	30.00	30.00	20.00	10.00	10.00	100.00
Maximum	25.68	27.75	20.00	7.84	10.00	86.76
Minimum	11.98	3.10	10.73	3.66	0.15	41.10
Mean	17.72	10.94	14.24	5.87	2.39	51.15
Median	13.86	9.78	13.86	5.75	1.79	48.12
Standard Deviation	2.82	5.21	1.88	0.75	2.18	9.81

Table 3: Intra-Group Correlation amongst Parameters of Teaching, Learning and Resources (TLR).

TLR Parameters	Ph.D. Students (FT)	Ph.D. Students (PT)	Faculty (Total)	Faculty with Ph.D.	Faculty with PG	Faculty Exp <15	Faculty Exp >15	Total TLR	Total (Overall)
Students Strength	<u>0.1924</u>	0.4548	0.9339	0.8385	0.8207	0.9156	0.8269	<u>-0.1873</u>	<u>0.0421</u>
Ph.D. Students (FT)	1	<u>0.0507</u>	<u>0.2147</u>	0.4350	<u>-0.1421</u>	<u>0.1169</u>	0.3569	0.3596	0.6810
Ph.D. Students (PT)		1	0.3699	0.2919	0.3800	0.3948	0.2701	<u>-0.2380</u>	<u>-0.0790</u>
Faculty (Total)			1	0.9211	0.8470	0.9705	0.9031	<u>0.0215</u>	<u>0.1199</u>
Faculty with Ph.D.				1	0.5733	0.8480	0.9137	<u>0.1593</u>	0.3004
Faculty with PG					1	0.8849	0.6532	<u>-0.1722</u>	<u>-0.1578</u>
Faculty Exp <15 yrs						1	0.7730	<u>-0.0157</u>	<u>0.0523</u>
Faculty Exp >15 yrs							1	<u>0.0846</u>	<u>0.2222</u>
Total TLR Score								1	<u>0.7118</u>

(0.75 to 1.00 =“Very High” Typeface=Bold; 0.50 to 0.74-“High” Typeface-*Italics*; 0.25 to 0.49=“Moderate” Typeface=Normal; 0.25 to -0.01=weak or no correlation, Typeface-Underline)

also higher than all other parameters. The total overall score for the top 100 ranked HEIs ranges from the minimum of 41.10 to the maximum of 86.76 which means while the 1st ranked institution secured 86.76, 100th ranked institution secured 41.10 and rest of the 98 HEIs secured total overall score between this range, i.e. difference of 45.66 marks.

Intra-parameter Correlation: Correlation between Parameters of each of the Five Broad Categories of Parameters

The intra-group correlation coefficient is used as a quantitative measure to determine strength of correlation amongst parameters in the same broad category of parameters. This section delves into intra-class or intra-group correlation amongst all the five broad categories of parameters.

Teaching, Learning and Resources (TLR)

Table 3 provides values of Pearson’s r for various parameters under the broad category “Teaching, Learning and Resources (TLR)”. All parameters under TLR correlate very strongly with each other in most of the cases, except for number of Ph.D. students (FT and PT) which has weak to moderate (even negative in some cases) correlation with all other parameters. Moreover, correlation between individual parameters and total TLR score, or total overall score is either very weak or even negative. However, total TLR score correlates strongly with Total Overall Score ($r=0.7118$). Moreover, number of fulltime Ph.D. students have strong correlation with total overall score ($r=0.6810$) whereas parttime Ph.D. students is negatively correlated with the total overall score ($r=-0.0790$).

Out of 45 values of Pearson’s r given in Table 3 (barring 10 values where Pearson’s $r=1$, which represent correlation with a parameter with itself), 18 values (40%) are between -0.001 and 0.249, 10 values (22.22%) are between 0.25 and 0.49, 4 values (8.89%) are between 0.50 and 0.74 and 13 values

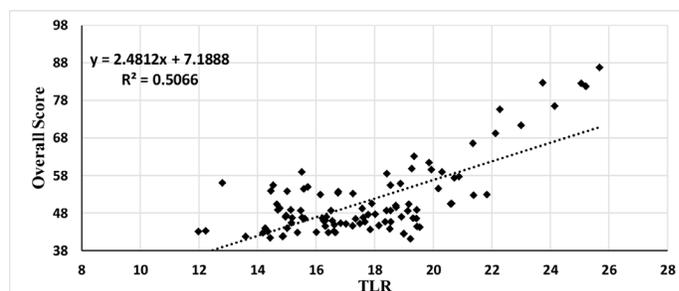


Figure 1: TLR V/s Total Overall Score.

(28.89%) are between 0.75 and 0.99. In other words, 27 out of 45 (60%) values of Pearson’s r reveal moderate to very strong correlation and remaining 18 values (40%) of Pearson’s r reveal weak or no correlation amongst various parameters of TLR.

Figure 1 is a scatter plot between the total TLR score and total overall score which depicts strong correlation between these two scores. The relationship between the two is represented by a linear regression equation, i.e. $\hat{y}=m.x+b$, where \hat{y} is predicted variable (overall total score), x is value of independent variable (total TLR score), m or slope is change in \hat{y} when x increases by one unit. b is Y intercept, i.e. value of Y when x is 0.

The strength of correlation between total overall score and total TLR score is shown in scatter plot (Figure 1) by the linear regression equation, i.e., $\hat{y}=2.4812x + 7.1888$ with value of $r = 0.7118$ and its determination, i.e., $R^2 = 0.5066$, which means that in approximately 51% of variation in Overall score occurred by TLR score independently. It can be observed that TLR score of HEIs is distributed around the mean score of 17.72 and most of the top-ranked 100 institutions are clustered between total TLR score of 14 and 20.

Table 4: Intra-Group Correlation amongst Parameters of Research and Professional Practices.

RP	Citations	HCP (Top 25)	Patents	Research Grants	Library Exp.	Lab. Exp.	Capital Exp.	Operational Exp.	Total RP	Total (Overall)
Publications	0.9281	0.9582	<i>0.5733</i>	<i>0.6887</i>	<i>0.5299</i>	<i>0.5414</i>	<i>0.5472</i>	<i>0.6214</i>	0.8823	0.8328
Citations	1	0.9608	<i>0.5455</i>	<i>0.7194</i>	<i>0.4528</i>	<i>0.5068</i>	<i>0.4807</i>	<i>0.5626</i>	0.8893	0.8598
HCP (Top 25)		1	<i>0.5444</i>	<i>0.7355</i>	<i>0.4902</i>	<i>0.5088</i>	<i>0.5031</i>	<i>0.5073</i>	0.9180	0.8673
Patents			1	<i>0.6427</i>	<i>0.4492</i>	<i>0.5898</i>	<i>0.5611</i>	<i>0.3489</i>	<i>0.6226</i>	<i>0.6066</i>
Res. Grants				1	<i>0.5867</i>	<i>0.7178</i>	<i>0.6567</i>	<i>0.3422</i>	<i>0.7407</i>	0.8261
Lib. Exp.					1	<i>0.7240</i>	0.8131	<i>0.4229</i>	<i>0.4970</i>	<i>0.5414</i>
Lab. Exp.						1	0.9374	<i>0.3952</i>	<i>0.5405</i>	<i>0.6091</i>
Capital Exp.							1	<i>0.4581</i>	<i>0.4992</i>	<i>0.5740</i>
Oper. Exp.								1	<i>0.3879</i>	<i>0.4572</i>
Total RP									1	0.9098

(0.75 to 1.00 =“Very High” Typeface=Bold; 0.50 to 0.74=“High” Typeface-*Italics*; 0.25 to 0.49=“Moderate” Typeface=Normal; 0.25 to -0.01=weak or no correlation, Typeface-Underline)

Research and Professional Practice (RP)

Table 4 provides values of Pearson’s *r* for various parameters under the broad category “Research and Professional Practice (RP)”. It can be observed that individual parameters under RP correlate strongly to very strongly with each other in most of the cases as well as with total RP score and with total overall score. Moreover, total RP score has very strong correlation with total overall score (0.9098). Maximum value of Pearson’s *r* is 0.9608 and 0.9582 between citations and highly cited publications (HCP) and publications and HCP respectively. Interestingly, expenditure on library has moderate to good correlation with publications, citations, HCP and research grants. Likewise, number of patents has good correlation with publications, citations, HCP, research grants, capital expenditure, total RP and total overall score.

Out of 55 values of Pearson’s *r* given in Table 4 (barring 11 cases where values of Pearson’s *r* is 1, which represent correlation with a parameter or a sub-parameter with itself), 20 values (36.36%) are between 0.25 and 0.49, 23 values (41.82%) are between 0.50 and 0.74, 12 values (21.82%) are between 0.75 and 0.99. In other words, 35 out of 55 (63.64%) values of Pearson’s *r* reveal strong to very strong correlation and remaining 20 values (36.36%) of Pearson’s *r* reveal moderate correlation amongst various parameters of RP.

Interestingly, none of the parameters under RP has Pearson’s *r* in the range of 0.000 to 0.249 which reveals that parameters grouped under RP are compact and coherent with certain degree of overlap or interdependence.

Figure 2 is a scatter plot between the total RP score and total overall score which depicts strong correlation between total RP score and total overall score secured by the HEIs in overall category. The linear regression equation, i.e., $y=1.7152x + 32.386$ with $R^2=0.8277$ as coefficient of determination, where *x* and *y* represent the total RP score and total overall

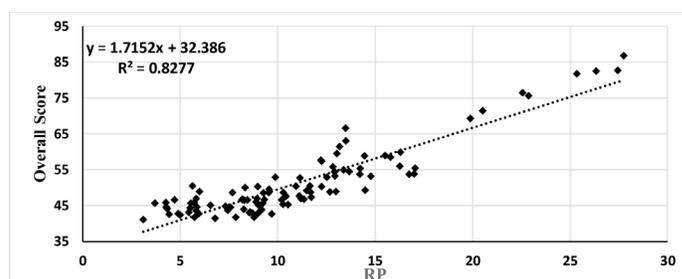


Figure 2: RP V/s Total Overall Score.

score respectively, which means that in 83% of variation are contributed by RP score to achieve best overall score.

Graduation Outcomes (GO)

Table 5 provides values of Pearson’s *r* for various parameters under the broad category “Graduation Outcomes (GO)”. It may be noted that out of four parameters under “Graduation Outcomes (GO)”, only two parameters, namely students graduated (including Ph.D. students graduated) and university examination are used, placement and higher studies and median salary of students placed in jobs are not used as parameters for ranking of HEIs in overall category. It can further be observed that individual parameters under GO has weak or very weak correlation amongst each other as well as with the total GO score and with total overall score. The only exception is Ph.D. students graduated which have very strong and positive correlation with total GO score with 0.8689 as value of Pearson’s *r* which also happened to be the maximum value of Pearson’s *r*. Strength of Pearson *r* between total GO score and total overall score is 0.5330, which is fairly good.

The strength of correlation between total overall score and total GO score is shown in scatter plot (Figure 3) by a linear regression equation $\hat{y}=2.7755x + 11.636$ with $R^2=0.2841$ as coefficient of determination, where *x* and *y* represent the total GO score

and total overall score respectively. Since value or Pearson r and its determination is very low, it cannot be used to predict the value of overall total score with change in total GO score.

Out of 10 values of Pearson's r given in Table 5 (barring 5 cases where values of Pearson's r is 1, which represent correlation with a parameter with itself), 4 values (40%) are between -0.001 and 0.249, 3 values (30%) are between 0.25 and 0.49, 2 values (20%) are between 0.50 and 0.74, and 1 value (10%) is between 0.75 and 0.99. In other words, 6 out of

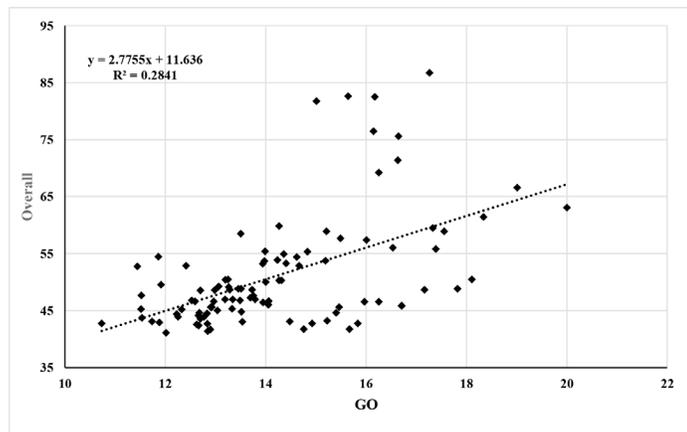


Figure 3: GO V/s Total Overall Score.

Table 5: Intra-Group Correlation amongst Parameters of GO.

Graduation Outcomes	Ph.D. Students Graduated	% of Students Graduated (GUE)	Total GO	Total (Overall)
Students Graduated	0.2985	<u>0.1377</u>	0.3043	<u>0.0475</u>
Ph.D. Students Graduated	1	<u>0.1168</u>	0.8689	0.5346
% of Students Graduated (GUE)		1	0.3016	<u>-0.0403</u>
Total GO Score			1	0.5330

(0.75 to 1.00 = "Very High" Typeface=Bold; 0.50 to 0.74- "High" Typeface-Italics; 0.25 to 0.49="Moderate" Typeface=Normal; 0.25 to -0.01=weak or no correlation, Typeface-Underline)

Table 6: Intra-Group Correlation amongst Parameters of Outreach and Inclusivity (O&I).

Outreach and Inclusivity (O&I)	Int. Students	Women Students	Women Faculty	EBS&SCS	Tuition Fee Refund	Total O & I	Total (Overall)
Regional Diversity	0.7828	0.7775	0.8426	0.7162	0.8416	0.4441	<u>0.0932</u>
Int. Students	1	0.5623	0.5899	0.5246	0.6335	0.3788	<u>-0.0606</u>
Women Students		1	0.9188	0.6242	0.8996	0.3423	<u>-0.0690</u>
Women Faculty			1	0.7103	0.9044	0.3644	<u>-0.0585</u>
EBS&SCS				1	0.9014	<u>0.2007</u>	<u>0.0300</u>
Tuition Fee Refund					1	0.3100	<u>-0.0234</u>
Total O & I Score						1	<u>0.1600</u>

(0.75 to 1.00 = "Very High" Typeface=Bold; 0.50 to 0.74- "High" Typeface-Italics; 0.25 to 0.49="Moderate" Typeface=Normal; 0.25 to -0.01=weak or no correlation, Typeface-Underline)

10 (60%) values of Pearson's r reveal moderate to very strong correlation and remaining 4 values (40%) of Pearson's r reveal weak or no correlation amongst various parameters of GO.

Outreach and Inclusivity (O&I)

Table 6 provides values of Pearson's r for various parameters under the broad category "Outreach and Inclusivity (O&I)". It can be seen that individual parameters of O & I correlate strongly or very strongly with each other in almost all the cases. However, correlation between individual parameters of O & I with total O & I score is moderate or weak (in case of EBS & SCS) and correlation between individual parameters of O & I with total overall score is negative in most of the cases or very weak in few cases. Maximum value of Pearson's r is 0.9188 and 0.9044 between women faculty and women students and women faculty & tuition fee refund respectively.

Out of 28 values of Pearson's r given in Table 6 (barring 8 values where Pearson's $r=1$, which represent correlation with a parameter or a sub-parameter with itself), 8 values (28.57%) are between -0.001 and 0.249, 5 values (17.86%) are between 0.25 and 0.49, 7 values (25%) are between 0.50 and 0.74 and 8 values (28.57%) are between 0.75 and 0.99. In other words, 20 out of 28 (71.43%) values of Pearson's r reveal moderate to very strong correlation and remaining 8 values (28.57%) of Pearson's r reveal weak or no correlation amongst various parameters of O & I.

Figure 4 is a scatter plot between total O&I score and total overall score which depicts lack of correlation between O&I and total overall score secured by the HEIs in overall category. The linear regression equation shown is scatter plot is $\hat{y}=2.106x + 38.795$ with $R^2=0.0256$ as coefficient of determination. Evidently, since value or Pearson r and its determination is very low, it cannot be used to predict value of overall total score with change in total O&I score.

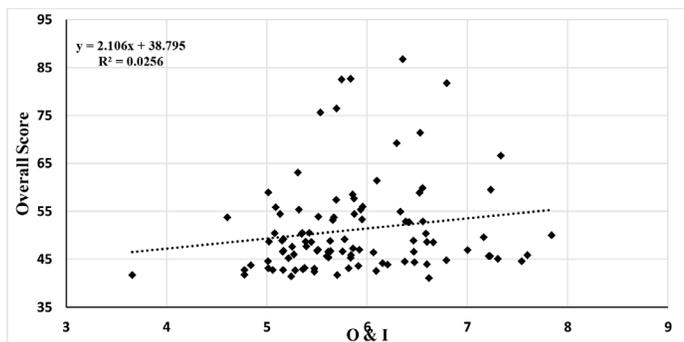


Figure 4: O & I v/s Total Overall Score.

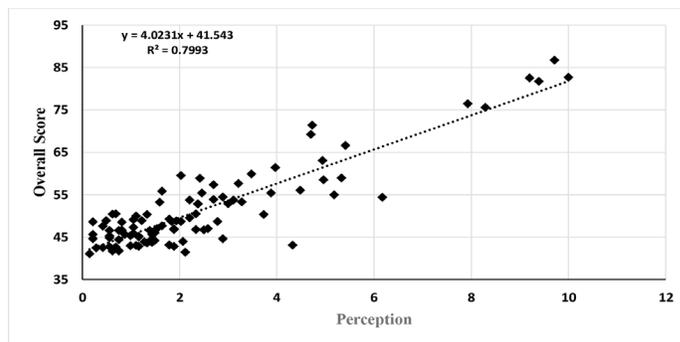


Figure 5: Perception V/s Total Overall Score.

Table 7: Inter-correlation between Top 100 Ranked HEIs and their Scores of Broad Categories of Parameters of India Rankings 2021.

Parameters	RPP		GO		O & I		PR		Overall	
	P r*	S r**	P r*	S r**	P r*	S r**	P r*	S r**	P r*	S r**
TLR	0.4512	<u>0.1493</u>	0.2633	<u>0.1488</u>	0.2898	0.3192	0.5079	<u>0.1771</u>	0.7118	0.4916
RPP	1	1	0.3380	0.3230	<u>-0.0176</u>	<u>0.0036</u>	0.8387	0.6860	0.9098	0.8358
GO			1	1	<u>-0.0255</u>	<u>-0.0750</u>	0.3965	0.3144	0.5330	0.5276
O & I					1	1	<u>0.0678</u>	<u>0.0910</u>	<u>0.1600</u>	<u>0.1874</u>
PR							1	1	0.8941	0.7080

*Pearson’s *r*; **Spearman’s *r*

(0.75 to 1.00 =“Very High” Typeface=Bold; 0.50 to 0.74-“High” Typeface-*Italics*; 0.25 to 0.49=“Moderate” Typeface=Normal; 0.25 to -0.01=weak or no correlation, Typeface-Underline)

Perception (PR)

As mentioned before, Perception (PR) has only two parameters, i.e. academic perception and employer’s perception and scores of these two parameters are added to derive the total score of Perception. As such, intra-group correlation is not possible between these two parameters. However, correlation between Perception (PR) and total overall score is positive and very strong with Pearson’s *r*=0.9098.

Figure 5 is a scatter plot between the total perception score and total overall score which depicts strong correlation between total perception score and total overall score secured by the HEIs in overall category. The linear regression equation, i.e., $\hat{y} = 4.0231x + 41.543$ with $R^2=0.7993$ as coefficient of determination, where *x* and *y* represent the total PR score and total overall score respectively. It means that in 80% of the variation reflected in the Overall score is due to perception score.

Inter-group Parameter Correlation: Correlation between Score of Five Broad Categories of Parameters and the Total Scores in Overall Categories for 100 Top-Ranked Institutions

The inter-group or inter-class correlation coefficient (Pearson’s *r*) is used as a quantitative measure to determine strength of correlation amongst parameters of five broad categories of parameters mentioned above. Correlation

matrix given in Table 7 provides values of Spearman’s Rank Correlation Coefficient (Spearman *r*) and Pearson’s Correlation Coefficient (Pearson’s *r*) between the scores of five broad categories of parameters of the top 100 ranked HEIs for India Rankings 2021 in Overall category.

The values for Pearson’s *r* and Spearman’s *r* in Table reveals the followings

Values for Spearman’s *r* for all parameters is lower than values of Pearson’s *r*. Since Pearson’s *r* uses actual scores that has low range dispersion in comparison to rank that are dispersed from 1 to 100. For example. Overall score is distributed from minimum of 41.10 to maximum of 86.76 (difference of 45.66), that are assigned ranks from 1 to 100. As such, Pearson’s *r* can be considered as more reliable in comparison to Spearman’s *r*.

The value of Pearson’s *r* for GO and O & I with each other as well as with values of Pearson’s *r* of other three parameters is either moderate, low or negative. However, GO has good correlation with total overall score with 0.5330 as value of Pearson’s *r*, whereas O & I has very weak correlation with total overall score (Pearson’s *r*=0.1600)

TLR and RP are moderately correlated with 0.4512 as value of Pearson’s *r*. However, values of Pearson’s *r* between TLR and PR is good (0.5079). It can, however, be observed that TLR correlate positively and strongly with total overall score (0.7118).

The value of Pearson's r between RP and PR is positive and very strong with Pearson's $r = 0.8387$. It can also be observed that RP has near perfect correlation with total overall score with value of Pearson's r as 0.9098.

It can thus be inferred that the values of TLR, RP, GO, and PR and its parameters not only correlate with each other, but scores of their parameters also correlate positively and strongly with the total overall scores of ranked institutions with a few exceptions specially in case of some parameters of TLR and GO. Because value of Spearman's r is higher than the value of Pearson's r , inter-group correlation analysis between parameters of four broad categories of parameters is being done using Spearman's r .

Inter-Group Parameter Correlation: Correlation between Scores of Parameters under Five Broad Categories of Parameters

In-depth correlation analysis using Spearman's r is done amongst parameters of all the five broad categories of parameters, i.e. TLR, RP, GO, O & I and PR in this section of the article. Table 8 to 13 provide values of Pearson's r for various parameters under these five broad categories of parameters. These six Tables (Table 8 to 13) provides values of inter-group Pearson's r for 33 parameters including 27 parameters, 5 broad categories of parameters and total overall score. All permutations and combinations were used to examine correlation amongst all parameters under five broad categories. Duplicate values of correlation across tables (specially correlation of individual parameters with total scores of broad categories of parameters) have been avoided intentionally in the interest of brevity.

Inter-Group Correlation between Scores of Parameters

of TLR and RPP

Table 8 given below provides values of Pearson's r for scores of parameters of TLR and RP. The values for Pearson's r in Table 8 reveals weak or modest correlation between all parameters of TLR and RP with the following exceptions:

Number of full-time Ph.D. students that has good or strong correlation with all parameters of RP as well as with PR.

Expenditure on libraries & laboratories, operational and capital expenditure have good or strong correlation with all parameters of TLR (with exception of student strength in case of expenditure on libraries and laboratories that has weak correlation with student strength).

All parameters of TLR have very weak (modest in few cases) correlation with total score of RP except for fulltime Ph.D. students as mentioned above.

Inter-Group Correlation between Scores of Parameters of TLR and GO

Table 9 given below provides values of Pearson's r for scores of parameters of TLR and GO. The values for Pearson's r reveal weak or modest correlation between all parameters of TLR and GO with a few exceptions mentioned below:

Students graduated is very strongly correlated with all parameters of TLR except for fulltime and parttime Ph.D. students where the correlation is good.

Student strength and number of fulltime Ph.D. students are very strongly correlated with students graduated (Pearson's $r = 0.9566$) and number of fulltime Ph.D. students (Pearson's $r = 0.8566$) respectively for obvious reasons, i.e. number of students and number of full-time Ph.D. students (intake) would obviously be correlated with number of students graduated and number Ph.D. students graduated respectively.

Table 8: Inter-correlation between Scores of Parameters of TLR and RP in Overall Category of India Rankings 2021.

TLR v/s RP	Student Strength	Ph.D. Students (FT)	Ph.D. Students (PT)	Total Faculty	Faculty Exp. < 15 years	Faculty Exp. > 15 years
Publications	0.3952	0.6634	0.1248	0.4028	0.3088	0.5101
Citations	0.2377	0.6836	-0.0152	0.2361	0.1505	0.3534
HCP (Top 25)	0.2319	0.6936	0.0184	0.2268	0.1412	0.3453
Patents	0.2838	0.2565	0.2278	0.3024	0.3054	0.2519
Research Grants	-0.0715	0.5541	-0.0676	0.0307	-0.0149	0.1074
Library Expenditure	0.1710	0.5299	0.4528	0.4902	0.4492	0.5867
Lab Expenditure	0.1392	0.5414	0.5068	0.5088	0.5859	0.7178
Capital Expenditure	0.2769	0.5472	0.4807	0.5031	0.5611	0.6567
Operational Expenditure	0.6358	0.6214	0.5626	0.5073	0.3489	0.3422
Total RP	0.0661	0.5653	-0.0320	0.0827	0.0197	0.1826

(0.75 to 1.00 = "Very High" Typeface=Bold; 0.50 to 0.74 = "High" Typeface=Italics; 0.25 to 0.49 = "Moderate" Typeface=Normal; 0.25 to -0.01 = weak or no correlation, Typeface=Underline)

Table 9: Inter-correlation between Scores of Parameters of TLR and GO.

TLR v/s GO	Students Graduated	Ph.D. Students Graduated	% of Students Graduated	Total GO	Total PR
Student Strength	0.9566	<i>0.1440</i>	<i>0.1173</i>	<i>0.1516</i>	<i>0.0548</i>
Ph.D. Students (FT)	0.2798	0.8566	<i>-0.1861</i>	<i>0.7444</i>	<i>0.6215</i>
Ph.D. Students (PT)	0.4515	<i>-0.0392</i>	<i>0.1069</i>	<i>0.0330</i>	<i>-0.0092</i>
Total Faculty	0.8717	<i>0.1571</i>	<i>0.0672</i>	<i>0.1494</i>	<i>0.0714</i>
Total Faculty with Ph.D.	0.8130	0.3775	<i>-0.0378</i>	0.3207	<i>0.2154</i>
Total Faculty (Masters)	<i>0.7248</i>	<i>-0.1847</i>	<i>0.1931</i>	<i>-0.1235</i>	<i>-0.1440</i>
Faculty < 15 years' Experience	0.8493	<i>0.0708</i>	<i>0.1152</i>	<i>0.0777</i>	<i>0.0200</i>
Faculty > 15 years' Experience	0.7815	0.2874	<i>-0.0282</i>	0.2549	<i>0.1522</i>

(0.75 to 1.00 =“Very High” Typeface=Bold; 0.50 to 0.74-“High” Typeface-*Italics*; 0.25 to 0.49=“Moderate” Typeface=Normal; 0.25 to -0.01=weak or no correlation, Typeface-Underline)

Table 10: Inter-Group Correlation between Scores of Parameters of TLR and O & I.

TLR v/s O & I	Regional Diversity	Int. Students	Women Students	Women Faculty	EBS & SCS	Tuition Fee Refund	Total O & I
Student Strength	0.9168	<i>0.7041</i>	0.8913	0.9058	0.8007	0.9444	0.2573
Ph.D. Students (FT)	<i>0.1058</i>	<i>0.0174</i>	<i>0.1265</i>	<i>0.0372</i>	<i>0.0990</i>	<i>0.1220</i>	<i>-0.0413</i>
Ph.D. Students (PT)	0.3686	0.3223	0.4151	0.4124	0.3449	0.4243	<i>0.0248</i>
Total Faculty	0.8680	<i>0.6613</i>	0.8621	0.9396	0.7610	0.9051	0.3329
Total Faculty with Ph.D.	<i>0.7382</i>	<i>0.5567</i>	0.7767	0.7897	<i>0.6577</i>	0.7984	0.2655
Total Faculty (Masters)	0.8191	<i>0.6318</i>	0.7539	0.8994	<i>0.7037</i>	0.8149	0.3382
Faculty <15 yrs. Exp.	0.8724	<i>0.7005</i>	0.8443	0.9251	<i>0.7405</i>	0.8864	0.3562
Faculty >15 yrs. Exp.	<i>0.7306</i>	0.4927	0.7649	0.8252	<i>0.6838</i>	0.8031	<i>0.2416</i>

(0.75 to 1.00 =“Very High” Typeface=Bold; 0.50 to 0.74-“High” Typeface-*Italics*; 0.25 to 0.49=“Moderate” Typeface=Normal; 0.25 to -0.01=weak or no correlation, Typeface-Underline)

Correlation between Ph.D. students graduated is strong with total score of GO and PR (Pearson’s $r=0.7444$ and 0.6215 respectively). Moreover, while correlation between total faculty and faculty with > 15 years of experience with total GO and total PR score is moderate, correlation between various parameters of TLR with total GO and total PR score is very weak or moderate.

Inter-Group Correlation between Scores of Parameters of TRL and O & I

Table 10 provides values of Pearson’s r for scores of parameters of TLR and O & I. The values for Pearson’s r reveal that all parameters of TLR and O & I are strongly or very strongly correlated except for weak correlation in case of fulltime and parttime Ph.D. students. Furthermore, all parameters of TLR are moderately correlated with total O & I score except for weak correlation in case of fulltime & parttime Ph.D. students and faculty with <15 years of experience.

The highest correlation is Pearson’s $r=0.9444$ between tuition fee refund and students strength, followed by Pearson’s $r=0.9396$ between total faculty and women faculty.

Inter-Group Correlation between Scores of Parameters

of RP and GO

Table 11 given below provides values of Pearson’s r for scores of parameters of RP and GO. The values for Pearson’s r reveal that correlation between most of the parameters of RP with parameters of GO is weak or moderate or even negative in some cases with the following two exceptions:

Correlation between patents and operational expenditure with students graduated is strong, with values of Pearson’s r as 0.7215 and 0.6451 respectively.

Correlation between publications, HCP (Top 25) and citations with Ph.D. students graduated is moderate to good with values of Pearson’s $r = 0.4740, 0.5019$ and 0.4897 respectively.

All parameters of RP, in general, have positive and moderate to very strong correlation with total score of PR, however, their correlation with total score of O & I is negative or weak in all other cases.

Inter-Group Correlation between Scores of Parameters of RP and O&I

Table 12 given below provides values of Pearson’s r for scores of parameters of RP and O & I. Most of the parameters of RP

Table 11: Inter-Group Correlation between Scores of Parameters of RPP and GO.

RP V/s GO	Students Graduated	Ph.D. Students Graduated	% of Students Graduated	Total GO	Total O & I	Total PR
Publications	0.3622	0.4740	<u>-0.1589</u>	0.4249	<u>0.0483</u>	0.7884
Citations	<u>0.2162</u>	<i>0.5019</i>	<u>-0.2165</u>	0.3989	<u>0.0286</u>	0.8353
HCP (Top 25)	<u>0.2116</u>	0.4897	<u>-0.2079</u>	0.4221	<u>-0.0097</u>	0.8356
Patents	<i>0.7215</i>	<u>0.0011</u>	<u>0.1541</u>	<u>0.0364</u>	<u>0.2138</u>	<u>0.0485</u>
Research Grants	<u>-0.0611</u>	0.3954	<u>-0.1650</u>	0.3657	<u>0.0462</u>	0.7843
Library Exp.	<u>0.1366</u>	<u>0.2011</u>	<u>-0.1530</u>	<u>0.1829</u>	<u>0.1561</u>	0.4189
Lab Exp.	<u>0.0942</u>	<u>0.1976</u>	<u>-0.0966</u>	<u>0.2007</u>	<u>0.1978</u>	0.5325
Capital Exp.	<u>0.2309</u>	<u>0.1858</u>	<u>-0.0579</u>	<u>0.2025</u>	<u>0.2446</u>	0.4973
Operational Exp.	<i>0.6451</i>	<i>0.5160</i>	<u>-0.0542</u>	0.4263	<u>0.1259</u>	0.3783

(0.75 to 1.00 =“Very High” Typeface=Bold; 0.50 to 0.74-“High” Typeface-*Italics*; 0.25 to 0.49=“Moderate” Typeface=Normal; 0.25 to -0.01=weak or no correlation, Typeface-Underline)

Table 12: Inter-Group Correlation between Scores of Parameters of RP and O & I.

RP V/s O & I	Regional Diversity	Int. Students	Women Students	Women Faculty	EBS & SCS	Tuition Fee Refund
Publications	0.4006	<u>0.1571</u>	<u>0.2005</u>	<u>0.2228</u>	0.3211	0.2889
Citations	0.2668	<u>0.0650</u>	<u>0.0575</u>	<u>0.0578</u>	<u>0.1861</u>	<u>0.1349</u>
HCP Top 25	0.2616	<u>0.0622</u>	<u>0.0316</u>	<u>0.0322</u>	<u>0.2007</u>	<u>0.1289</u>
Patents	<i>0.7355</i>	<i>0.5372</i>	<i>0.6521</i>	<i>0.7393</i>	0.9991	0.9164
Research Grants	<u>-0.0066</u>	<u>-0.0910</u>	<u>-0.1433</u>	<u>-0.1296</u>	<u>-0.0869</u>	<u>-0.1280</u>
Library Exp.	0.2535	<u>0.1231</u>	<u>0.0933</u>	<u>0.2086</u>	<u>0.1276</u>	<u>0.1250</u>
Lab Exp.	<u>0.1922</u>	<u>0.0675</u>	<u>0.0748</u>	<u>0.1348</u>	<u>0.1925</u>	<u>0.1477</u>
Capital Exp.	0.3373	<u>0.2120</u>	<u>0.1849</u>	0.2826	0.2604	0.2503
Operational Exp.	<i>0.5470</i>	0.2740	<i>0.5366</i>	<i>0.5857</i>	0.4353	<i>0.5358</i>
Total PR	<u>0.0859</u>	<u>-0.0245</u>	<u>-0.0812</u>	<u>-0.0769</u>	<u>0.0556</u>	<u>-0.0143</u>

(0.75 to 1.00 =“Very High” Typeface=Bold; 0.50 to 0.74-“High” Typeface-*Italics*; 0.25 to 0.49=“Moderate” Typeface=Normal; 0.25 to -0.01=weak or no correlation, Typeface-Underline)

have weak to modest or negative correlation with parameters of O & I with the following two exceptions:

Operational expenditure has modest to good correlation with all parameters of O & I which seems logical given the fact that expenditure is committed on various communities of students and faculty represented as parameters of O & I.

Patents have strong or very strong correlation with all parameters of O & I which seems coincidental and cannot be explained.

Inter-Group Correlation between Scores of Parameters of GO and O&I

Table 13 given below provides values of Pearson’s *r* for scores of parameters of GO and O & I. While Ph.D. students graduated and % of Students Graduated (GUE) have no correlation or even negative correlation with parameters of O & I, students graduated is strongly to very strongly correlated with various parameters of O & I, which is logical since students graduated belongs to various categories of students represented by

Table 13: Inter-Group Correlation between Scores of Parameters of GO and O & I.

I&O v/s GO	Students Graduated	Ph.D. Students Graduated	% of Students Graduated
Regional Diversity	0.8147	<u>0.0089</u>	<u>0.0739</u>
International Students	<i>0.6066</i>	<u>-0.0375</u>	<u>0.1162</u>
Women Students	0.9024	<u>0.1674</u>	<u>0.1314</u>
Women Faculty	0.8555	<u>0.0255</u>	<u>0.1122</u>
EBS & SCS	<i>0.7007</i>	<u>-0.0004</u>	<u>0.1540</u>
Tuition Fee Refund	0.8913	<u>0.0872</u>	<u>0.1594</u>
Total GO	0.3043	0.8689	0.3016

(0.75 to 1.00 =“Very High” Typeface=Bold; 0.50 to 0.74-“High” Typeface-*Italics*; 0.25 to 0.49=“Moderate” Typeface=Normal; 0.25 to -0.01=weak or no correlation, Typeface-Underline)

parameters of O & I. It is interesting to note that correlation between students graduated and women students in Pearson’s *r*=0.9024 which is the highest followed by Pearson’s *r*=0.8913 between students graduated and tuition fee refund, which

Table 14: Spearman's *r* as well as Pearson's *r* between ranks of HEIs and between Cumulative Scores on Ranking Parameters in Different Years.

Years	Top 100				Top 50				Top 10			
	Overlap		Correlation		Overlap		Correlation		Overlap		Correlation	
	No.	%	SR	PR	No.	%	SR	PR	No.	%	SR	PR
2017 V/s 2018	75	91.46	0.804	0.946	40	93.02	0.879	0.961	9	90.00	0.901	0.909
2018 V/s 2019	91	93.81	0.934	0.977	45	90.00	0.877	0.972	9	90.00	0.940	0.962
2019 V/s 2020	90	90.91	0.942	0.981	44	88.00	0.944	0.981	10	100.00	0.964	0.960
2020 V/s 2021	94	93.07	0.934	0.982	46	92.00	0.918	0.984	10	100.00	0.939	0.981
2017 V/s 2021	69	93.24	<i>0.737</i>	0.910	33	82.50	0.908	0.908	10	100.00	0.855	0.755
Maximum	94	93.81	0.942	0.982	46	93.02	0.944	0.984	10	100.00	0.964	0.981
Minimum	75	90.91	0.804	0.946	40	88.00	0.877	0.961	9	90.00	0.901	0.909

(0.75 to 1.00 =“Very High” Typeface=Bold; 0.50 to 0.74-“High” Typeface-*Italics*; 0.25 to 0.49=“Moderate” Typeface=Normal; 0.25 to -0.01=weak or no correlation, Typeface-Underline)

Table 15: Ranking Parameters and Number of Correlations with Pearson's *r*= 0.25 to 0.99 and their Correlation with Total Scores of Five Broad Group of Parameters.

Sl. No.	Ranking Parameters	B r o a d Category	No. of Correlations with Pearson's <i>r</i> =		TLR (Total)	RP (Total)	GO (Total)	PR (Total)	Overall Score
			0.25 to 0.9999	0.50 to 0.9999	Value of Pearson's <i>r</i>				
1	Operational Expenditure	RP	29	16	0.2649	0.3879	0.4263	0.3783	0.4572
2	Publications	RP	25	14	0.3637	0.8823	0.4249	0.7884	0.8328
3	Capital Expenditure	RP	24	7	0.3676	0.6226	0.1597	0.5764	0.6066
4	Patents	RP	23	9	0.6456	0.7407	0.3657	0.7843	0.8261
5	Ph.D. Students (FT)	TLR	19	10	0.3596	0.5653	0.7444	0.6215	0.6810
6	Citations	RP	19	11	0.4313	0.8893	0.3989	0.8353	0.8598
7	HCP (Top 25)	RP	19	11	0.3986	0.9180	0.4221	0.8356	0.8673
8	Library Expenditure	RP	19	5	0.4800	0.4970	0.1829	0.4189	0.5414
9	Lab Expenditure	RP	17	11	0.5242	0.5405	0.2007	0.5325	0.6091
10	Research Funds	RP	15	12	0.6456	0.7407	0.3657	0.7843	0.8261
11	Perception (PR)	PR	15	10	0.5079	0.8387	0.3965	1.000	0.8941
12	Ph.D. Students Graduated	GO	14	5	0.2945	0.3588	0.8689	0.4402	0.5346

conveys that a large number of recipients of tuition fee refund are amongst students who graduated.

Of three parameters of GO, students graduated, and graduate examination is moderately correlated with total GO score, whereas Ph.D. students graduated is strongly correlated with total GO score.

Year-to-Year Correlation between Rankings of Institutions

Progressive correlation between ranks and total scores in India Rankings 2017 and 2018, 2018 and 2019, 2019 and 2020 and 2020 and 2021 as well as correlation at interval of five years, i.e. 2017-2021 was carried out to examine year-to-year as well as long-term correlation in Overall category of India Rankings. Both methods of correlation, i.e. Pearson's

Product Moment Co-efficient of Correlation and Spearman's Ranks Order Coefficient Correlation was used to examine correlation between ranks and scores of institutions in overall category over past five years.

Table 14 provides values of Spearman's *r* as well as Pearson's *r* between ranks of institutions and between cumulative scores on ranking parameters between different years progressively at interval rank of 10, 50, and 100 in overall category. Table 12 also provide data on number of overlapping ranks between different years progressively. A very high and positive correlation can be observed from the table.

The maximum Spearman's *r* is 0.964 between ranks of IR 2019 and IR 2020 for the top 10 institutions followed by 0.944 between ranks of IR 2019 and IR 2020 for the top 50

institutions. The minimum Spearman r is 0.804 between ranks of IR 2017 and IR 2018 for Top 100 institutions.

The maximum Pearson's r is 0.984 between cumulative scores on all parameters of IR 2020 and IR 2021 for the top 50 institutions followed by Pearson's r of 0.982 between cumulative scores of IR 2020 and IR 2021 for the top 100 institutions. The minimum Pearson's r is 0.909 between cumulative scores of IR 2017 and IR 2018 for the top 10 institutions.

It can thus be concluded that Pearson's and Spearman's r between ranks of institutions for different years at different rank interval is near perfect in Overall category. Even the minimum correlation coefficient is "Very High", i.e. 0.804 (Spearman's r) and 0.909 (Pearson's r).

Maximum overlap between ranks is 100% (10 out of 10) for ranks secured by institutions in overall category in IR 2019 and IR 2020, IR 2020 and IR 2021 as well as in IR 2017 and IR 2021 followed by an overlap of 91 out of 97 (93.81%) for IR 2018 and IR 2019. It means that 91 out of 97 institutions ranked in 2019 were ranked amongst the top 100 in IR 2020 and remaining 7 institutions secured ranks beyond 100.

DISCUSSION AND CONCLUSION

Inter-correlation, intra-correlation and year-to-year correlation analysis amongst five broad categories of parameters amongst top 100 ranked institutions in Overall category of India Rankings 2021 reveal relative significance of these parameters considering the fact that correlation study was done on the raw values of data instead of its weighted score. As such, all 33 parameters or sub-parameters considered in this study were treated equal irrespective of weightage assigned to them in the ranking. As such, parameters identified as significant in this study can be used effectively by HEIs to improve their rankings and by the ranking system to re-assign weightage to the parameters based on correlation between themselves as well as with total overall score.

The inter-correlation analysis at the level of broad categories of parameters reveal that out of five broad categories of parameters, four parameters namely RP (Pearson $r=0.9098$), PR (Pearson $r=0.8941$), TLR (Pearson $r=0.7118$) and GO (Pearson $r=0.5330$) correlate strongly with the total overall score as well as with each other, therefore, these parameters contribute substantially to the ranking of HEIs. Parameters under O & I correlate strongly with each other but neither score of O & I or its parameters correlate with total overall score. It may further be observed that O & I include four India-centric parameters that are included as measures to provide social justice to disadvantaged sections of the society.

The intra-class or intra-group correlation coefficient (ICC), used in this study to measure strength of correlation within a broad category of parameter provides interesting insights as mentioned below:

Students and faculty-related parameters under TLR correlate strongly or very strongly with each other except for number of Ph.D. students which has weak or negative correlation with all other parameters although it has strong correction with total overall score (Pearson $r=0.6810$). However, correlation between individual parameters and total TLR score or total overall score is either very weak or even negative.

Individual parameters under RP correlate strongly to very strongly with each other as well as with total RP score and with total overall score. Interestingly, expenditure on library has very good correlation with publications, citations, HCP and research grants. Likewise, number of patents has good correlation with all other parameters of RP as well as with total RP and Total Overall score.

Individual parameters under GO has weak to very weak correlation amongst each other as well as with total GO score and with total overall score. The only exception is Ph.D. students graduated which have very strong and positive correlation with total GO score with 0.8689 as value of Pearson's r .

Individual parameters of O & I correlate strongly to very strongly with each other in almost all the cases. However, correlation between individual parameters of O & I with total O & I score is weak to very weak and correlation between individual parameters of O & I with total overall score is negative in most of the cases or very weak in few cases.

Intra-group correlation under parameters of Perception is not applicable. However, correlation between Perception (PR) and total overall score is positive and very strong i.e. 0.9098.

Inter-group correlation between scores of parameters amongst five groups of parameters reveals the followings:

Out of 50 values of Pearson's r between parameters of TLR and RP given in Table 8, 22 values (44%) are between 0.001 and 0.24, 16 values (32%) are between 0.25 and 0.49 and 12 values (24%) are between 0.50 and 0.74. There is no representation of values of Pearson's r between 0.75 and 0.99. In other words, 28 out of 50 (56%) values of Pearson's r reveal moderate to very strong correlation and remaining 22 values (44%) of Pearson's r reveal weak or no correlation amongst various parameters of TLR. It is noteworthy that number of full-time Ph.D. students has good or strong correlation with almost all parameters of RP.

Out of 40 values of Pearson's r between parameters of TLR and GO given in Table 9, 25 values (62.5%) are between 0.01 and 0.24, 6 values each (15%) are between 0.25 and 0.49 &

0.75 and 0.99 and 3 values (7.50%) are between 0.50 and 0.74. In other words, 25 out of 40 values (62.5%) of Pearson's r reveal weak or no correlation amongst parameters of TLR and GO and remaining 15 values (37.5%) of Pearson's r reveal moderate to very strong correlation.

It can also be observed that all parameters of TLR are strongly and positively correlated with number of students graduated and number of full-time Ph.D. students are strongly correlated with number of Ph.D. students graduated (Pearson's $r=0.8566$) as well as with total PR and total GO score with Pearson's $r=0.6215$ and 0.7444 respectively. All other parameters of TLR have weak or very weak correlation with other parameters of GO as well as with total GO and total PR scores.

Out of 56 values of Pearson's r between parameters of TLR and O & I given in Table 10, 9 values (16.07%) are between 0.01 and 0.24, 12 values (21.43%) are between 0.25 and 0.49, 11 values (19.64%) are between 0.50 and 0.74 and 24 values (42.86%) are between 0.75 and 0.99. In other words, 47 out of 56 values (83.93%) of Pearson's r reveal moderate to very strong correlation and remaining 9 values (16.07%) of Pearson's r reveal weak or no correlation amongst parameters of TLR and GO.

Correlation between all the six parameters of O & I with fulltime and parttime Ph.D. students is weak, however, correlation between all the six parameters of O & I with total faculty and faculty experience is good to very strong. All parameters of O & I have weak or negative correlation with Total O & I score.

Out of 54 values of Pearson's r between parameters of RP and GO given in Table 11, 33 values (61.11%) are between 0.01 and 0.24, 12 values (22.22%) are between 0.25 and 0.49 and 5 values (9.26%) are between 0.50 and 0.74. There is no representation of values of Pearson's r between 0.75 and 0.99. In other words, 33 out of 54 values (61.11%) of Pearson's r reveal weak or no correlation amongst parameters of TLR and GO, remaining 21 values (38.89%) of Pearson's r reveal moderate to very strong correlation.

The values for Pearson's r reveal that correlation between most of the parameters of RP with parameters of GO is weak or negative in few cases. However, correlation between patents and students graduated and operational expenditure is strong with Pearson's $r = 0.7215$ and 0.6451 respectively. Likewise, correlation between publications, citations, and Ph.D. students graduated is good with Pearson's $r = 0.4740$, 0.5019 and 0.4897 respectively.

Out of 60 values of Pearson's r between parameters of RP and O & I given in Table 12, 41 values (68.33%) are between 0.01 and 0.24, 15 values (25%) are between 0.25 and 0.49 and 4 values (6.67%) are between 0.50 and 0.74. There is no

representation of values between 0.75 and 0.99 in Table 11. In other words, 41 out of 54 values (68.33%) of Pearson's r reveal weak or no correlation amongst parameters of TLR and GO, remaining 19 values (31.67%) of Pearson's r reveal moderate to very strong correlation.

While most of the parameters of RP have very low or no correlation or even negative correlation (in case of research grants) with parameters of O & I except for patents and operational expenditure. While good correlation between operational expenditure and various parameters of O & I is logical given the fact that expenditure is committed on faculty and communities of students identified as parameters of O & I. However, positive and strong or very strong correlation between patents and various parameters of O & I seems coincidental and cannot be explained.

Out of 21 values of Pearson's r between parameters of GO and O & I given in Table 13, 12 values (57.14%) are between 0.01 and 0.24, 2 value each (9.52%) are between 0.25 and 0.74 and 0.50 and 0.74 and 5 values (23.81%) are between 0.75 and 0.99. In other words, 12 out of 21 values (57.14%) of Pearson's r reveal weak or no correlation amongst parameters of TLR and O & I, remaining 9 values (42.86%) of Pearson's r reveal moderate to very strong correlation.

While Ph.D. students graduated and % of students graduated have no correlation or even negative correlation with parameters of O & I, students graduated is strongly or very strongly correlated with various parameters of O & I. It is interesting to note that correlation between students graduated and women students in 0.9024 which is the highest followed by 0.8913 between students graduated and tuition fee refund, which conveys that many recipients of tuition fee refund are amongst students who graduated.

Out of 528 unique values of Pearson's r calculated for this study to examine correlations between 33 parameters under five broad categories of parameters, 224 values (42.42%) are between 0.001 and 0.2499, 132 values (25%) are between 0.25 and 0.49, 85 values (16.10%) are between 0.50 and 0.74 and 87 values (16.48%) are between 0.75 and 0.99. These 528 values of Pearson's r do not include 33 values of Pearson's r where Pearson's r is 1, i.e. correlation between a parameter or sub-parameter with itself. In other words, out of 528 values of Pearson's r , 304 values (57.58%) range between 0.25 to 0.99, denoting moderate to very strong correlation and remaining 224 values (42.42%) are between 0.001 and 0.2499 denoting low correlation or lack of correlation.

It was observed that the 12 parameters given in Table 15 had the highest numbers of correlations with total TLR, RP, GO, PR as well as total overall score with value of Pearson's r ranging between 0.250 to 0.990. The only exception is in the case of total GO which has weak correlation with three

different parameters of RP, namely capital, lab and library expenditure.

It can be observed that out of 12 parameters identified as the most significant includes all the 9 parameters under the broad category “Research & Professional Practices” (total weightage 0.30) whereas remaining three parameters represent one each of the broad category of parameters i.e., Ph.D. Students (Teaching, Learning and Resources; total weightage 0.30), Perception (total weightage 0.10), and Ph.D. Students Graduated (Graduation Outcomes; total weightage 0.20). Moreover, “Outreach and Inclusivity” with total weightage of 0.10 is not represented amongst parameters identified as significant in this study. As such, if all the 12 parameters identified in this study are given equal weightage, “Research & Professional Practices” will carry weightage of 7.5 (out of 10) and remaining three parameters will have a total weightage of 2.5.

Since all the 12 parameters given in Table 15 have the highest number of correlations with total TLR, RP, GO, PR as well as total overall score with value of Pearson’s r ranging between 0.2500 to 0.9900, these sets of parameters can potentially constitute a compact and coherent sets of performance indicators for ranking of HEIs. This essentially means that all ranking parameters (including sub-parameters) were considered equal in order to identify parameters that contribute more significantly to the ranking exercise. While HEIs may focus their attention to these indicators, ranking agencies may consider deeper study in this direction with aim to regroup and redistribute weightage to these 12 indicators.

Year-to-year correlation between ranking of institutions, i.e. India Rankings 2017 to 2021 as well as correlation at interval of five years, i.e. 2017–2021 reveals near perfect correlations in ranking table on year-to-year basis as well at interval of five years, i.e. 2017–2021 in Overall category. Even the minimum correlation coefficient is “High” or “Very High”, i.e. 0.725 (Spearman’s r) and 0.909 (Pearson’s r). This reaffirms consistency and reliability of ranking methodology used for India Rankings over a period of six years.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

Disclaimer

This article represents the opinions of the authors, and is the product of professional research. It is not meant to represent the position or opinions of the NBA or NIRF or INFLIBNET or the Ministry of Education nor the official position of any staff members. Any errors are the fault of the authors.

REFERENCES

1. NIRF (National Institutional Ranking Framework). New Delhi: NIRF; 2021 [cited Sep 1 2022]. Available from: <http://www.nirfindia.org>.
2. Marsh HW, Hattie J. The relation between research productivity and teaching effectiveness. *Journal of Higher Education*. 2002;73(5):603-41. doi: 10.1080/00221546.2002.11777170.
3. Terenzini PT, Pascareua ET. Living with myths: undergraduate education in America. *Change*. 1994;26(1):28-32. doi: 10.1080/00091383.1994.9938488.
4. Astin AW. Involvement in learning revisited: Lessons we have learned. *Journal of College Student Development*. 1999;40(5):587-98.
5. Liu NC, Cheng Y. The academic ranking of world universities. *Higher Education in Europe*. 2005;30(2):127-36. doi: 10.1080/03797720500260116.
6. Saisana M, d’Hombres B, Saltelli A. Ricketty numbers: Volatility of university rankings and policy implications. *Research Policy*. 2011;40(1):165-77. doi: 10.1016/j.respol.2010.09.003.
7. Van Raan AFJ. Challenges in ranking of universities. Invited paper for the First International Conference on World Class Universities. Shanghai: Shanghai Jiao Tong University. 2005;133-143
8. Espeland WN, Sauder M. Rankings and reactivity: How public measures recreate social worlds. *American Journal of Sociology*. 2007;113(1):1-40. doi: 10.1086/517897.
9. Roberts D, Thompson L. Reputation Management for Universities: university League Tables and the impact on student recruitment. Working Paper Series No. 2. Leeds. Cambridge: The Knowledge Partnership; 2007.
10. Chen KH, Liao PY. A comparative study on world university rankings: A bibliometric survey. *Scientometrics*. 2012;92(1):89-103. doi: 10.1007/s11192-012-0724-7.
11. Çakır MP, Acartürk C, Alasehir O, Çilingir CA. A Comparative analysis of global and national university ranking systems. *Scientometrics*. 2015;103(3):813-48. doi: 10.1007/s11192-015-1586-6.
12. Moed HF. A critical comparative analysis of five world university rankings. *Scientometrics*. 2017;110(2):967-90. doi: 10.1007/s11192-016-2212-y.
13. Nassa AK, Arora J. Revisiting ranking of academic institutions. An overview. *DESIDOC Journal of Library and Information Technology*. 2021;41(1):5-19. doi: 10.14429/djlit.41.1.16673.
14. NIRF (National Institutional Ranking Framework). Methodology for Ranking of Academic Institutions in India- Ranking metrics for Overall category. New Delhi: NIRF; 2021. Available from: <https://www.nirfindia.org/nirfpdfcdn/2021/framework/Overall.pdf> [cited 3/11/2022].