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Measuring Research Performance of 19th Century British Era Universities of Indian Subcontinent

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Abstract:

Objectives: This study aims to evaluate the research productivity of universities established by the British rulers during the 19th century in un-divided Indian sub-continent. Another objective of the study is to explore the collaboration patterns and to perform impact analysis on the research produced by the studied universities.

Methods: Bibliometric method was used to perform this analysis on the data retrieved from Scopus database. Research yield of studied universities in the form of bibliographic records of research publications was the sample of this study.

Results: Chemistry was the most published subject area in the studied universities. Researchers in the studied universities preferred to publish most of their research in the form of journal articles. Multi-authorship is a dominant authorship pattern. Collaborative research attracted more citations than the research publications with single-authorship.

Conclusion: This study is the first bibliometric study conducted to explore the research patterns and volume of British era universities of Indian sub-continent.

Keywords: University of the Punjab, University of Madras, University of Mumbai, University of Calcutta, University of Allahabad, Research Performance, Research Output, Bibliometrics, Research Audit, Research Productivity.

Introduction and Historical Background

Learning traditions are not new in South Asia. The region is heir to formal and informal traditions of learning and education since ancient times (Rahman, 2003). Indigenous education system was prevalent in India before the British took over the country (Radhakrishnan, 1990). The British have ruled the sub-continent for more than hundred years. The area now comprises Bangladesh, India and Pakistan with more than one-fourth of human population of the world ("World Population Clock: Worldometer," 2020).

It was the British rulers who introduced the modern western style education system in Indian subcontinent in early 19th century. Missionaries started the spread of western knowledge at the beginning. Later on, the government officials and few enlightened Indians joined to carry forward the task. Despite the initial flaws as observed by (Howell, 1872; Leitner, 1883) this western style education system thrived quickly. The missionaries and the Government established colleges for western education several years before the establishment of universities. The Government passed the acts of incorporation of universities of Madras, Calcutta and Bombay in 1957. University of the Punjab and University of Allahabad were established by specials acts of incorporation in 1882 and 1887, respectively, (Nurullah & Naik, 1943). These are the five oldest universities of undivided India established by the colonial rulers. After partition of the subcontinent, four of these universities were left with India, and the fifth one with Pakistan.

A huge volume of research has been produced by the institutions established by the British government. It is imperative to know how these institutions have performed in research during the colonial rule and under the present governments of their respective countries. This research aims to measure the research productivity of British era universities of Indian subcontinent to showcase their output. The study further aims to uncover the collaboration and authorship patterns of the research produced by these premier institutions of higher learning of Indian subcontinent. The results of the study will exhibit the share of these universities to the scholarly literature of the world. This paper will also help understanding the changing focus of governments on research, chronologically in 19th, 20th, and early 21st century. The findings of this research will help these universities to know their strengths and weaknesses in research. The findings will help determine the search standing of these universities in their respective countries. The findings will provide empirical evidence to the administrators of these universities for decision making in research grant proposals, designing research themes, investing in more funds for weak research areas, recruitments and promotions.

Literature Review

It is essential to communicate the results of scientific research. For this reason, scientists have to publish their research in scientific literature. Research in published form lays the foundation of bibliometric methods of research evaluation. Bibliometric method is an important method of assessment of scientific literature (Ellegaard & Wallin, 2015). Bibliometrics is widely used method

to measure scientific research of institutions. In parallel to the peer-review method, bibliometrics have become an important tool in the research evaluation of universities (Raan, 1999). Publications and citations counts are used to evaluate research progress of institutions using this method. The method provides an insight into the volume of research produced by particular institution, country, region, subject field, journal and authors.

Evaluating scientific research of academic institutions is imperative for decision making, funds allocations, and regional and international rankings. Several researches have been conducted to measure the research output of academic institutions around the world. A research study was prepared to measure the research performance of Chinese universities (Zhu, Hassan, Mirza, & Xie, 2014). Authors used citations and other impact metrics to measure the internationalization of research at Chinese universities. The study observed that Chines universities are performing well in terms of quantity but lagging behind in impact. It was further observed that chines universities produced three times more research papers than universities of Europe and America in the field of Engineering. The study found that the Chines universities' share of research in high ranked journals was relatively low.

To measure the research output of government hospitals in the capital city of Kingdom of Saudi Arabia a study was prepared by (Howaidi, Howaidi, & Howaidi, 2017). Authors used Scopus database to retrieve the publications data of studied hospitals. The study observed that King Faisal Specialist Hospital published most of the research with 44% share in Riyadh based government hospitals. It was observed that top most cited publications of these hospitals were published in "The Lancet" journal, a reputed name in the health care journals list.

Using ISI's Essential Science Indicators (Huang, Chang, & Chen, 2006) prepared a study for research evaluation of Taiwanese universities. NTU leads in overall ranking of the Taiwanese universities considering bibliometric indicators. The study concluded that each of the studied university had strengths in various subject fields. It was observed that Taiwan based research universities need to bridge the gap between quantity and impact of their research.

A similar study to analyze the research performance of major Iranian medical universities was carried out (Abolghassemi Fakhree & Jouyban, 2011). The study observed that authors of selected medical universities preferred to publish their research in Iranian journals. The study concluded

that despite the limited budget for research, Iran's research output performance is better compared to other countries. The study recommends following the internationally recognized standards of naming of authors and affiliations.

Literature reveals that several studies have been prepared in subcontinent measuring research performance of academic institutions. A recent study involved a comparison of two peer universities of the British era, University of the Punjab, Pakistan, and University of Allahabad, India (Ahmad, Javed, Khahro, & Shahid, 2020). The study applied the bibliometric method to perform the analysis on Scopus data. The authors observed a slow growth in research publications of PU and AU during the British period and early decades after the partition of Indian sub-continent.

A large scale assessment of Islamabad based universities and degree-awarding institutions was performed by the two of the authors of this study (Javed, Ahmad, & Khahro, 2020). The study concluded that the collaboration trend was high in public sector universities than the ones in private sector. The study found that best performing universities had the higher number of authors per publication compared with the low-performing institutions.

Another study depicting the state of research of King Edward Medical University (KEMU), one of the oldest medical universities of British era sub-continent, was carried out (Ahmad, 2020). The study observed a slow progress during the first hundred years of its establishment, while a sharp increase was witnessed with the onset of 21st century. Researchers of KEMU preferred to publish their research in local journals majority of those not indexed in Scopus, Web of Science, Medline and other international indexing services.

Measuring scientific research in Indian subcontinent, (Mahbuba & Rousseau, 2010) compared the scientific developments of Bangladesh, Pakistan and Sri Lanka with neighboring India. The authors examined the BIPS countries share and evolution of research in Web of Science database. Some other researchers (Maharana & Das, 2013; Maharana & Sethi, 2013; Meera & Sahu, 2014; Sri & Visvesvaraya, 2008) also carried out their research studies to evaluate the research performance of institutions of Indian subcontinent.

However, as per authors' best knowledge, no study has been exclusively made to evaluate the research performance of British Era universities in comparison with each other. Considering this gap in literature, we conduct this study to answer the following research questions:

- What is the volume of research produced by British Era universities of Indian sub-continent?
- How good is the research of these universities in terms of impact/citations?
- What is the structure of knowledge created by these universities?
- What is the position of these universities comparing with each other?
- Which are the preferred sources of publications for the authors associated with these universities?
- In which research areas these universities are publishing the most?
- What is the forecast of research productivity of these universities?

Methodology

Bibliometric indicators were used to perform analysis on the data. Bibliographic records of research publications affiliated with the following universities are the sample of this study.

- University of Allahabad (AU)
- University of Calcutta (CU)
- University of the Punjab (PU)
- University of Madras (UM)
- University of Mumbai (MU)

Date range: all the years till 2019

Database Selection: Selection of database is the foremost important step in bibliometric studies. Scopus database was selected to retrieve the bibliographic records affiliated with the studied universities considering broad coverage policy of the database. Scopus is one of the largest and comprehensive database of peer-reviewed research literature.

Data Retrieval: Affiliation search was conducted with each of the official names of the above-mentioned universities. Retrieved data was exported to MS Excel for further processing and analysis. Data was retrieved in February, 2020, simultaneously, by two of the authors of the study

for cross verification purposes. Data was retrieved from the beginning till the year 2019. We excluded the year 2020 as it was not representing the complete year.

Data Cleansing and Labeling: Data was reviewed by all the authors of this study. A data cleansing exercise was performed:

- To remove the duplicate records
- To fix the records with incomplete or missing information
- To remove the unformatted bibliographic records
- To label the data according o the access type. Zero (0) was assigned to the subscription-based contents while one (1) was assigned to the contents in open access domain
- Special characters in author names and titles were removed to have a compatible data format

Limitations:

1. Data is limited to Scopus database only. The data from other indexing databases like, Web of Science, PubMed, Dimensions etc. may produce different results of publications records of selected universities.
2. Study is limited to public sector universities only that were established by the British rulers of India during the 19th century.

Data Analysis

Preferred Access Types: More than of 88% of research output of these universities is published in priced based sources while 11.7% only in open access sources as depicted in Figure 1. Researchers in PU opted for open access publishing with 22.4% of their publications, the highest ratio in the group of studied universities. MU recorded the highest share of 93.5% of its publications in priced based journals. AU constitutes 92% of its research share of total publications in the closed access category followed by CU with 90.5% share. MU contributes the lowest share of 6.5% in total number of open access publications of studied universities.

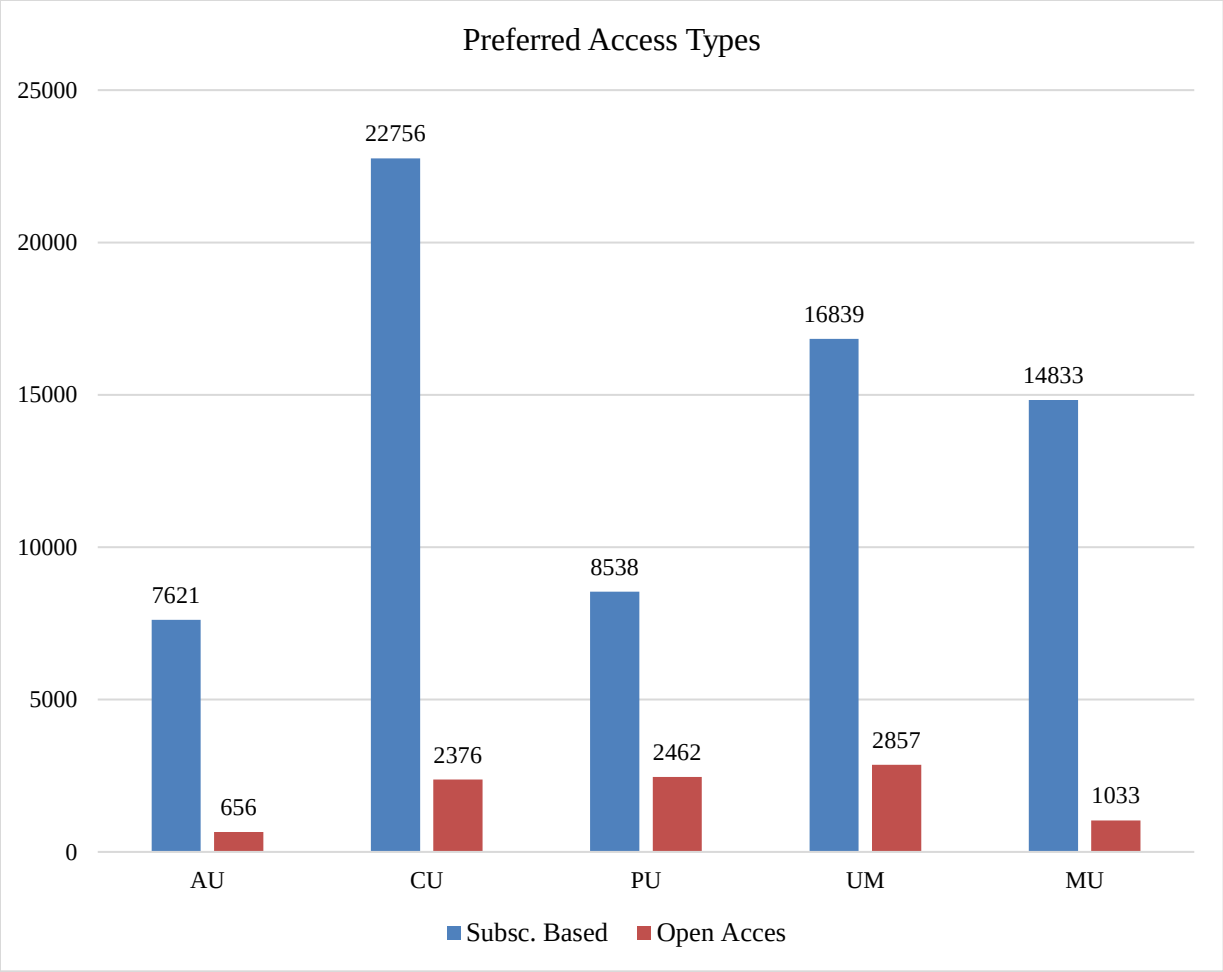

Figure 1 shows preferred access types.

Preferred Document Types: About 82.4% of research of these universities is published in this form of journal articles. Conference paper is the second most common form of publications to publish research (11.2 % of total). Reviews and book chapters stand at number 3 and 4 respectively. Figure 2 displays the types of publications in which researchers of studied universities prefer to publish their research.

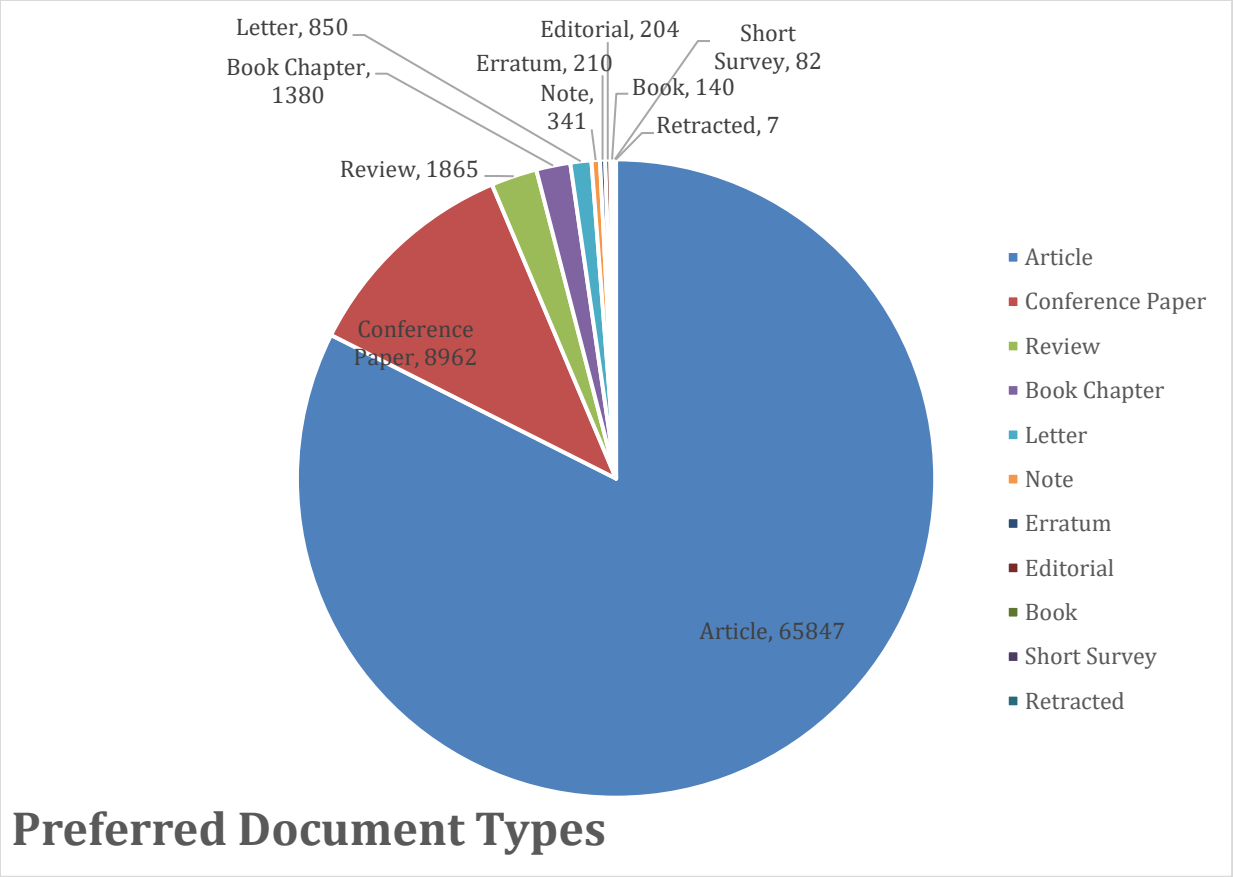

Figure 2: Shows distribution of research publications in document types

Subject Distribution of Research: Scopus database has 28 predefined subject areas. The study analyzed the distribution of research in these predefined subject areas shown in Table 1. The group of five selected universities for this study published 13.2 % of their research in chemistry out of 28 subject areas, the most in any subject category followed by physics and astronomy with 12.1 % share. Materials science, biochemistry, genetics & molecular biology, and engineering are other prominent subject areas with 9.3, 9.2, and 9.0 % ages. The five major subject areas stated in previous lines constitute more than half of the research output of these universities (52.7%). The highest number of research publications in a particular subject area is published by UM in the field of Chemistry (5942) followed by AU (2609). Figure 3 displays the overall, collective distribution of research in Scopus predefined subject areas.

Table 1. Subject distribution of research published by the studied universities

AU		CU		PU		UM		MU	
Chemistry	2609	Physics and Astronomy	6107	Agricultural and Biological Sciences	2326	Chemistry	5942	Engineering	3966
Physics and Astronomy	2137	Chemistry	4988	Physics and Astronomy	2269	Physics and Astronomy	4517	Computer Science	3854
Biochemistry, Genetics and Molecular Biology	1443	Biochemistry, Genetics and Molecular Biology	4275	Chemistry	1546	Materials Science	4433	Chemistry	3740
Materials Science	1280	Engineering	4108	Materials Science	1538	Biochemistry, Genetics and Molecular Biology	4224	Pharmacology, Toxicology and Pharmaceutics	2400
Engineering	999	Materials Science	3877	Biochemistry, Genetics and Molecular Biology	1478	Engineering	2457	Physics and Astronomy	2211
Agricultural and Biological Sciences	969	Agricultural and Biological Sciences	2658	Medicine	1265	Pharmacology, Toxicology and Pharmaceutics	2457	Materials Science	2155
Pharmacology, Toxicology and Pharmaceutics	698	Computer Science	2472	Engineering	1242	Medicine	2082	Chemical Engineering	2084

Medicine	592	Mathematics	2447	Environmental Science	798	Agricultural and Biological Sciences	1919	Biochemistry, Genetics and Molecular Biology	1670
Chemical Engineering	542	Pharmacology, Toxicology and Pharmaceutics	1825	Mathematics	737	Chemical Engineering	1493	Mathematics	1329
Environmental Science	517	Medicine	1804	Pharmacology, Toxicology and Pharmaceutics	714	Mathematics	1375	Environmental Science	1195
Mathematics	410	Environmental Science	1563	Computer Science	707	Environmental Science	1252	Energy	977
Computer Science	324	Chemical Engineering	1523	Immunology and Microbiology	660	Computer Science	1078	Medicine	920
Earth and Planetary Sciences	323	Earth and Planetary Sciences	1201	Social Sciences	644	Immunology and Microbiology	692	Agricultural and Biological Sciences	662
Social Sciences	289	Social Sciences	720	Chemical Engineering	485	Multidisciplinary	533	Social Sciences	595
Multidisciplinary	221	Immunology and Microbiology	697	Earth and Planetary Sciences	458	Earth and Planetary Sciences	445	Business, Management and Accounting	571

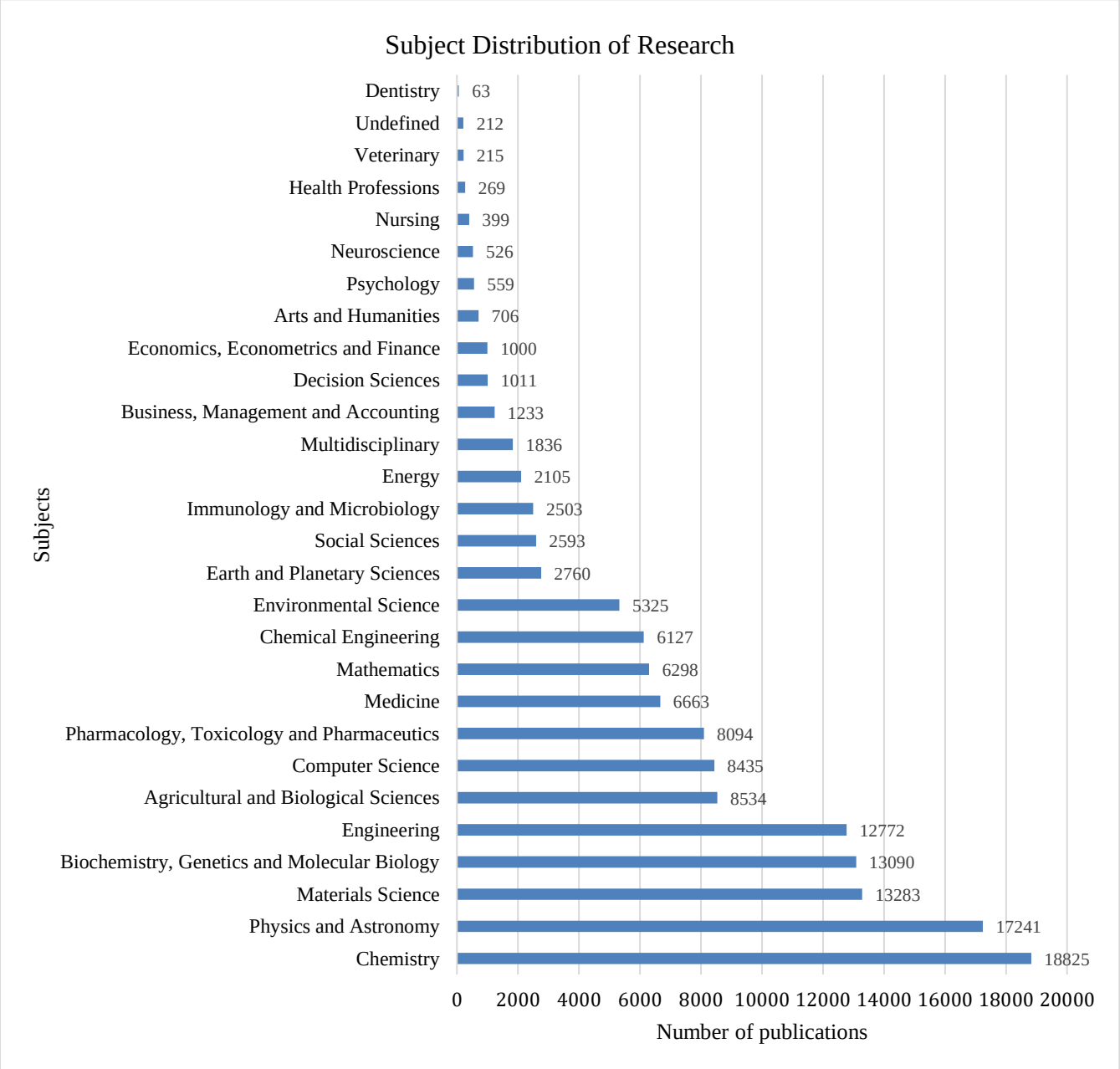

Figure 3: Overall, subject wise distribution of published research

Co-Authorship Patterns-Publications

The highest number of authors collaborating in one publication is 2462, 1583, and 717 for Calcutta, Mumbai and Punjab universities, respectively. Collectively, from all the selected universities,

408,718 authors produce 79,226 publications with an average of 5.16 authors per publication and 0.19 publications per author in all five universities.

CU has the highest number of articles (2561) authored by a single author, while PU has 495 research studies with single authorship. CU also has the highest publications (7317) with two authors. MU and UM are at number two and three with 6353, and 5406 publications with two authors, respectively.

PU has the highest number of publications (3303) with six or more authors. MU is at the second place with 2600 publications. CU, MU and AU have 2405, 1166 and 725 articles, respectively with six or more authors.

Highest average authors are from PU (14.80), which is almost three times more than the average of the remaining four universities. For remaining four universities averages are almost equal as Allahabad (3.09), Calcutta (3.89), Madras (3.62) and Mumbai (3.23)

Considering the open access publishing model, we found that Madras is at the top with 2857 publications with 124 single authorship, followed by PU with 2462 total, and 47 single authored publications. CU is at number three with 2376 publications and MU and AN are at number 4 and five with 1033 and 656 publications respectively. For open access, Table 2 represents the number of publications as per contributors.

Universities/ No. of Authors	**1**	**2**	**3**	**4**	**5**	**6+**
AU	88	186	122	85	81	94
CU	164	556	504	402	246	504
PU	47	296	319	315	399	1086
UM	124	510	480	594	713	436
MU	68	360	240	140	86	139

Table 2. Publications in open access journals by number of authors

Co-Authorship Patterns-Citations

To have a clear idea about the year wise citation trend, we categories the years as <=1950, 1951-1980, 1981-2000, 2001-2010 and 2011-2019. The overall citation trend is increasing. Before the year 1951, the total citation received for all the five universities were 2317, while the citations received during the last decade were 321,349.

The total citations received to all the universities were 833,428. MU had the highest share of246,580 citations followed by CU, UM, PU and AU with 243,112, 150,560, 109,716 and 83,460, respectively. with from CU. MU received. PU and AU received 109,716 &

Distribution of citation per number of authors reveals that two authors received more citations 220,111 (26.41%) followed by 180,318 (21.64%) for three authors. Six plus authors received 169679 (20.36%) citations and five and single authors are at bottom with 86,168 (10.34 %) and 37.786 (4.53%).

Total citations received to closed access publications are 736,587. UM is at the top with 220,295 citations, and CU is ranked second with 217,753 citations. MU, PU and AU follows with 142,741, 84,163 and 71,635 citations, respectively.

For open access publications, five universities received 96,841 total citations. Once again UM is number one with 26,285 citations followed by PU with 25,553 citations. CU is very near to PU with 25,359 Citations. AU received 11,825 while MU received 7,819 citations in open access journals.

	1	2	3	4	5	6+
AU	3.96	8.50	10.25	13.54	14.47	15.90
CU	5.76	8.23	8.95	10.68	11.14	20.30
PU	6.32	8.86	8.86	8.91	7.56	13.50
UM	7.10	10.51	12.28	13.00	12.21	19.41
MU	5.57	9.16	9.99	10.74	8.63	12.25

Table 3. Average citations for number of authors

Citation Impact-Publications-Authors

The study analyzed the citation impact of publications with respect to number of authors for studied five universities as shown in Table 4.

University		Authors						Total
		1	2	3	4	5	6+	
AU	Publication	1079	3025	1631	1155	662	725	8277
	Citations	4276	25714	16717	15644	9578	11531	83460
	Citation Impact	4.0	8.5	10.2	13.5	14.5	15.9	10.1
CU	Publication	2561	7317	6297	3762	2045	2405	24387
	Citations	14741	60202	56378	40186	22782	48823	243112
	Citation Impact	5.8	8.2	9.0	10.7	11.1	20.3	10.0
PU	Publication	495	2167	1921	1658	1456	3303	11000
	Citations	3129	19202	17016	14777	11014	44578	109716
	Citation Impact	6.3	8.9	8.9	8.9	7.6	13.5	10.0
UM	Publication	1255	5406	4345	3436	2654	2600	19696
	Citations	8911	56810	53335	44663	32402	50459	246580
	Citation Impact	7.1	10.5	12.3	13.0	12.2	19.4	12.5
MU	Publication	1208	6353	3692	2244	1203	1166	15866
	Citations	6728	58181	36869	24107	10387	14288	150560
	Citation Impact	5.6	9.2	10.0	10.7	8.6	12.3	9.5

Table 4. Citation impact of studied universities

Analysis of data shows that the publications with more authors had more citation impact and that goes upward with the increment in number of authors. All the universities showed this trend. As for as the citation impact of total publications is concerned, UM lead the other universities with citation impact of 74.5. AU and CU are at second and third places with citation impact of 66.5 and 65.1, respectively,

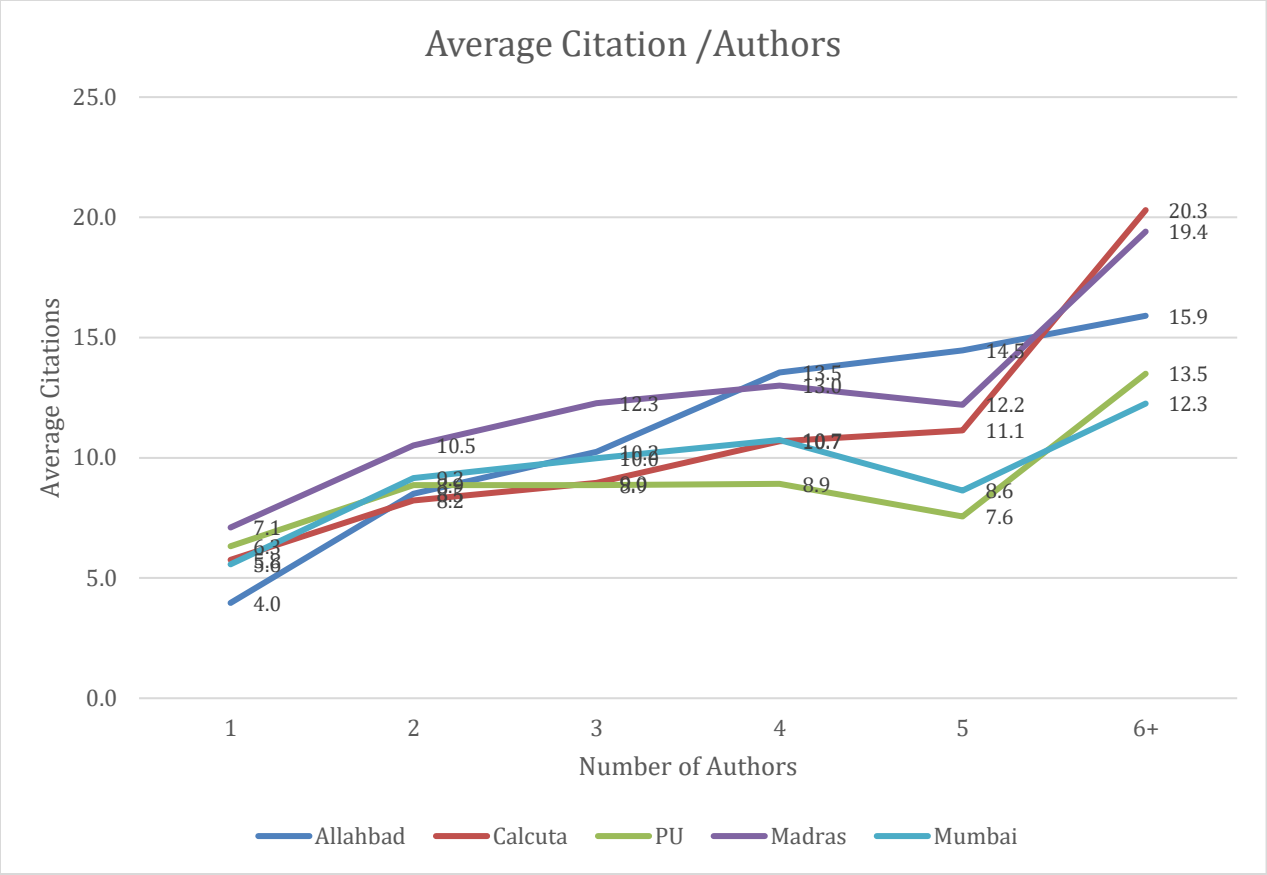

Figure 4. Average citations per number of authors in studied universities.

The average citations per number of authors increased with the increase in the number of authors as shown in figure 4. Studies with the single authorship had the lowest average of citations. The highest average citations per number of authors was observed for the studies with 6 or more authors. The trend was upwards for all the universities for this variable.

Preferred Journals

Table 5: Preferred Journals

	Journal	No. of Published Documents	% age to total publication	Quartile	Country	Cite Score	SJR	SNIP
AU	Journal of The Indian Chemical Society	243	2.94	Q4	India	0.5	0.111	0.104
	Nature	105	1.27	Q1	United Kingdom	51	14.047	8.82
	Journal of Chemical Physics	101	1.22	Q1	United States	5.2	1.047	0.991
	Physical Review B	101	1.22	Q1	United States	6.6	1.811	1.025
	Kolloid Zeitschrift	98	1.18	N/A	Germany	N/A	N/A	N/A
CU	Journal of The Indian Chemical Society	365	1.50	Q4	India	0.5	0.111	0.104
	Indian Journal of Experimental Biology	261	1.07	Q3	India	N/A	0.227	0.512
	Nature	229	0.94	Q1	United Kingdom	51	14.047	8.82
	Rsc Advances	206	0.84	Q1	United Kingdom	6.5	0.736	0.827
	Advances in Intelligent Systems and Computing	173	0.71	Q3	Germany	0.9	0.184	0.429
PU	Pakistan Journal of Zoology	485	4.41	Q3	Pakistan	1.3	0.28	0.792
	Journal of Animal and Plant Sciences	211	1.92	Q3	Pakistan	1	0.233	0.509
	Journal of The Chemical Society of Pakistan	193	1.75	Q4	Pakistan	0.6	0.152	0.184
	Pakistan Journal of Botany	164	1.49	Q3	Pakistan	1.5	0.319	0.707
	Acta Crystallographica Section E Structure Reports Online	141	1.28	N/A	United Kingdom	N/A	N/A	N/A
UM	Acta Crystallographica	127	0.64	N/A	United Kingdom	N/A	N/A	N/A

	Section E Structure Reports Online							
	Asian Journal of Chemistry	107	0.54	Q4	India	0.6	0.14	0.223
	Aip Conference Proceedings	107	0.54	Not Yet Assigned	United States	0.6	0.19	0.373
	Proceedings of The Indian Academy of Sciences Section A	104	0.53	N/A	India	N/A	N/A	N/A
	International Journal of Chemtech Research	102	0.52	Q3	India	N/A	0.164	0.851
MU	Indian Drugs	102	0.64	Q4	India	0.2	0.121	0.154
	Indian Journal of Pharmaceutical Sciences	82	0.52	Q3	India	1	0.209	41
	Asian Journal of Chemistry	78	0.49	Q4	India	0.6	0.14	0.223
	Chemical Engineering Science	78	0.49	Q1	United Kingdom	6.1	0.998	1.577
	Journal of Applied Polymer Science	66	0.42	Q2	United States	4.2	0.541	0.852

The data in above table shows the top five most preferred journals selected for publications by the selected five universities. Journal metrics (CiteScore, SJR and SNIP [latest available data at the time of study]), number, and percentage of total publications is also given. It was observed that 4 out of these five universities preferred to published in local journals. “Journal of The Indian Chemical Society” was preferred journal of two universities i.e. AU, and CU. *Acta Crystallographica Section E Structure Reports Online* is the only international journal published from the UK which had the highest publications from University of Madras. *Pakistan Journal of Zoology* is the journal in which PU researchers preferred to published their publications. Nine of these preferred journals belonged to India, six to the United Kingdom, four to the United States and Pakistan, while two belonged to Germany.

Forecast Analysis

On the basis of publications data from 2000 to 2019, the authors performed forecast analysis with 50% confidence interval [In statistics, a range of values based on the observed data which are likely to contain the true unknown value for a specified proportion of the time (confidence level) usually expressed as a percentage]. The table below reveals that in 2025 the number of publications from these universities will be as:

Table 6: Forecast about publications

University	Forecast (Publications)	Lower Confidence Bound (Publications)	Upper Confidence Bound (Publications)
AU	529.13	488.35	569.90
CU	1942.29	1844.36	2040.22
PU	1978.83	1860.70	2096.95
UM	1589.17	1519.69	1658.66
MU	1730.40	1573.97	1886.82

PU from Pakistan may have 1979 publication followed by CU from India with 1842 estimated publications in year 2025. MU expected a little behind the PU and UM is at number 4. Publications form AU are forecasted at 529 the lowest from all and the only one with less than 1,000 publications in this group of universities. Figure 5 shows the forecast publication of AU till 2025 and it shows that the publication may reach bear 600+, Figure 6 shows the forecast publication of CU till 2025 and it shows that the publication may reach bear 2000+, Figure 7 shows the forecast publication of PU till 2025 and it shows that the publication may reach bear 2000+ that is highest among all selected universities, Figure 8 shows the forecast publication of UM till 2025 and it shows that the publication may reach bear 1600+ that is highest among all selected universities, Figure 9 shows the forecast publication of MU till 2025 and it shows that the publication may reach bear 1800+ that is highest among all selected universities.

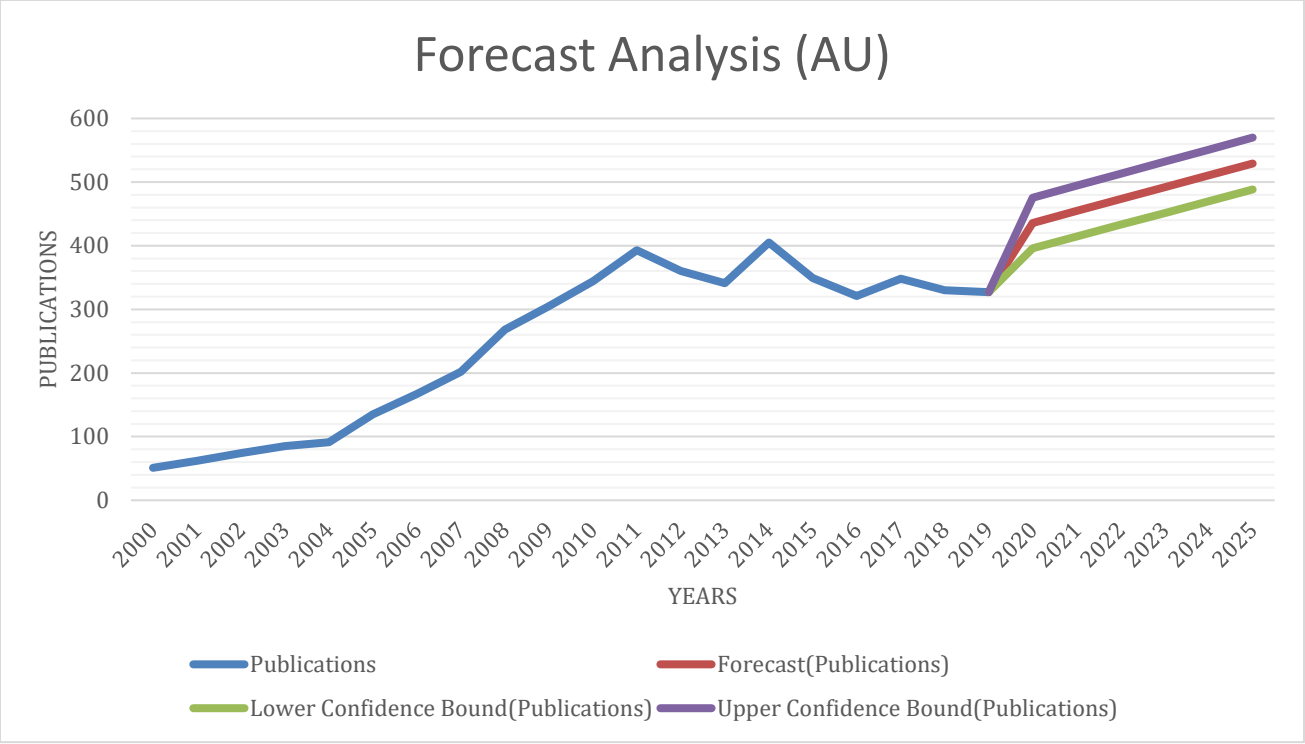

Figure 5: Forecast of AU publication till year 2025

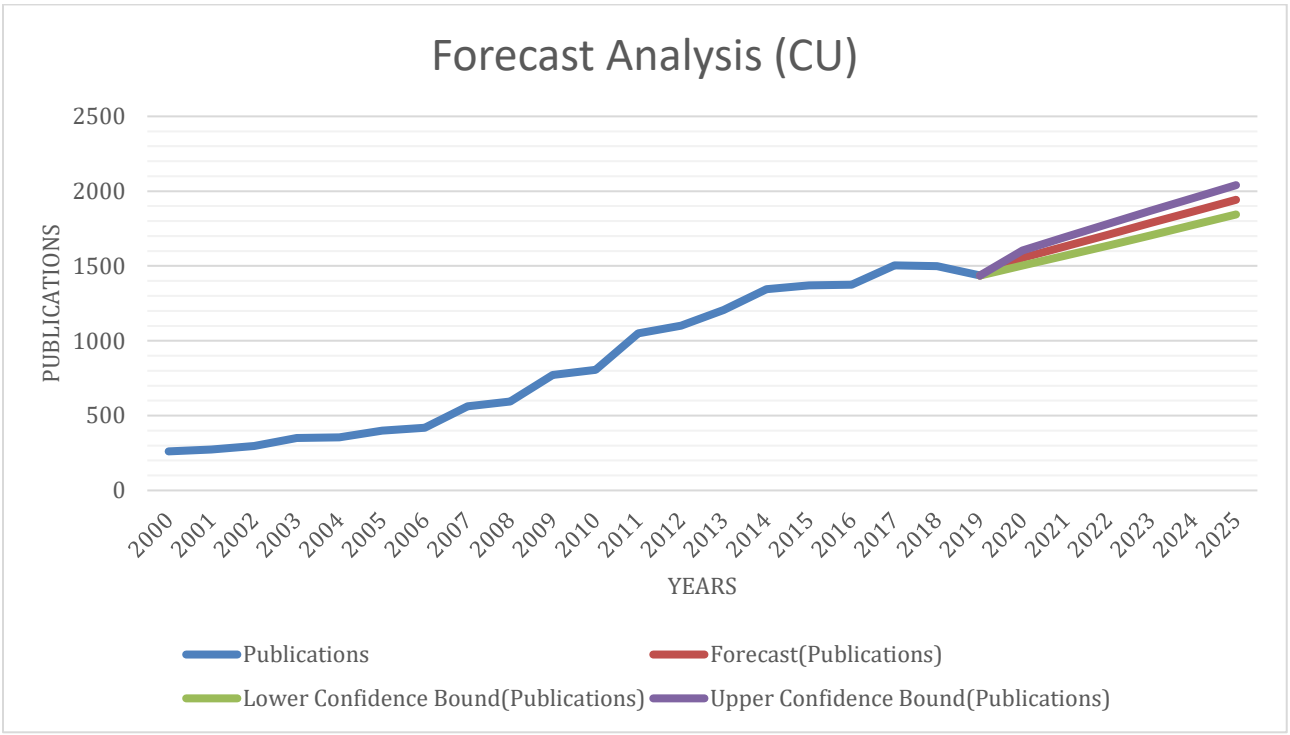

Figure 6: Forecast of CU publication till year 2025

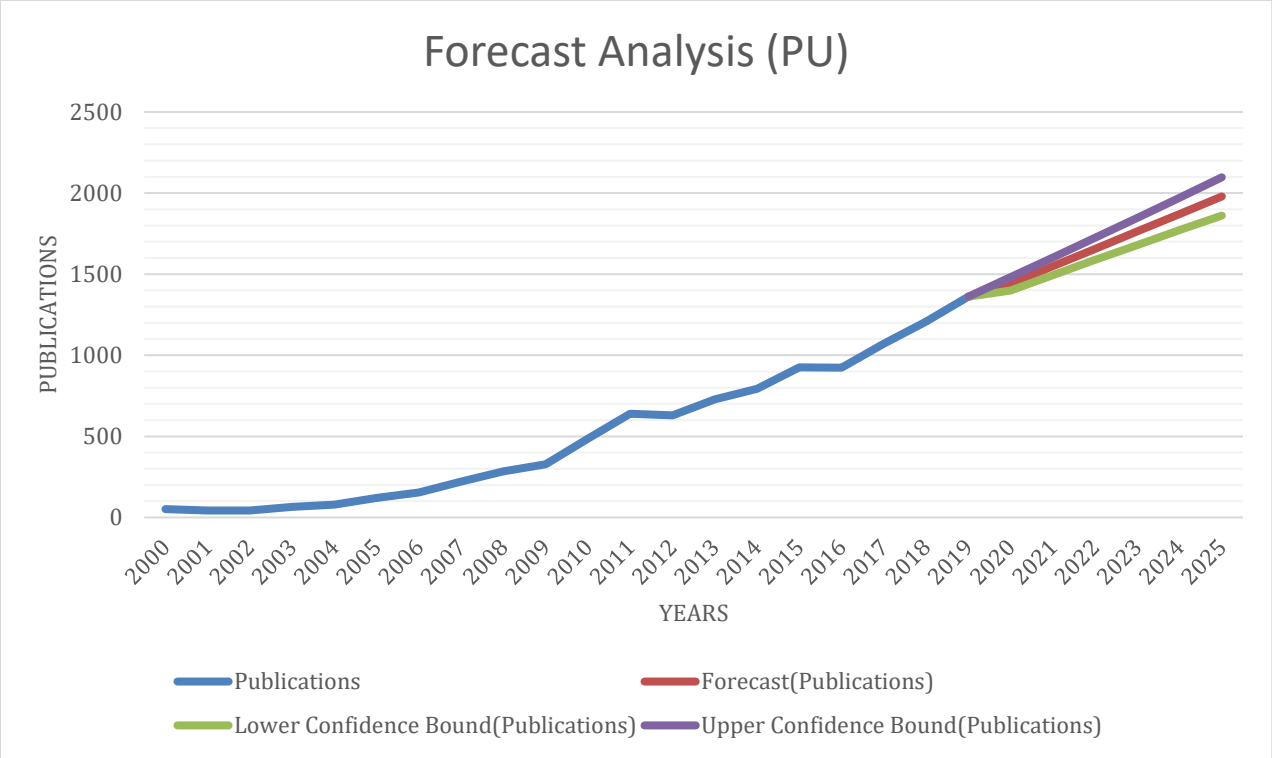

Figure 7: Forecast of PU publication till year 2025

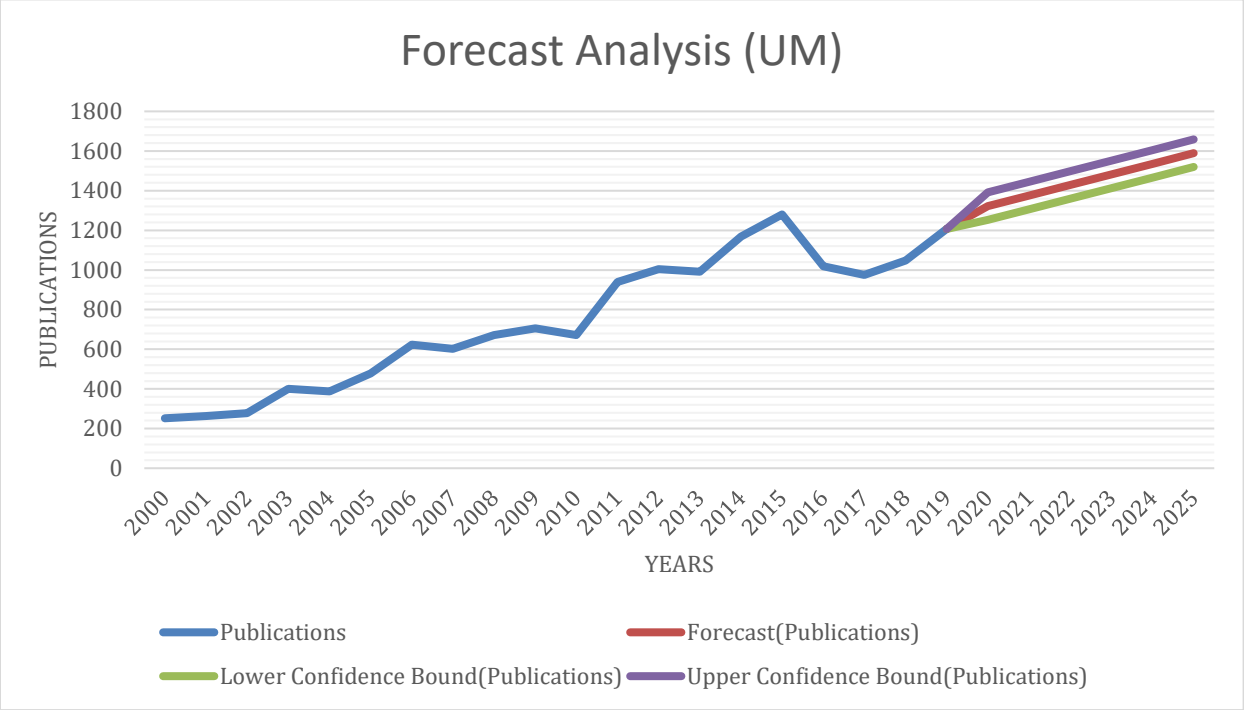

Figure 8: Forecast of UM publication till year 2025

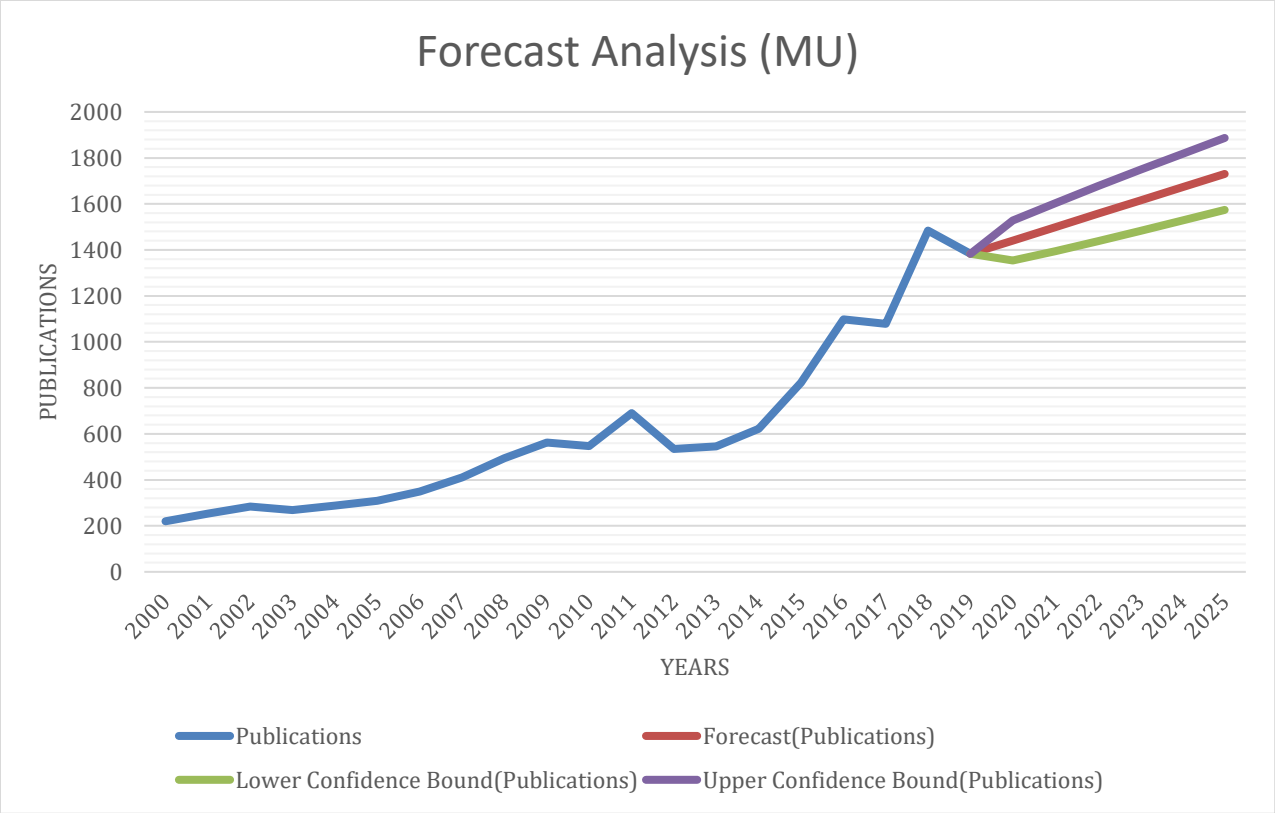

Figure 9: Forecast of MU publication till year 2025

Conclusion and Future Research Directions

This study focuses on research productivity of universities established in 19th century in undivided India of British Era. Bibliometric method was used to perform the analysis. The publications of each university were retrieved since each university started publishing their research. The study analyzed collaboration patterns, performed impact analysis, and conducted forecast analysis on the data that has been collected. It is evident from the findings that publishing research was not on priority until the beginning of 21st century. It was observed that the selected universities started putting efforts in research starting from first decade of 21st century. Forecast analysis shows that PU will produce a good amount of research while CU will also reach a same level or slightly lower than PU. The study also shows that amount of collaboration and funding has been increased that led to higher research productivity. Independent studies may be performed to evaluate the research performance of each of these universities separately. Furthermore, the correlation of funding with the research output can be checked for these universities. Studies can be conducted on

classification of research direction for each university as well as their alignment with national vision.

Declarations

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