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Research Output Analysis of Most Productive Universities of Tamil Nadu, India : A Scientometric Analysis

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Abstract

Scientometrics is an important field of information science as it represents a unique set of techniques and tools for the monitoring and analysis of information resources and for the management of knowledge in social and organizational contexts. This article analysed the various Scientometric components of the articles published by top six universities of Tamil Nadu from 2000-2017. The study identifies research trend, characteristics growth and collaboration pattern of published literature. The analysis of data reveals that the average growth rate increases at the rate of 9.76%. Further, the average citation per paper observed is 12.18%. High degree of international collaboration is notified and USA and South Korea are found to be the most preferred collaborative countries. The CAGR calculated for six universities are 9.76. The major research publications outputs are from the field of Chemistry, Crystallography and Pharmacy.

Key Words: Scientometrics, CAGR, Citation Analysis, h-index, International Collaboration Studies, Annamalai University, Madras University, Alagappa University, Bharathiar University, Bharathidasan University, Madurai Kamaraj University.

Introduction

Higher Education is the shared responsibility of both the Centre and the States. The organization and maintenance of standards in Universities & Colleges is assigned to the UGC and other constitutional regulatory bodies. Higher Education sector has witnessed a remarkable increase in the number of Universities. Govt. of India has established 45 Central Universities and 318 State Universities of which are under the control of Ministry of Human Resource Development and has given the importance of science and technology in economic development of a nation, India's higher education system is the third largest in the world. MHRD funded jointly by the state governments to state universities to improve the Science and technology. The benefits of science are delivered to the people and society through technology development.

Tamil Nadu is home to some of the most reputed institutes for higher education in India. There are 21 state universities are functioning in Tamil Nadu which include Arts and Science, Engineering, Agricultural and Medical disciplines. Among them six universities are highly reputed universities disseminating Arts and Science Education. They are University of Madras (MU), Annamalai University (AU), Bharathiar University (BU), Bharathidasan University (BDU), Madurai Kamaraj University (MKU) and Alagappa University (ALU). The first university established was University of Madras in 1857 at Chennai (earlier Madras), followed by Annamalai University Annamalainagar in 1929. These two universities are pre independence universities of our Nation. In 1965 Madurai Kamaraj University was established in Madurai, followed by Bharathiar and Bharathidasan in 1982 at Coimbatore and Trichy respectively. Alagappa University started its service from 1985 in Karaikudi. Among the other universities in Tamil Nadu, these six universities produce a number of PhDs in science, engineering and social sciences and also contribute a large number of research articles every year.

In the present study, an effort has been taken to analyze all the 25,569 research papers published by top six Universities of Tamil Nadu (MU Chennai, AU Annamalainagar, MKU Madurai, BU Coimbatore, BDU Trichy, and ALU Karaikudi) published by them during the period 2000- 2017. The remaining universities of Tamil Nadu are newly established and contributed less number of papers to the total output of the state as well as India. Therefore, the contributions of other universities are not taken for the present study.

Review of literature

Several studies in the past have been published in literature dealing with the research performance of countries, different subjects and institutions. Maharana[1] studied the articles published in Utkal University and revealed that 1.53 average authors per paper and 0.66 productivity per author. Pawan[2] analysed in his article maps the growth pattern of higher education in India with particular focus on enrolment growth and change in funding patterns. On analysis of the trends, it identifies the concerns and builds a case for change in Indian higher education so that the country’s virtuous cycle of economic growth fuelled mainly by its large pool of qualified manpower is sustained. Patra[3] analysed LIS education in universities and reveled that India has the infrastructure and facilities for education and research in LIS, but LIS

literature from India is rather low as reflected by the LISA database. Agarwal[4] in his study focused that the standards of academic research are low and declining. A few problems of the Indian higher education, such as the serious affiliating system, stiff academic structure, unbalanced capacity across various subjects, dwindling down autonomy of academic institutions, and the low level of public financial support are well known. Pawan[5] witnessed in his findings that higher education now holds a central position in the country's policy for global competitiveness and inclusive growth, and quite a lot of steps have been adopted for its enhancement and he proposes an outline for the creation of a cutthroat environment in higher education that would make positive utilization of public money and development of both public and private institutions. Sevukan[6] analyzed the research output of central universities to which he found that the contribution to the literature on the subjects from the central universities has been steadily growing further there is a trend noticed towards collaborative research.

Kumar H[7] in his study analysed the research output of Gujarath University and revealed that impact of research is an important yardstick in evaluation of any research and counting the citations is one of the important and common criteria used in calculating the impact of research. Nagpaul[8] examined the contribution of Indian universities to the mainstream scientific literature during 1987-1989 along two distinct, but inter-related dimensions of quantity and quality of research output. The quantity of output is assessed through the number of articles published in journals covered by Science Citation Index, while the quality of output is assessed through the impact factors of journals in which the articles are published. Altbach[9] Measured research productivity in universities. He stressed that it is a complicated and problematic process. Yet, such measurements are important for calculating the productivity of institutions, individual researchers, and academic systems.

Abbot M[10] in his study found that research income, academic staff and postgraduates are all positively associated with research output. There are noticeable differences across different types of universities, with the newer universities lagging in research performance. Abramo[11] in his study explained a methodology for measuring the technical efficiency of research activities. It depends on the appliance of data enclosed analysis to bibliometric data on the Italian university system. Gangan Prathap[12] projected a more coherent procedure for ranking the research output performance of universities by categorizing the indicators that are best correlated with each other and then using a composite indicator coming out as a product of these. Amsaveni[13]in her study found that Research productivity relative growth rate analysis shows a declining trend and doubling time have increased. Research collaboration helped to publish more publication.

Objectives of the study

- To examine the pattern of growth of the research output of the six universities;
- To evolve into the dissemination pattern of the six universities in terms of journals originating country and the impact factor of these journals;
- To investigate the distribution of citation pattern and to identify highly cited authors;
- To identify the research areas in which the results are published; and

• To identify the most preferred country of collaboration for publishing their research results.

Methodology

The study was undertaken based on the data downloaded from Web of Science database for the period 2000-2017 using the search strategy under the name of University and Address tag. Bibliographic details downloaded consisted of name of author(s), document title, year, source title, volume, issue, pages, citation count, source and document type, DOI and Bibliographical information included affiliations, serial identifiers (e.g. ISSN), DOI, publisher, editor(s), language of original document, correspondence address, abbreviated source title. The data was downloaded on 23-04-2018. The data downloaded was analyzed according to the objectives of the study. To analyze the data whole counting method is followed. Irrespective of Single or multiple authored publications, every author is given credit of one count for every publication that bears his/her name.

Scientometric indicators Used

The scientometric indicators used in this study are - Total Number of Publications (TNP); Total Number of Citations (TNC); Citations per Paper (CPP); and Relative Citation Impact (RCI) as measures of output and impact. Total Number Publications and Total Number of Citations are supreme indicators, while CPP and RCI are relative or virtual indicators. The values of TNP and TNC were directly obtained from the downloaded data. CPP is the average number of citations per paper (C/P). It has been widely used in scientometric studies to normalize a large disparity in volumes of published output among disciplines, countries and institutions for a meaningful comparison of research impact. RCI is a measure of both the influence and visibility of a nation's research in global perspective. It is defined as "a country's share of world citations in the subspecialty/country's share of world publications in the subspecialty". RCI = 1 denotes a country's citation rate equal to world citation rate; RCI < 1 indicates a country's citation rate less than world citation rate and also implies that the research efforts are higher than its impact; and RCI > 1 indicates a country's higher citation rate than world's citation rate and also imply high impact research in that country. These indicators have been used by Sadik Batcha(Batcha, 2018) for assessment of oral cancer research in India.

Results and discussion

Types of Document

The selection of an appropriate outlet often has an influence on the visibility and impact of the published research. Hence, analyses of the types of document used for communicating research results are very important. The results of the analysis on the type of documents used by six universities for publishing research results are given in Table 1 which indicates that about 95% of the output was published as journal articles. The proportion of journal papers was almost equal for all universities except Madras University yet it is closely followed. Next to that all the six universities published highest (1.63%) papers as Review papers followed by proceeding papers and Meeting abstracts (1.47%).

Table 1 – Type of Documents Published by Universities of Tamil Nadu

Document Type	MU	AU	BU	BDU	MKU	ALU	Total
Article	6413 (92.97)	5800 (95.93)	3736 (95.79)	3330 (93.67)	2978 (94.42)	1947 (96.58)	**24204 (94.66)**
Review	94 (1.36)	94 (1.55)	59 (1.51)	91 (2.56)	72 (2.28)	6 (0.30)	**416 (1.63)**
Proceeding Paper	105 (1.52)	83 (1.37)	41 (1.05)	44 (1.24)	46 (1.46)	57 (2.83)	**376 (1.47)**
Meeting Abstract	221 (3.20)	79 (1.31)	32 (0.82)	1 (0.03)	39 (1.24)	3 (0.15)	**375 (1.47)**
Letter	0 (0.00)	75 (1.24)	5 (0.13)	44 (1.24)	8 (0.25)	0 (0.00)	**132 (0.52)**
Correction	30 (0.43)	18 (0.30)	9 (0.23)	20 (0.56)	2 (0.06)	3 (0.15)	**82 (0.32)**
Editorial Material	35 (0.51)	15 (0.25)	14 (0.36)	23 (0.65)	9 (0.29)	0 (0.00)	**96 (0.38)**
Retracted Publication	0 (0.00)	6 (0.10)	3 (0.08)	2 (0.06)	0 (0.00)	0 (0.00)	**11 (0.04)**
others	0 (0.000)	2 (0.033)	1 (0.026)	0 (0.000)	0 (0.000)	0 (0.000)	**3 (0.01)**
Total	**6898**	**6046**	**3900**	**3555**	**3154**	**2016**	**25569**

Publication pattern of six Universities

During the study period, the six universities published 25,569 papers. Among these Madras University (MU) published the highest (26.98%) of the papers closely followed by Annamalai University (AU) with 23.65% of the papers. The lowest number of papers was published by Alagappa University (ALU) with 7.88% of the output. The share of BU, BDU and MKU were 15.25, 13.90 and 12.34 percentages respectively. Data presented in Table 2 indicates that the output of the six universities has grown continuously during the period of study. Data were examined for change in output during 2000-2005 (block 1), 2006-2011 (block 2) and 2012-2017 (block 3). Data presented in Table 2 indicates that in one block to other block the output by all six universities have shown an increasing trend. Except MU and AU, other four universities have doubled their output from block 2 to 3. Yet MU and AU have shown a steady growth from block 1 to 3. The highest increase was for MU followed by AU and BU. Compound Annual Growth Rate also examined (CAGR) of six universities during 2000 to 2017. The values of CAGR for different universities are MU (6.65%), AU (12.04%), BU (13.70%), BDU (10.49%), MKU (7.69%) and ALU (11.29%), which has been calculated by using the formula of CAGR **=((End Value/Start Value)^(1/(Periods))-1.** . It indicates that highest CAGR was secured by BU followed by AU. The overall CAGR indicates for 9.76%.

Table 2 –Research Growth pattern of Universities of Tamil Nadu

Year	MU	%	AU	%	BU	%	BDU	%	MKU	%	ALU	%	Total	%
2000	189	2.74	57	0.94	64	1.64	55	1.55	78	2.47	35	1.74	478	1.87
2001	206	2.99	56	0.93	64	1.64	67	1.88	116	3.68	41	2.03	550	2.15
2002	223	3.23	97	1.60	107	2.74	89	2.50	122	3.87	48	2.38	686	2.68
2003	309	4.48	128	2.12	103	2.64	122	3.43	131	4.15	39	1.93	832	3.25
2004	280	4.06	189	3.13	108	2.77	117	3.29	125	3.96	58	2.88	877	3.43
2005	360	5.22	183	3.03	100	2.56	135	3.80	128	4.06	58	2.88	964	3.77
Block 1	**1567**	**22.72**	**710**	**11.74**	**546**	**14.00**	**585**	**16.46**	**700**	**22.19**	**279**	**13.84**	**4387**	**17.16**
2006	447	6.48	227	3.75	105	2.69	143	4.02	128	4.06	88	4.37	1138	4.45
2007	424	6.15	421	6.96	102	2.62	137	3.85	152	4.82	93	4.61	1329	5.20
2008	397	5.76	417	6.90	127	3.26	135	3.80	156	4.95	62	3.08	1294	5.06
2009	425	6.16	380	6.29	135	3.46	188	5.29	136	4.31	62	3.08	1326	5.19
2010	352	5.10	420	6.95	194	4.97	198	5.57	131	4.15	99	4.91	1394	5.45
2011	401	5.81	490	8.10	212	5.44	290	8.16	220	6.98	151	7.49	1764	6.90
Block 2	**2446**	**35.46**	**2355**	**38.95**	**875**	**22.44**	**1091**	**30.69**	**923**	**29.26**	**555**	**27.53**	**8245**	**32.25**
2012	358	5.19	492	8.14	260	6.67	261	7.34	206	6.53	151	7.49	1728	6.76
2013	370	5.36	461	7.62	281	7.21	278	7.82	213	6.75	176	8.73	1779	6.96
2014	460	6.67	462	7.64	350	8.97	319	8.97	258	8.18	176	8.73	2025	7.92
2015	550	7.97	581	9.61	434	11.13	344	9.68	285	9.04	203	10.07	2397	9.37
2016	545	7.90	544	9.00	509	13.05	346	9.73	273	8.66	236	11.71	2453	9.59
2017	602	8.73	441	7.29	645	16.54	331	9.31	296	9.38	240	11.90	2555	9.99
Block 3	**2885**	**41.82**	**2981**	**49.30**	**2479**	**63.56**	**1879**	**52.86**	**1531**	**48.54**	**1182**	**58.63**	**12937**	**50.59**
Block 1+2+3	**6898**	**26.98**	**6046**	**23.65**	**3900**	**15.25**	**3555**	**13.90**	**3154**	**12.34**	**2016**	**7.88**	**25569**	**100**
CAGR	**6.65**		**12.04**		**13.70**		**10.49**		**7.69**		**11.29**		**9.76**	

Citation analysis of Articles

Research impact of individual researchers is measured in terms of citations received, journal's rank or journal impact factor wherein an author's works appeared in, and collaboration matrix of collaborating authors. Citation analysis measures the eminence of research productivity, which presumes that the greater the eminence, command, or priority of a particular publication, the more intermittently it will be cited in the scientific literary works. By counting citations, one can judge the domination or perceptibility of individuals or groups or institutions. Scientific supremacy and visibility of a scientific publication have been observed by noteworthy citations it received. An author's perceptibility can be deliberated through a calculation of how frequently it has been cited in subsequent publications. Batcha S[15] in his study revealed that collaboration of more number of authors per article dominates in publications activities in the research and brings more number of citation count.

Table 3 – Publication Count and Citation Pattern of Tamil Nadu Universities

University	h-index	TPC	TNC	CPP	Cited	Cited %	Un-cited	Un-cited %
MU	88	6898	83748	12.14	5304	76.89	1594	23.11
AU	86	6046	74826	12.38	4890	80.88	1156	19.12
BU	75	3900	46381	11.89	3129	80.23	771	19.77
BDU	73	3555	42652	12.00	2997	84.30	558	15.70
MKU	72	3154	38390	12.17	2677	84.88	477	15.12
ALU	58	2016	25495	12.65	1771	87.85	245	12.15
Total	-	25569	311492	12.18	20768	82.51	4801	17.49

TPC- Total Publication Count; TNC- Total No of Citations; CPP- Citation Per Paper

Table 3 gives the distribution of citations received by journal articles during 2000-2017. Out of the total articles published by faculty members of six universities of Tamil Nadu, 23.11 % of the MU articles did not get any citation followed by BU (19.77%), AU (19.12%), BDU (15.70%), MKU (15.12%) and ALU (12.15%). Out of the cited articles highest 87.85% articles of ALU were cited one or more times, MKU (84.88%), BDU (84.30%), AU (80.88%), BU (80.23%) and MU (76.89%). Considering the theme of citations also, one can conclude that the scientific impact of the six universities is strongly connected to the mainstream science as more than four-fifth of the papers were cited in the international literature though their number of research output differ.

Table 4- Publication with High Citations

S.No	Author and Bibliographical Details	TNC	Country of Origin	ACP	University
1	*Naghavi, Mohsen. et.al. *Lancet*, 385(9963) (2015) 117-171.	2012	U.K	503.00	MU
2	*Kumarasamy, Karthikeyan K. et al. *Lancet Infectious Diseases*, 10(9) (2010) 597-602.	1320	U.K	146.67	MU
3.	*Vos, Theo. et al. *LANCET*, 386(9995) (2015) 743-800.	1234	U.K	308.5	MU
4.	***Namasivayam, C; Kavitha, D. Dyes and Pigments, 54(1) (2002) 47-58	824	U.K	48.47	BU
5.	*Murray, Christopher J. L. et al. *Lancet*, 386(10009) (2015) 2145-2191.	787	U.K	196.75	MU
6.	*Forouzanfar, Mohammad H. et al. *Lancet*, 386(10010) (2015) 2287-2323.	656	U.K	164.00	MU
7.	**Reddy, AR; Chaitanya, KV; Vivekanandan, M. Journal of Plant Physiology, 161(11) (2004) 1189-1202.	629	Germany	41.93	BDU
8.	*Parolini, Ornella. et al. Stem Cells, 26(2) (2008) 300-311.	496	United States	45.09	MU
9.	*Kathiresan, K; Bingham, BL. Advances in Marine Biology, 40 (2001) 81-251.	485	United States	26.94	AU
10.	*Munoz-Price, L.et al. *Lancet Infectious Diseases*, 13(9) (2013) 785-796.	472	U.K	78.67	MU
11.	***Kavitha, D.; Namasivayam, C. Bio Resource Technology, 98(1) (2007) 14-21.	467	Netherlands	38.92	BU

12.	*Kassebaum, Nicholas J. et al. *Lancet*, 384(9947) (2014) 980-1004.	424	U.K	84.80	MU
13.	**Fayaz, Amanulla Mohammed. et al. Nanomedicine - Nanotechnology Biology and Medicine, 6(1) (2010) 103-109	401	Netherlands	44.56	MU
14.	***Dharmaraj, N; Viswanathamurthi, P; Natarajan, K. Transition Metal Chemistry, 26(1-2) (2001) 105-109.	393	Netherlands	21.83	BU
15.	***Krishnaraj, C.; Jagan. et al. Colloids and Surfaces B-Biointerfaces, 76(1) (2010) 50-56	391	Netherlands	43.44	MU
		10991		**732.73**	

*International collaborative paper; **Domestic collaborative paper, ***Institutional collaborative (Author of one institute)

Highly cited Papers Table 4 demonstrates 15 highly cited papers which received more around 400 citations. Out of the 15 highly cited papers, highest 5 papers are from MU, yet fourth one was from BU. Out of 15 top cited papers, 10 papers are from MU. It is really appreciable. 3 papers are from BU, one paper is from AU and one more paper is from BDU. The 15 papers received 10991 of the total citations, with an average of 723.73 citations per paper. Out of 15 highly cited papers, 9 papers had international collaborations. Three BU papers and one MU paper were published with institutional collaborations. One paper of BU and one paper of MU published with domestic collaborations. The paper published in the high IF journals and received citations more than 2000 and 390 citations. A study by Sadik Batcha[16] also showed that papers with international collaborations had higher citations.

Preferred journals

A higher emergence rate of periodicals in a subject field can be a measure of the growth of knowledge in that field. It is a recognized fact that in the field of science and technology there is ostensibly an increasing rate of emergence of new journals to meet the rapid explosion of information. The most preferred journals used to communicate research results are depicted in Table 5, which indicates that there remain differences in communicating their research results in journals. However, there are also some high impact journals in which six universities publish their papers. These are RSC advances, Tetrahedron Letters, Chemico Biological Interactions, Spectrochimica Acta Part A Molecular and Biomolecular Spectroscopy, Journal Of Materials Science Materials in Electronics. Acta Crystallographica Section E Structure Reports Online, Spectrochimica Acta Part A Molecular and Biomolecular Spectroscopy, and Acta Crystallographica Section E Structure Reports Online are the highly preferred journals of universities of Tamil Nadu. The table also gives a picturesque of preferences of journals of individual universities.

Table 5 – Preferred Journals of Tamil Nadu Universities

S.No	Name of Journal	TNP	%	Publishing Country	IF (2017)	Univ
1.	Acta Crystallographica Section E Structure Reports Online	577	8.365	UK	0.21 (2015)	MU
2.	Spectrochimica Acta Part A Molecular and Biomolecular Spectroscopy	366	6.054	Colombia	2.098 (2011)	AU
3.	Acta Crystallographica Section E Structure Reports Online	215	6.048	UK	0.21 (2015)	BDU
4.	Acta Crystallographica Section E Structure Reports Online	212	6.722	UK	0.21 (2015)	MKU
5.	Tetrahedron Letters	104	1.508	UK	2.193	MU
6.	Journal of Molecular Structure	103	1.704	Netherlands	1.753	AU
7.	Spectrochimica Acta Part A Molecular and Biomolecular Spectroscopy	95	2.672	Colombia	2.098 (2011)	BDU
8.	Current Science	92	2.917	India	0.843	MKU
9.	Indian Journal Of Animal Sciences	91	1.319	India	0.185	MU
10.	RSC Advances	89	1.29	UK	3.108	MU
11.	Indian Journal of Geo Marine Sciences	88	1.456	India	0.172 (2016)	AU
12.	Molecular and Cellular Biochemistry	88	1.276	Netherlands	2.669	MU
13.	Acta Crystallographica Section E Structure Reports Online	83	1.373	UK	0.21 (2015)	AU
14.	RSC Advances	82	2.103	UK	0.185	BU
15.	RSC Advances	81	2.568	UK	0.185	MKU
16.	Spectrochimica Acta Part A Molecular And Biomolecular Spectroscopy	79	2.026	Colombia	2.098 (2011)	BU
17.	Rsc Advances	75	2.11	UK	0.185	BDU
18.	Acta Crystallographica Section E Crystallographic Communications	74	1.073	UK	0.347 (2011)	MU
19.	Asian Journal of Chemistry	72	1.191	India	0.14 (2015)	AU
20.	Chemico Biological Interactions	71	1.029	Germany	2.577 (2014)	MU
21.	Synthetic Communications	71	1.029	USA	1.134	MU
22.	Journal of Environmental Biology	66	1.092	India	0.697	AU
23.	Spectrochimica Acta Part A Molecular and Biomolecular Spectroscopy	66	2.093	Colombia	2.098 (2011)	MKU
24.	Current Science	65	1.828	India	0.843	BDU
25.	Journal Of Materials Science Materials in Electronics	63	3.125	Netherlands	2.019 (2016)	ALU

Preferred Countries for collaboration

Table 6 shows the international research collaboration with the preferred countries. All the six universities of Tamil Nadu mostly collaborate with USA still their preferences differ. MU mostly prefers USA, Malaysia, South Korea, and Japan. AU highly collaborates with USA, Italy, Malaysia and South Korea. BU highly publishes their articles in collaboration with South Korea, USA, Taiwan, China and Saudi Arabia. BDU finds its collaboration from USA, South Korea,

Switzerland, Japan and Germany. MKU and ALU both prefer South Korea and Taiwan for their international collaboration.

Table 6 - Preferred Countries for collaboration

S.No	Country	TNP	%	Univ & Rank	S.No	Country	TNP	%	Univ & Rank
1.	USA	371	5.378	MU/1	13.	Peoples R China	151	3.872	BU/4
2.	South Korea	329	8.436	BU/1	14.	Italy	147	2.431	AU/2
3.	USA	287	9.1	MKU/1	15.	Saudi Arabia	140	3.59	BU/5
4.	USA	256	6.564	BU/2	16.	Taiwan	118	5.853	ALU/2
5.	Taiwan	190	4.872	BU/3	17.	Italy	109	2.795	BU/6
6.	USA	189	3.126	AU/1	18.	Switzerland	109	3.066	BDU/3
7.	Malaysia	188	2.725	MU/2	19.	Japan	108	2.769	BU/7
8.	South Korea	182	9.028	ALU/1	20.	South Korea	100	3.171	MKU/1
9.	USA	178	5.007	BDU/1	21.	Japan	98	2.757	BDU/4
10.	South Korea	177	2.566	MU/3	22.	Taiwan	92	2.917	MKU/2
11.	Japan	173	2.508	MU/4	23.	Germany	88	2.475	BDU/5
12.	South Korea	169	4.754	BDU/2	24.	Malaysia	86	1.422	AU/3
					25.	South Korea	84	1.389	AU/4

Specialization and Preferred Research Areas

Table 7 focuses on the specialization of individual universities and their core concentration of research. All the studied universities of Tamil Nadu except Alagappa University (AU) mostly concentrate on Chemistry whereas the ALU's core concentration is on Material Sciences. The rank of research areas and the rank of universities' preferences have been presented in the table. Chemistry, Crystallography, Pharmacology Pharmacy, Biochemistry Molecular Biology and Physics are top five research areas in which maximum number of papers published by six universities of Tamil Nadu. Spectroscopy by AU and Toxicology as well as Environmental Science Ecology by MU is sole specializations of these universities and they are not concentrated by other four universities.

Table 7 – Preferred Research Areas of Tamil Nadu Universities

S.No	Research Areas	Rank of Res.Area	TNP	%	Univ & Rank of Research Areas
1.	Chemistry	1	1,431	20.745	MU/1
2.	Chemistry	1	1,304	21.568	AU/1
3.	Chemistry	1	1,145	29.359	BU/1
4.	Chemistry	1	1,033	32.752	MKU/1
5.	Chemistry	1	908	25.541	BDU/1
6.	Crystallography	2	870	12.612	MU/2
7.	Pharmacology Pharmacy	3	717	11.859	AU/2
8.	Biochemistry Molecular Biology	4	635	9.206	MU/3
9.	Pharmacology Pharmacy	2	622	9.017	MU/4
10.	Physics	5	600	16.878	BDU/2

11.	Materials Science	6	598	29.663	ALU/1
12.	Engineering	7	590	9.759	AU/3
13.	Materials Science	6	567	9.378	AU/4
14.	Materials Science	6	543	7.872	MU/5
15.	Materials Science	6	542	3.897	BU/2
16.	Physics	5	519	3.308	BU/3
17.	Physics	5	502	7.277	MU/6
18.	Chemistry	1	489	24.256	ALU/2
19.	Physics	5	460	22.817	ALU/3
20.	Crystallography	2	416	11.702	BDU/3
21.	Spectroscopy	8	394	6.517	AU/5
22.	Engineering	7	384	5.567	MU/7
23.	Biochemistry Molecular Biology	4	363	6.004	AU/6
24.	Physics	5	363	6.004	AU/7
25.	Engineering	7	347	8.897	BU/4
26.	Toxicology	9	346	5.016	MU/8
27.	Environmental Science Ecology	10	336	5.557	MU/9

Conclusion

In this study, the analysis of comparative research performances in terms of publication outputs and its impact in terms of citations during the period 2000- 2017 of six universities of Tamil Nadu is presented. It is observed from the study that though the research publications of six universities has grown from 478 in 2000 to 2555 in 2017, but in an inconsistent way. Considering the pattern of citations also, it can be concluded that the scientific impact of the six universities is strongly connected to the mainstream science as more than four-fifth of the papers were cited in the international literature. The collaborative countries are found vary from one university to other university. The research areas found in six universities are common yet Annamalai University with spectroscopy and Madras University with Toxicology and Environmental Science Ecology stand to be a specialized research centre in these areas of research.

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