ISSN (Print): 0972-2467
ISSN (Online): 0976-2477
SRELS Journal of Information Management, Vol 54(3), June 2017, p. 158-164 DOI: 10.17821/srels/2017/v54i3/112332

S & T Publications from Bangalore City: A Scientometric Analysis

B.B. Chand*

Institute for Social Economic Change (ISEC), Nagarabhavi — 560 072, Bangalore, India;
bbchand@isec.ac.in

Abstract

Scientometric analysis of research publication from Bangalore city published between 2001-2015 shows that Indian Institute of Science has the highest number of publications but its share is coming down gradually. Also the share of Bangalore city's publications to Indian research publication is showing a declining trend. There is a healthy intracity and foreign collaboration among research institutions in Bangalore city. Research publications from Jawaharlal Nehru Centre for Advanced Scientific Research are cited more often. It is encouraging to observe that the research publications are growing both quantitatively and qualitatively over the years.

Keywords: Scientometrics, Scientific Research, Research Collaboration, Research Quality

1. Introduction

Bangalore is known for its scientific institutions. Research Institutions such as Indian Institute of Science, Jawaharlal Nehru Centre for Advanced Scientific Research, Raman Research Institute, Indian Institute of Astrophysics, and National Centre for Biological Sciences, National Institute of Mental Health and Neurosciences have been the centres of research activity in Bangalore. In fact The Indian Institute of Science (IISc) Bangalore is a public university ranked 33rd in the 2016 edition of the QS University Rankings: Asia and joint 152nd in the QS World University Rankings 2016-2017, making it the top university in India[10]. The contributions of other institutions are also significant considering their size. These institutions are producing quality research and have collaborations across the globe. Studying research output from a city which is known for science will allow us to understand the research focus and the progress the city has made in terms for quantity and quality of research. It will explain the behaviour of scientific strength and research acumen.

2. Objective

The major objectives of the study are as follows:

- To assess the research output in Sciences from Bangalore;
- To find out the major areas of scientific research in Bangalore;
- To examine the status of intracity and foreign collaboration of research institutions in Bangalore; and
- To assess the quality of research done in Bangalore city.

3. Methodology

The major data source used for the study was Science Citation Index-Expanded available in Web of Science. Using advanced search feature of the database we retrieved all the publications emanating from Bangalore. The document type "article" only was considered for the current study. The study period was restricted to 2001-2015. All the articles published during the period were considered for the study. A total of 41991 articles were retrieved using query (CI=Bangalore or CI=Bengaluru) and Document Types: (Article) Time Span=2001-2015 Indexes=SCI-EXPANDED. The data with respect to total publication, research areas, global collaborations, organizations were retrieved and analysed. For qualitative analysis the study included rolling five year citation data

*Author for correspondence

for individual organizations. Institutions with more than 1000 publications were included for qualitative analysis for the period 2008-2012 i.e. for articles published in the year 2008 and citations received during 2008-2012. Average citation per paper for quality analysis was derived by dividing total citations received during the rolling five year by the total papers published during that year.

4. Literature Review

Mapping research output is an important activity in scientometric research. Mapping of Science and Technology publications from India have been studied at different point of time with an objective to showcase the progress of Indian Science concluded that the progress is good but need to achieve more with policy interventions (Arunachalam, Srinivasan, & Raman, 1998, Kademani et.al., 2007 and Gupta and Dhawan 2008)[1,5,6]. Comparison of scientific productivity between India and China shows that government interventions and increased research funding are important factor for growth in scientific productivity (Panat, 2014)[9]. A review by Frenken and Hoekman (2014)[2] indicates that spatial aspects of scientific activity using spatial scientometric data is on the rise; while earlier most studies were carried out at country level, scientometric research now take into account regional and urban level data. Matthiessen and Schwarz (2010)[8] study the 100 largest cities in the world in terms of publication and citation output for two periods: 1996–1998 and 2004–2006. The study observes that research in Europe, North America and Japan are rapidly being supplemented with fast-growing centres, especially located in south-east Asia. Asian cities such as Seoul and Beijing are producing higher number of research output than their global counterparts. Grossetti et al. (2013)[4] finds that in most countries in the world, research environment in science is spreading geographically i.e. large cities are seeing a relative decline of their share in a country's scientific output. Using WoS data studies on France, with a specific focus on small and medium-sized cities by Levy and Je´gou (2011)[7] shows that the number of publications has increased over time. The paper has observed it is not only more institutions participated in the publication process but also the research has become more internationalised. Richard Van Noorden (2010)[11] in his paper quoting Elsevier study says that Boston and Cambridge, Massachusetts, receive twice as many citations per paper as the global average. US cities dominate the quality table, with only Cambridge, UK, breaking into the top 10. The number of publications has increased significantly from Beijing, however, is below par in the quality stakes: its papers in the five-year period ending 2008 attracted 63% of the global average-citation rate. A study by Garg and Kumar (2013)[3] on Scientometric profile of Science and Technology Publications in India finds that Indian Institute of Science (Bangalore) published the highest number of papers; and the Jawaharlal Nehru Centre for Advanced Scientific Research (Bangalore) made the highest impact.

Table 1. Growth of scientific research output from Bangalore city

Sl. No.	Year	Global Research Output	Indian Research Output	Indian Research Output % Share of Global output	Research Publications from Bangalore	Research Pub. from Bangalore as % Share of Global Output	Research Publications from Bangalore as % Share of Indian Output
1	2001	716940	17519	2.44	1578	0.22	9.01
2	2002	734582	18651	2.54	1659	0.23	8.89
3	2003	770844	20521	2.66	1809	0.23	8.82
4	2004	807968	22023	2.73	1837	0.23	8.34
5	2005	848516	23966	2.82	2067	0.24	8.62
6	2006	891687	27056	3.03	2142	0.24	7.92
7	2007	930812	31649	3.40	2520	0.27	7.96
8	2008	985363	35999	3.65	2726	0.28	7.57
9	2009	1020723	37594	3.68	2966	0.29	7.89
10	2010	1060277	40788	3.85	3177	0.30	7.79
11	2011	1128774	44672	3.96	3415	0.30	7.64
12	2012	1184648	46853	3.96	3575	0.30	7.63
13	2013	1253928	51554	4.11	3882	0.31	7.53
14	2014	1290514	56091	4.35	4291	0.33	7.65
15	2015	1332598	57838	4.34	4347	0.33	7.52
	Total	**14958174**	**532774**	**3.56**	**41991**	**4.10**	**7.88**

5. Results and Discussion

5.1 Growth of Scientific Research

Growth of scientific research output from Bangalore city vis-à-vis Global and Indian research production is presented in Table 1. Though global research output has nearly doubled during the period 2001-2015 the research output from India and Bangalore has grown nearly 3 times. In absolute terms the research output from Bangalore has gone up from 1578 to 4396 during this period. The percentage share of Indian Research Output to Global one has gone up from 2.44% in 2001 to 4.34% in 2015. The percentage share of research output from Bangalore to Global research output has also seen a steady growth from 0.22% to 0.33. Global research output has grown with a CAGR of 4.53% annually where as the Indian research output has grown at a higher CAGR at 8.91%. The research output from Bangalore has also grown with a good CAGR of 7.51%.

The growth of science literature from Bangalore is quite high but still it is lower than India as a whole. This can also be seen from the figures of Bangalore city's scientific research output as a percentage share of Indian research output, which has been declining steadily from 9.01% in 2001 to 7.52% in the year 2015. The prime reason being many new institutions were set up across India especially IITs, IISERs, AIIMs which were responsible for growth of literature from other parts of India where as not many new institutions came up in Bangalore city recently (Figure 1).

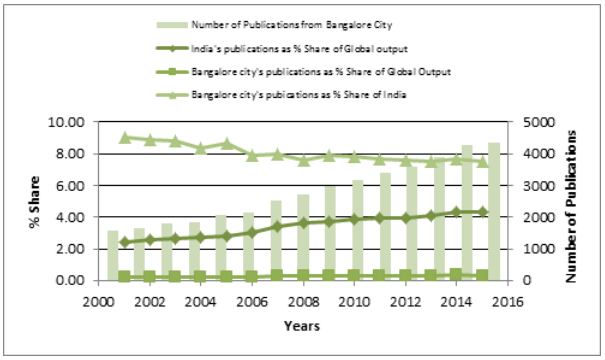

Figure 1. Bangalore city's research output vis-à-vis India and Global research output.

5.2 Institutional Contribution to Bangalore City's Scientific Output

The top 10 institutional contributors to Bangalore city's scientific output for the period from 2001 to 2015 are shown in the Table 2. Indian Institute of Science (IISc) being the biggest and oldest institution takes the lead with a total 18884 publications, with 4857 coming during the 1st 5 years, 6242 from the 2nd 5 year interval and 7785 from the final 5 year interval. But the percentage share of IISc's contribution vis-à-vis Bangalore City's research production has come down from 54.27% in 1st 5 years to 39.90% in the latest 5 years. The second highest contribution is from Jawaharlal Nehru Centre for Advanced Scientific Research with 3379 at 8.05% and here also we can observe similar decline. Bangalore University, National Institute of Mental Health Neurosciences India, Raman Research Institute, National Centre for Biological

Table 2. Institutional contribution to Bangalore city's scientific output

Sl. No.	Institutions	Period 2001-2015	% Share	Period 2001-05	% Share	Period 2006-2010	% Share	Period 2011-2015	% Share
1.	Indian Institute of Science	18884	44.97	4857	54.27	6242	46.13	7785	39.90
2.	Jawaharlal Nehru Centre For Advanced Scientific Research	3379	8.05	899	10.05	1077	7.96	1403	7.19
3.	Bangalore University	1757	4.184	379	4.24	645	4.77	733	3.76
4.	National Institute of Mental Health Neurosciences India	1580	3.763	277	3.10	556	4.11	747	3.83
5.	Raman Research Institute	1436	3.42	332	3.71	492	3.64	612	3.14
6.	National Centre for Biological Sciences	1276	3.039	229	2.56	386	2.85	661	3.39
7.	Indian Institute of Astrophysics	1186	2.824	330	3.69	387	2.86	469	2.40
8.	University of Agricultural Sciences Bangalore	822	1.958	294	3.29	254	1.88	274	1.40
9.	National Aerospace Laboratories India	780	1.858	173	1.93	269	1.99	338	1.73
10.	Indian Inst Horticultural Research	445	1.06	87	0.97	124	0.92	234	1.20

Sciences have contributed between 3-4% and Indian Institute of Astrophysics, University of Agricultural Sciences Bangalore, National Aerospace Laboratories India, Indian Institute of Horticultural Research have contributed between 1-2%. It is noteworthy to mention here that contribution from National Centre for Biological Sciences has seen a positive growth over different block years.

5.3 Publications in Major Research Area

Table 3 presents the major research areas we can observe that highest number of publications are in Chemistry, Physics, Material Science and Engineering with 19.9%, 16.95%, 13.66% and 13.08% share respectively. Science Technology Other Topics which could not be classified into one of these categories contributes 7.32%. Biochemistry Molecular Biology, Astronomy Astrophysics, Computer Science and Mathematics contribute between 4-6%. Publications from subject areas such as Neurosciences, Neurology, Crystallography, Pharmacology, Mechanics, Metallurgy Metallurgical Engineering, Agriculture, and Environmental Sciences, Ecology ranges between 2-3%. For all other subject areas it is less than 2%.

Table 3. Publications in major research area

Sl. No.	Research Area	Number of Publication	Percentage
1.	Chemistry	8016	19.09
2.	Physics	7116	16.95
3.	Materials Science	5736	13.66
4.	Engineering	5492	13.08
5.	Science Technology Other Topics	3074	7.32
6.	Biochemistry Molecular Biology	2509	5.98
7.	Astronomy Astrophysics	1822	4.34
8.	Computer Science	1697	4.04
9.	Mathematics	1532	3.65
10.	Neurosciences Neurology	1218	2.90
11.	Crystallography	1218	2.90
12.	Pharmacology Pharmacy	1216	2.90
13.	Mechanics	1202	2.86
14.	Metallurgy Metallurgical Engineering	1058	2.52
15.	Agriculture	1001	2.38
16.	Environmental Sciences Ecology	919	2.19

5.4 Sources of Publications

Top 10 sources used by the researchers in Bangalore city to publish their research work are presented in Table 4.

Table 4. Sources of publications

Sl No.	Name of the Journal	Number of Papers	% Share
1.	Current Science	741	1.765
2.	Physical Review B	449	1.07
3.	Plos One	429	1.02
4.	Acta Crystallographica Section E Structure Reports Online	373	0.89
5.	Monthly Notices of The Royal Astronomical Society	346	0.82
6.	Physical Review E	328	0.78
7.	Journal of Applied Physics	318	0.76
8.	Astrophysical Journal	317	0.76
9.	Journal of Chemical Physics	308	0.73
10.	Journal of Physical Chemistry B	292	0.7

While studying the sources of publications we observed that Current Science has the highest number of papers counting 741 with a percentage share of 1.77%. Where as Physical Review B has 2nd highest number of publications with 449. PLOS One comes close third at 429 though the journal itself was started more recently than the other two mentioned above. Most of the other journals in the top 10 sources of publication have contributed between 0.7% to 0.89%. A total of 4362 different sources of publications were used to publish their research work which is well spread out.

5.5 Collaborating Countries

Foreign collaborations at different periods are shown in Table 5 below. Over all 20023 papers have foreign collaborators which constitute around 47.69%. A further breakup shows that there is an increasing trend in foreign collaborations from 34.37% during 2001-05 to 39.78% during 2006-2010 and to 58.81% between 2011-2015.

Table 5. Foreign collaborations at different period

Sl No.	Period	Number of Collaborations	Number of Countries	% Share
1	2001-2015	20023	159	47.69
2	2001-2005	3166	93	35.37
3	2006-2010	5383	108	39.78
4	2011-2015	11474	153	58.81

Figure 2 shows the level of collaborations with different countries for scientists from Bangalore. United States of America is the most preferred research partner country with whom 5085 number of papers were published by institutions in Bangalore city. Around 12% of total papers have collaborators from USA. England comes second with

3.29% of publication with 1383 number of collaborations. Germany and France Followed with 2.98% and 2.7 % share respectively. Among Asian countries Japan has highest number of partnership of 831 followed by South Korea and China with a percentage share of 2%, 1.3% and 1.1% respectively.

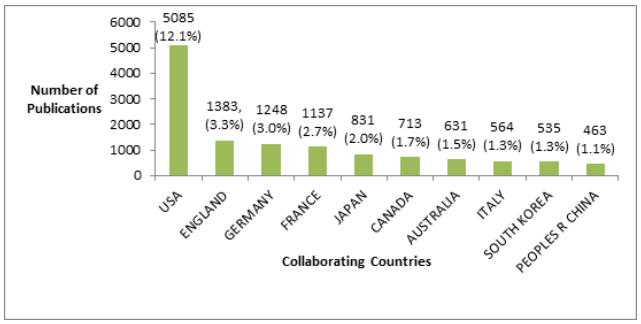

Figure 2. Foreign collaborations.

While looking at intra-city collaborations we studied major research institutions with at least 1000 publications and observe that IISc being the premier research institute has collaborated with most of the other good research institutions in Bangalore City. The Table 6 shows the collaboration matrix of research institutions in Bangalore city. IISc has good level of collaboration with JNCASR which is at 1330 number of publications. IISc also has collaborated with Bangalore University (BU) with 175 publications, Raman Research Institute (RRI) with 129 publications and National Center for Biological Sciences (NCBS) with 105 publications. RRI and NCBS have 68 collaborative papers together. NIMHANS being a very specialized institution has not collaborated with RRI. Indian Institute of Astrophysics also has not collaborated with NIMHANS and NCBS either. Overall there are healthy intracity collaborations between research institutions in Bangalore city.

5.6 Research Quality

Though quantity of research is an important scientometric indicator, it is important to study the quality as well to understand the value of research that is being produced by the scientific community. Studying citations allows us to understand how many times an article is being used for further research. As discussed earlier we have considered citations received by publications to study the quality aspect both in terms of trend analysis and institutional comparison. Table 7 presents data on citations received by the publications from institutions across Bangalore city. Total citations received in rolling 5 year period of publication was only 9977 in the year 2001, which has gone up to 35546 in the year 2012. Also, we can observe that the citation per paper has gone up from 6.32 in the year 2001 to 10.74 in the year 2011. Only in the latest year

Table 6. Intra-city institutional collaboration

Institutes	IISC	JNCASR	BU	NIMHANS	RRI	NCBS	IIA
IISC	_	1330	175	77	129	105	53
JNCASR	1330	_	6	41	13	27	4
BU	175	6	_	5	18	9	14
NIMHANS	77	41	5	_	0	25	0
RRI	129	13	18	0	_	68	29
NCBS	105	27	9	25	68	_	0
IIA	53	4	14	0	29	0	_

Table 7. Average citation per paperover the years

Sl. No.	Years	Number of Articles	Citations Received in Rolling 5 year	Average Citation per paper
1.	2001	1578	9977	6.32
2.	2002	1659	10122	6.10
3.	2003	1809	12281	6.79
4.	2004	1837	14418	7.85
5.	2005	2067	15528	7.51
6.	2006	2142	16266	7.59
7.	2007	2520	19888	7.89
8.	2008	2726	24093	8.84
9.	2009	2966	29182	9.84
10.	2010	3177	32182	10.13
11.	2011	3415	36687	10.74
12.	2012	3575	35546	9.94

it has come down a little to 9.94. However the growth in average citations per paper is very impressive which confirms that the quality of research has increased over the years.

To further analyze the citation pattern we considered 7 institutions with more than 1000 papers. Table 8 shows the institution-wise number of papers, total citations received during rolling 5 year period and average citations per paper. For IISc the average citation per paper has gone up from 9.77 to 10.65 during the period with highest in the year 2001 at 11.46. For JNCASR the average citation score varies between 17 and 18. The only exception was 2011 where it was 14.37. For Bangalore University it varies between 4.87 to 7.66, which is below the city's average. Likewise for NIMHANS also it is largely below the city's average except for the year 2011 for which it was 10.98. The average citation received by RRI is largely in line with the city average. NCBS and IIA have maintained higher average citations per paper over the period of study.

Figure 3 indicates that three institutions i.e. JNCASR, NCBS and IIA have higher average citations per paper than that of Bangalorecity as a whole. Bangalore University and NIMHANS have lower average citation per paper than that of the Bangalore city. Also we can observe from the figure that for 2010 JNCASR and for 2011 NCBS have received very high average citations per paper of around 20.

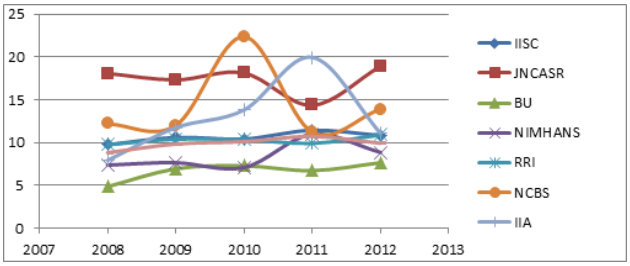

Figure 3. Institutions-wise average citation per paper.

6. Conclusion

The scientific literature emanating from institutions in Bangalore city has increased considerably over the years. The CAGR is ahead of Global growth rate. But the share of scientific publications from Bangalore with respect to India has come down which suggests that contributions from other cities / towns have increased. Indian Institute of Science being the largest institute in terms of resources both physical and human has the highest share of publications, but its share is decreasing over the years, which confirms that other institutions are also contributing. Basic science areas such as Physics, Chemistry and Material Science are prime contributors. Foreign collaborations are dominated by USA followed by countries such as England, Germany and France. Collaborative papers have grown indicating that research is largely performed by teams. The scientific

Table 8. Institutions-wise number of papers, citation and average citation per paper

Institutions		2008	2009	2010	2011	2012	Total
Indian Institute of Science (IISc)	TC	11888	14281	14084	15697	16132	72082
	NP	1217	1345	1350	1370	1487	6769
	ACP	9.77	10.62	10.43	11.46	10.85	10.65
Jawaharlal Nehru Center for Advanced Scientific Research (JNCASR)	TC	3817	3762	4532	3694	4770	20575
	NP	211	217	250	257	252	1187
	ACP	18.09	17.34	18.13	14.37	18.93	17.33
Bangalore University (BU)	TC	628	995	1235	1261	1257	5376
	NP	129	143	169	187	164	792
	ACP	4.87	6.96	7.31	6.74	7.66	6.79
National Institute of Mental Health Neurosciences (NIMHANS)	TC	864	898	980	1252	1110	5104
	NP	117	117	138	114	125	611
	ACP	7.38	7.68	7.10	10.98	8.88	8.35
Raman Research Institute (RRI)	TC	1026	1041	1056	1102	1232	5457
	NP	105	100	102	111	113	531
	ACP	9.77	10.41	10.35	9.93	10.90	10.28
National Centre for Biological Sciences (NCBS)	TC	854	1106	2194	1191	1866	7211
	NP	70	92	98	106	134	500
	ACP	12.20	12.02	22.39	11.24	13.93	14.42
Indian Institute of Astrophysics (IIA)	TC	580	917	1092	2197	913	5699
	NP	73	78	79	110	82	422
	ACP	7.95	11.76	13.82	19.97	11.13	13.50

TC=Total Citations, NP=Number of papers, ACP=Average citation per paper

research has become more dispersed i.e. more institutions are participating than ever before. The quality of research is also increasing which can be observed from increased level of citations.

7. References

1. Arunachalam, S., Srinivasan, R., and Raman, V. (1998). Science in India–A profile based on India's publications as covered by Science Citation Index 1989–1992. Current Science, 74(5):433-441.
2. Frenken, K., and Hoekman J. "Spatial scientometrics and scholarly impact: A review of recent studies, tools, and methods." Measuring scholarly impact. Springer International Publishing, 2014. 127-146.
3. Garg, K.C., Kumar, S. (2013). Scientometric Profile of Indian Science as Seen Through Science Citation Index – Expanded 2010-2011. SRELS Journal of Information Management, 50(5), 529–542.
4. Grossetti, M., Eckert, D., Gingras, Y., Je, L., and Larivie, V. (2007). Cities and the geographical deconcentration of scientific activity: A multilevel analysis of publications (1987–2007), 51(10), 2219–2234. http://doi.org/10.1177/0042098013506047
5. Gupta, B. M., and Dhawan, S. M. (2008). A Scientometric Analysis of S & T Publications Output by India during 1985-2002. DESIDOC Journal of Library & Information Technology, 28(2), 73–85.
6. Kademani, B.S., Sagar, A., Kumar, V., and Gupta, B. M. (2007). Mapping of Indian Publications in S & T.: A Scientometric Analysis of Publications in Science Citation Index. DESIDOC Journal of Library & Information Technology, 27(1):17–34.
7. Levy, R., and Jegou, L. (2011). City , Culture and Society Diversity and location of knowledge production in small cities in France. City, Culture and Society, 4(4), 203–216. http://doi.org/10.1016/j.ccs.2013.06.003 Access on 15/02/2017
8. Matthiessen, C.W., Schwarz, A.W., and Find, S. (2010). World Cities of Scientific Knowledge: Systems , Networks and Potential Dynamics . An Analysis Based on Bibliometric Indicators, 47(August), 1879–1897. http://doi.org/10.1177/0042098010372683 Access on 12/02/2017
9. Panat, R. (2014). On the data and analysis of the research output of India and China: India has significantly fallen behind China. Scientometrics. http://doi.org/10.1007/s11192-014-1236-4 Access on 12/02/2017
10. QS Top Universities. https://www.topuniversities.com/about-qs Access on 02/02/2017
11. Van Noorden, R. "Cities: Building the best cities for science." Nature News 467.7318 (2010): 906-908.