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Full Length Research Paper

Growth and impact of research output of Bangalore University, 1971-2010: A scientometric study

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In this paper, an attempt has been made to highlight quantitative growth and development of the Bangalore University (BU) in Science and Technology in terms of publication output as per Science Citation Index from 1970 to 2010. During the period of the study, a total of 2,188 publications were published with 9,401 citations in their credit. The average number of publications per year was 54.7. The highest numbers of papers (152) were published in 2008. BU has collaborated with 27 countries and USA is the top collaborating country with 74(31.09%) of papers followed by France with 20(8.4%). Authorship and collaboration trend were towards multi-authored paper. There were 1940(88.66%) multi-authored/collaborative papers and only 248(11.33%) single authored publications. The prolific authors were: S. M. Mayanna with 113 papers, and N. Rudraiah with 101 papers. P. V. Kamath with 98 papers with the highest *h* and *p* values 21 and 26.52, respectively. The most preferred journals for publication by the scientists were: Current Science with 168 publications, Indian Journal of Chemistry-B with 81 publications and Indian Journal of Chemistry-C with 39 publications.

Key words: Publication productivity, citation analysis, authorship pattern, Bradford's law of scattering.

INTRODUCTION

The generation of knowledge today, particularly, scientific knowledge, takes place primarily in universities. Several attempts have been made in the past to evaluate different departments within the universities, the most notable of which were carried out on universities in the United States by the American Council on Education (ACE) (Carter, 1966). Research productivity in higher education is gaining importance for the past one decade in India. Teaching and research are the two major functions of the university faculties. However, research has gained momentum during the past one and half decade, mainly due to support received through Ph.D. Program, in-house projects, and government funding projects (Kumbar et al., 2008).

Bangalore University was established in July 1964 as an offshoot of the University of Mysore. It has completed forty-six years of fruitful existence and has come to be hailed as one of the largest universities of Asia. Though it originally intended to be a federal university, it has eventually emerged as an affiliating University. The University has been accredited in 2009 by NAAC and has received 'A' Grade Status. Academically, the university is structured into six faculties- Arts, Science, Commerce and Management, Education, Law and Engineering. It has 41 post-graduate departments, one post-graduate Centre at Kolar (started during 1994 to 1995), three constituent colleges, 673 affiliated colleges (of which 108 have PG courses) and several other Centers and Directorates of higher learning and research under its purview. At present, the University offers 51 postgraduate courses.

In this paper, an attempt has been made to describe growth, contribution and impact of research, channels of communication, collaboration, authorship pattern, analysis of strong and weak areas of research carried out by the scientists at Bangalore University in Science and

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Table 1. Quinquennial year-wise productivity of Bangalore University.

Year	Single aut	2-aut	3 -aut	4 - aut	5 - aut	6 -10 aut	11 -20 aut	Multi aut	Total papers	%	Citation	%	CC
1971-1975	42	91	10	3	0	1	0	105	147	6.71	548	5.82	0.378
1976-1980	53	139	37	7	2	0	0	185	238	10.88	1145	12.17	0.426
1981-1985	32	127	78	15	4	0	0	224	256	11.7	1205	12.81	0.509
1986-1990	40	73	54	11	1	0	0	139	179	8.19	772	8.22	0.457
1991-1995	5	43	42	12	8	3	0	108	113	5.16	972	10.33	0.601
1996-2000	22	108	78	26	9	15	4	240	262	11.98	2033	21.65	0.568
2001-2005	28	145	122	48	43	26	2	386	414	18.92	1876	19.95	0.6
2006-2010	26	160	164	108	58	59	4	553	579	26.46	850	9.05	0.64
Total	248	886	585	230	125	104	10	1940	2188	100	9401	100	
Percentage	11.33	40.5	26.74	10.51	5.7	4.75	0.47						
Citations	842	3696	3200	840	259	449	115	8559	9401				
Percentage	8.96	39.31	34.04	8.94	2.76	4.78	1.22	91.04	100				

Aut = author (s); CC - Collaboration Coefficient.

Technology during the period from 1970 to 2010.

METHODOLOGY

Publication and citation data for the study was downloaded from the Web of Science database. A larger time coverage data has been used from 1970 to 2010 for analyzing the growth and impact of the university research to ensure accurate results. Standard bibliometric fields were analyzed by normal count procedure for various domains such as authors and journals, etc. (Surwase et al., 2008).

The index is based on the distribution of citations received by a given researcher's publications. “A scientist has index *h* if *h* of [his/her] Np papers have at least *h* citations each, and the other (Np- *h*) papers have at most *h* citations each.” The index was suggested by Hirsch (2005), a physicist at UCSD, as a tool for determining theoretical physicists' relative quality. *p* -index (performance-index) is the new performance indicator suggested by Prathap (2010). The p-index strikes the best balance between activity (total citations C) and excellence (mean citation rate C/P). The aforementioned two popular indices (*h* and *p*) were used to evaluate the publications and their impact.

RESULTS AND DISCUSSION

Publication productivity

BU had published 2,188 publications during 1970 to 2010, among which highest 152 papers published in 2008. The average number of publications per year was 54.7. Quinquennial period-wise trends in publications such as the single-authored, multi-authored, cumulative number of papers and citations are shown in Table 1 and Figure 1. Out of 2,188 publications, 248 (11.33%) were single authored and 1940 (88.66%) were multi-authored papers. Out of which 886 (40.5%) papers were double-authored with 3696 (39.31%) of citations, 585 (26.74%) papers were publications written by three authors with 3200 (34.04%) citations, 230 (10.51%) of papers were four-authored with 840 (8.94%) of citations and only 10 (0.47%) papers with 115 (1.22%) citations of authors eleven to twenty.

During the period of this study, 2188 papers have been cited 9401 times, and 29,489 cited references were found. Years 2008, 2009 and 2007 are the most productive years with 152, 149 and 133 papers respectively. To measure the collaborative research pattern an indicator called Collaborative Coefficient (CC) (Ajiferuke et al., 2005) was used. The highest CC was 0.65 during 2006 to 2010, and the average CC was 0.52.

Growth of publications

Figure 2 illustrates the growth rate of publications in different five year blocks. During 1971 to 1975 the growth rate of publications was very low and in the years 1986 to 1990 and 1991 to 1995 no exponential growth was observed. Thereafter, during 1996 to 2000 the growth rate of the publications was highest of all the years of the publications that is, (131.86%) with 262

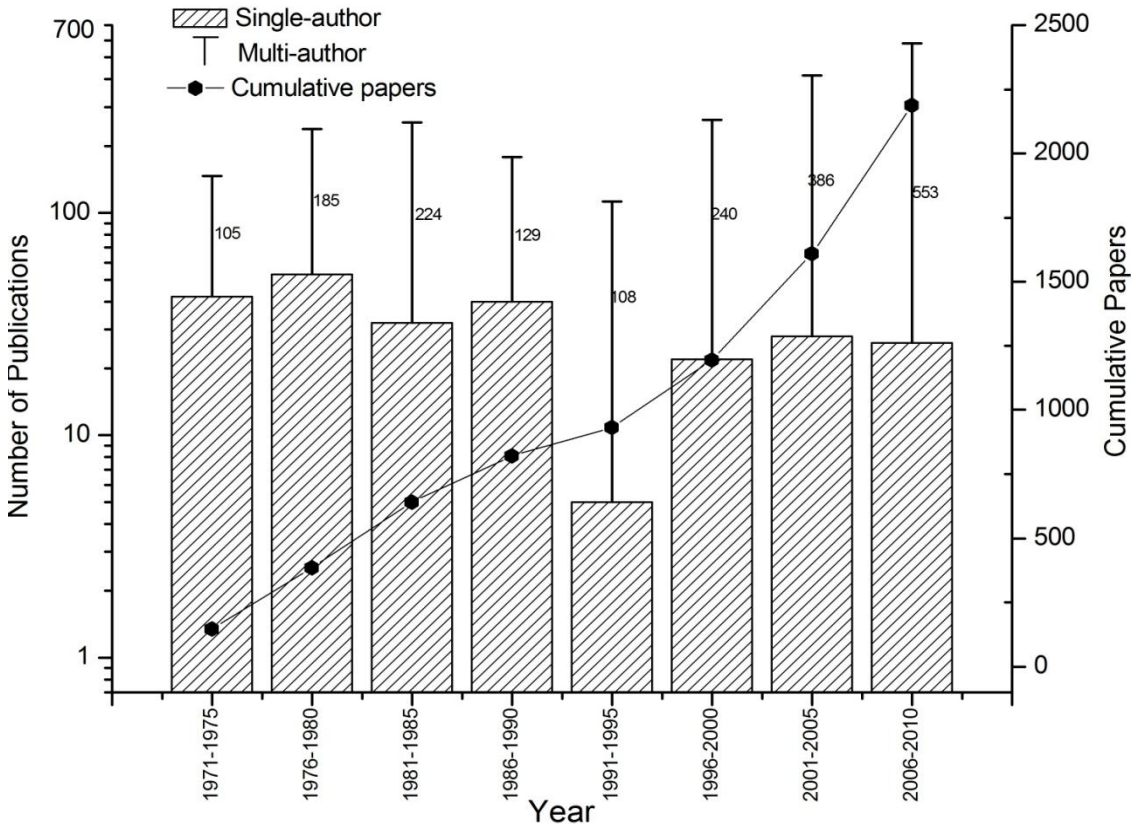

Figure 1. Year-wise publication productivity of Bangalore University, Bangalore.

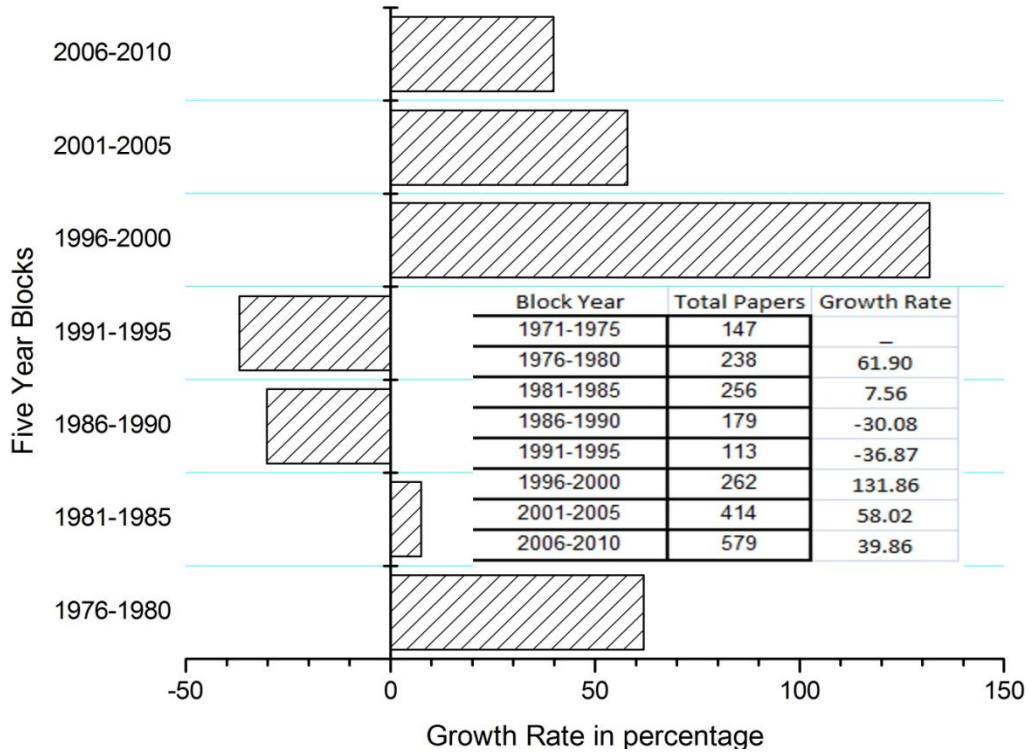

Figure 2. Growth rate in percentage.

publications. Subsequently there was a gradual decrease in the growth rate in the five-year blocks of 2001 to 2005 and 2006 to 2010 (Girap et al., 2009).

Most prolific author and their productive profile

A sum of 1,840 authors contributed 2,188 papers during the period of the study 1971 to 2010. The prolific authors and their publications, citations, years of association, and *h* & *p*-indices are recorded in Table 2, which confirm 117 most productive authors with more than 10 publications. The most productive authors were: SM Mayanna (Central College, Dept Post Graduate Studies Chemistry) is the most productive author with (113) papers with (806) citations during 1973 to 2008 and N Rudraiah (Dept. Mathematics, UGC Centre for Advanced Studies in Fluid Mechanics) with (101) papers with (600) citations during 1973 to 2009. PV Kamath (Central College, Dept Post Graduate Studies Chemistry) has got the highest citations (1, 352) from (98) papers during 1991 to 2009. The top 10 authors account about 32.13% of entire publications and 4,408(46.89%) of whole citation counts.

h-index and *p*-index

The index is based on the distribution of citations received by a given researcher's publications. “A scientist has index *h* if *h* of (his/her) Np papers have at least *h* citations each, and the other (Np- *h*) papers have at most *h* citations each.” The index was suggested by Hirsch (2005), a physicist at UCSD, as a tool for determining theoretical physicists' relative quality.

p -index (performance-index) is the new performance indicator suggested by Prathap (2010). The p-index strikes the best balance between activity (total citations C) and excellence (mean citation rate C/P).

Figure 3 shows the *h* and *p* values of the scientists and the collaborators of BU. It was found that PV Kamath (Central College, Dept Post Graduate Studies Chemistry) in his 20 years span of research career has published 98 papers which have got 1352 citations, has the highest *p*- and *h* values that is 26.52 and 21, respectively. Followed by M. Jayananda (Department of Geology) with *p* and *h* value 20.38 and 11 respectively. Here we observe that the *p* value is much larger than *h* value, because *p* captures the larger citations that *h* fails to capture.

International collaboration of the university

Figure 4 gives the country-wise collaboration trend of Bangalore University. Out of 2188 publications 238 (10.88% of total) publications have international collaboration. BU has collaborated with 27 countries, out of which the leading collaborating country is USA with 74 (31.09%) papers, followed by France 27 (11.34), Canada 20 (8.4%), UK 19 (7.98%) and Japan 18(7.56%).

Channels of communication

The Bangalore University has published its 2188 research output in 615 peer reviewed national and international source journals in different disciplines of Science and Technology. The top two journals in terms of publications were: Current Science (168) and Indian Journal of Chemistry Section B (81) papers. Top two journals in terms of Citations were: Journal of Applied Electrochemistry (281) and Journal of the Electro-chemical Society (275) citations. The publication density was 3.58.

Frequency distribution of papers in various journals, citations, impact factors is presented in the Table 3 and Figure 5.

Bradford distribution

Bradfords law is one of several statistical expressions that describes how the literature on a particular subject is scattered or distributed in various journals. If journals are ranked by the number of articles they contain on a given topic they can be divided into three zones; the first zone deemed as a central nucleus of the most important journals and followed by other two zones each containing the same number of articles as the nucleus (but each containing many more journals) (Bence and Oppenheim, 2004). In addition, Zipf’s Law (1972) describes the frequency distribution of words in a given text, with familiar words being used many times and many words being used only once. Bradfords and Zipfs laws have been shown to be mathematically identical (Brookes, 1968) and so the distribution is often referred to as the Bradford-Zipf distribution. Zone-wise papers and journals can be divided as shown in Table 4.

In this case the Bradford Multiplier is 5.05 and average Bradford multiplier is 4.85. According to this multiplier the number of journals in the third zone should be 535. In reality, it is 488. We found that the number of journals in the third zone was closer to the actual number, but the data does not strictly follow Bradford law.

Conclusion

The analysis is based on publication data consisting of 2,188 research papers, published by the university staff during 1970 to 2010. The quality of research in pro-gressed in terms of citations per paper is 4.29. The growth rate of publications was low in the beginning, but picked up during 1966 to 2000 to 131.86%. The research publication trend was collaborative. The international

Table 2. Highly productive authors and collaborators of Bangalore University during 1970 to 2010.

S/N	Author	No. of Publications	Total Citations	FPY-LPY	Total Years	*h*-index	*p*-index
1	Mayanna SM	113	806	1973-2008	36	16	17.91
2	Rudraiah N	101	600	1973-2009	37	13	15.28
3	Kamath PV	98	1352	1991-2010	20	21	26.52
4	Babu VVS	81	374	1988-2009	22	9	12.00
5	Puttaswamy	63	72	1997-2010	14	4	4.35
6	Pasha MA	59	240	1999-1999	1	8	9.92
7	Chandrasekharaiah DS	55	501	1976-2010	35	12	16.59
8	Gowda NMN	45	249	1974-2008	35	8	11.13
9	Shakuntala K	45	146	1974-2010	37	7	7.80
10	Sureshbabu VV	43	68	2006-2010	5	4	4.76
11	Reddy GKN	41	375	1973-2000	28	9	15.08
12	Puttaraja	40	89	1972-2007	36	5	5.83
13	Nagendrappa G	39	114	1989-2009	21	6	6.93
14	REDDY SR	37	162	1974-1989	16	8	8.92
15	Sivanandaiah KM	35	282	1974-1998	25	8	13.15
16	Shivakumara IS	35	147	1984-2009	26	6	8.52
17	Begum NS	34	67	1994-2009	16	4	5.09
18	Venugopal KR	33	7	2001-2009	9	1	1.14
19	Patnaik LM	32	1	2006-2009	4	1	0.31
20	Sheshadri BS	31	177	1975-2006	32	9	10.04
21	Siddheshwar PG	30	177	1986-2010	25	8	10.15
22	Nirmala KA	30	37	1975-2008	34	3	3.57
23	Kokila MK	29	45	1992-2008	17	3	4.12
24	Mohan S	29	24	1975-2009	35	3	2.71
25	NAGESWAR S	29	23	1976-1988	13	3	2.63
26	Nayeemunnisa	29	15	1974-2003	30	2	1.98
27	Ahmed MF	28	217	1973-2009	37	9	11.89
28	RADHA E	28	128	1973-1985	13	7	8.36
29	Devi LG	28	85	1999-2010	12	5	6.37
30	Jayananda M	27	478	1989-2009	21	11	20.38
31	DEVARAJ N	27	84	1974-1993	20	5	6.39
32	Chandrappa GT	25	160	1999-2010	12	7	10.08
33	Kulkarni MV	25	68	1990-2008	19	5	5.70
34	Anavekar RV	23	79	1985-2010	26	6	6.47
35	Ramesh KP	23	73	1985-2009	25	5	6.14
36	Chandramani R	22	71	1975-2009	35	4	6.12
37	Rathod HT	22	34	1995-2008	14	4	3.75
38	Sullia SB	22	31	1973-2006	34	3	3.52
39	Lakshminarasappa BN	22	30	1983-2010	28	3	3.45
40	Ramesh TN	21	92	2002-2010	9	6	7.39
41	Devi SA	20	106	1981-2009	29	6	8.25
42	Jayashankara VP	20	104	2004-2008	5	5	8.15
43	Puttaswamy NG	20	50	1975-1999	25	4	5.00
44	Mahabaleswar B	19	269	1976-2003	28	6	15.62
45	Vasanthakumar GR	19	112	2000-2005	6	6	8.71
46	Shetty NJ	19	85	1975-2009	35	5	7.24
47	Ramakrishna J	19	67	1976-2008	33	5	6.18
48	Somashekar RK	19	66	1984-2009	26	4	6.12
49	Devi ARU	19	63	2000-2010	11	4	5.93
50	Singh F	19	29	2003-2009	7	3	3.54
51	Jagadeesh RV	19	10	2002-2008	7	2	1.74

Table 2. Contd.

52	Gayathri V	18	66	1986-2010	25	5	6.23
53	Veerabhadrappa PS	18	60	1976-1996	21	4	5.85
54	Venkatachalappa M	18	49	1976-2006	31	5	5.11
55	Damle R	18	35	1997-2010	14	4	4.08
56	Saravanan J	18	0	2003-2008	6	0	0.00
57	Gopi HN	17	110	1998-2002	5	6	8.93
58	Ananda K	17	83	1998-2002	5	5	7.40
59	Tantry SJ	17	48	2002-2009	8	4	5.14
60	Chakradhar RPS	17	39	2005-2009	5	4	4.47
61	Girija CR	17	21	2003-2008	6	3	2.96
62	Subramanyam MVV	16	95	1989-2009	21	6	8.26
63	Nagabhushana BM	16	43	2004-2010	7	4	4.87
64	Vaz N	16	1	2000-2008	9	1	0.40
65	Rajamathi M	15	280	1997-2009	13	10	17.35
66	Patil BS	15	101	2002-2006	5	5	8.79
67	Shivakumara C	15	91	2005-2009	5	7	8.20
68	GURUSIDDAPPA S	15	85	1979-1991	13	5	7.84
69	GOWDA DSS	15	79	1976-1988	13	4	7.47
70	Asokan S	15	72	1994-2008	15	5	7.02
71	Nijalingappa BHM	15	34	1974-2001	28	3	4.26
72	Tharamani CN	15	32	2001-2009	9	4	4.09
73	Shivaprakash NC	15	23	1992-2006	15	3	3.28
74	Chopra D	15	0	2003-2008	6	0	0.00
75	Kumar SG	14	20	2008-2010	3	2	3.06
76	Hemantha HP	14	16	2007-2010	4	3	2.63
77	Chandrasekhara BC	13	175	1978-2001	24	5	13.31
78	Gowda NMM	13	69	1997-2008	12	5	7.15
79	CHOWDAIAH BN	13	35	1975-1985	11	4	4.55
80	Ranganath RM	13	34	1982-2009	28	3	4.46
81	Mahendra KN	13	24	1984-2010	27	2	3.54
82	Nagabhushana H	13	24	2003-2009	7	3	3.54
83	Kantharaju	13	21	2002-2010	9	2	3.24
84	Puttaraju HP	13	18	1985-2009	25	2	2.92
85	BAI ARK	13	15	1974-1985	12	3	2.59
86	Narendra N	13	14	2007-2010	4	3	2.47
87	NAGARAJ M	13	13	1976-1987	12	2	2.35
88	Sudarshan NS	13	12	2005-2009	5	2	2.23
89	Vasu	13	0	2003-2007	5	0	0.00
90	JAYACHANDRA	12	136	1979-1981	3	6	11.55
91	Radha AV	12	91	2003-2009	7	7	8.84
92	Bali G	12	74	1987-2009	23	4	7.70
93	Aravinda CL	12	52	1999-2003	5	5	6.09
94	Prakash BSJ	12	41	1974-2009	36	4	5.19
95	Venkataramanarao R	12	41	2006-2008	3	3	5.19
96	PONNUCHAMY R	12	38	1979-1988	10	5	4.94
97	Radhakrishna MC	12	35	1997-2009	13	3	4.67
98	Nanjundaswamy HM	12	21	2004-2007	4	3	3.32
99	Vasundhara DE	12	7	2006-2009	4	2	1.60
100	Jayashree RS	11	227	1999-2003	5	8	16.73
101	SETTY THV	11	70	1973-1976	4	4	7.64
102	Acharya KV	11	52	1994-2002	9	4	6.26
103	Ananthamurthy S	11	52	2000-2010	11	4	6.26

Table 2. Contd.

104	Tejavathi DH	11	27	1977-2010	34	3	4.05
105	Choi MS	11	19	2004-2010	7	3	3.20
106	RAO TA	11	18	1981-1988	8	3	3.09
107	Karigar CS	11	17	2004-2010	7	3	2.97
108	Rao CK	11	6	1973-1997	25	2	1.48
109	Sankarapapavinasam S	10	135	1991-2000	10	6	12.21
110	Malashetty MS	10	98	1982-2009	28	5	9.87
111	Thomas GS	10	95	2001-2008	8	5	9.66
112	WALVEKAR SP	10	41	1973-1990	18	4	5.52
113	Ramachandrappa R	10	26	1998-2002	5	1	4.07
114	Min JY	10	17	2004-2010	7	3	3.07
115	GOWDA HS	10	16	1986-1990	5	2	2.95
116	Ramani	10	15	1975-2008	34	3	2.82
117	Chennakrishnareddy G	10	14	2007-2010	4	3	2.70

Note: Authors having same number of publications, ranked according to their number of citations.

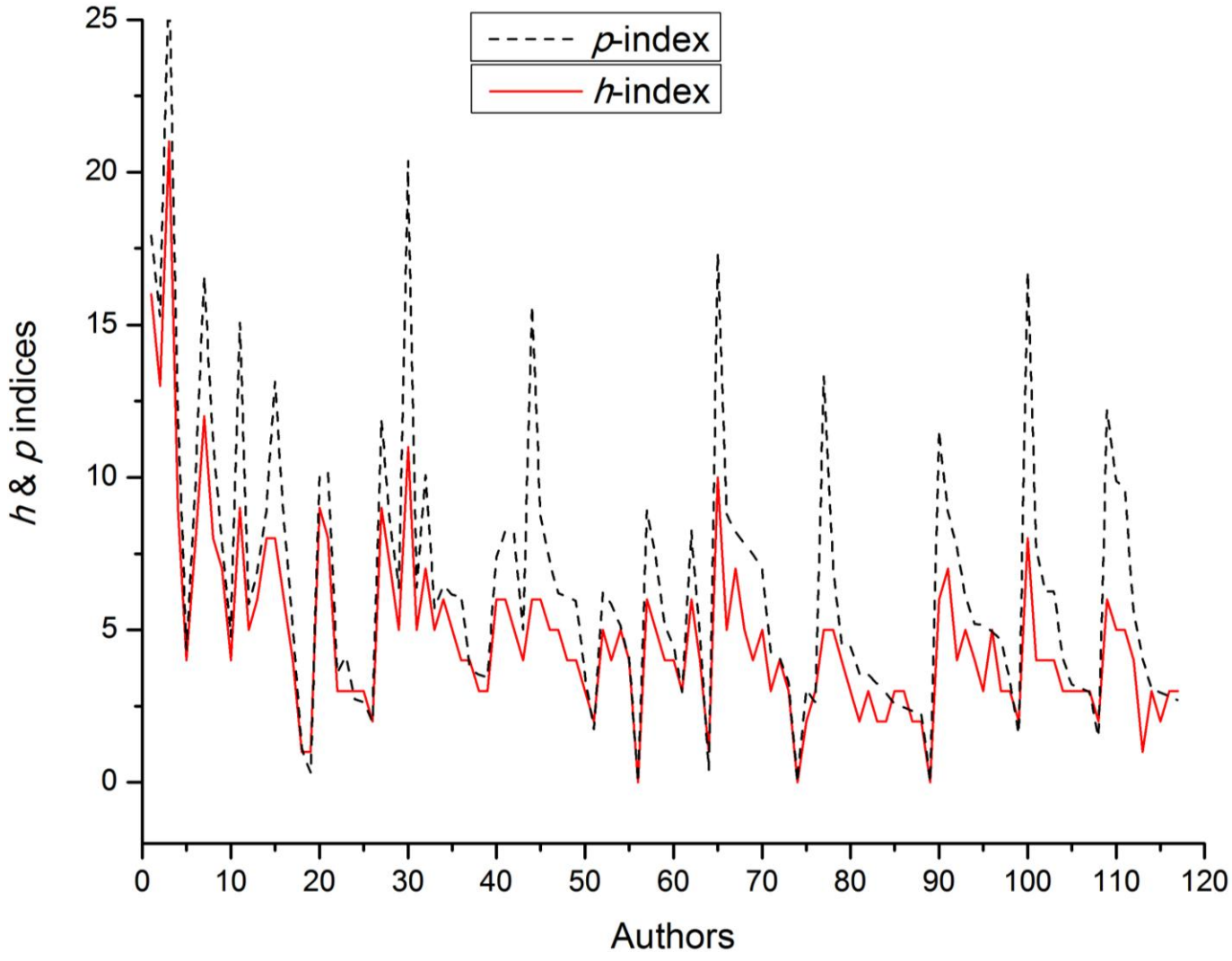

Figure 3. *h* and *p*-indices of authors and collaborators of Bangalore University.

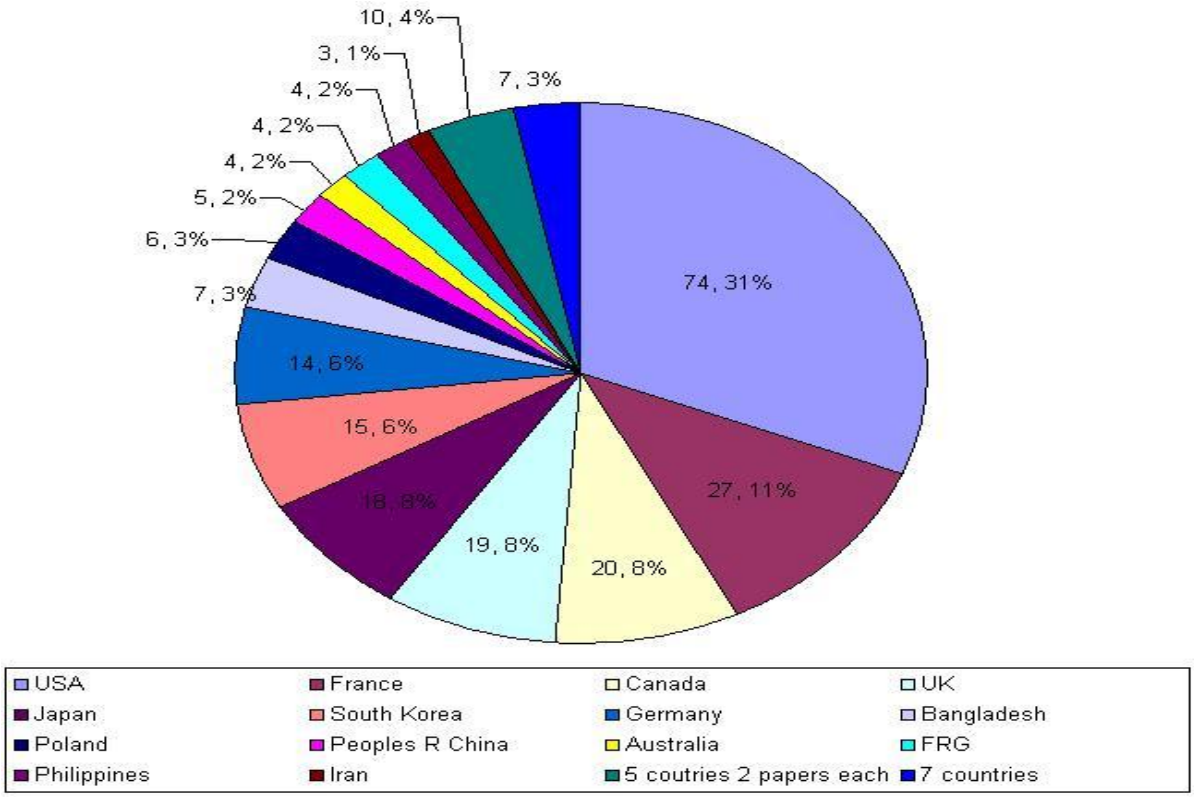

Figure 4. Country-wise distribution of collaborative publications of BU.

Table 3. Journals preferred for publishing articles by the scientists of BU during 1971-2010.

Rank	Journals	No. of papers	Cumulative papers	Citations	Cumulative citations	Impact factor*
1	Current Science	168	168	254	254	0.782
2	Indian Journal of Chemistry Section B-Organic Chemistry Including Medicinal Chemistry	81	249	208	462	0.437
3	Indian Journal of Chemistry Section A-Inorganic Bio-Inorganic Physical Theoretical & Analytical Chemistry	39	288	118	580	0.617
4	Acta Crystallographica Section E-Structure Reports Online	36	324	21	601	0.411
5	Journal of the Geological Society of India	32	356	50	651	0.424
6	Synthetic Communications	32	388	57	708	0.961
7	Acta Crystallographical Section C-Crystal Structure Communications	31	419	85	793	0.782
8	Indian Journal of Experimental Biology	31	450	52	845	0.55
9	Acta Mechanica	26	476	170	1015	1.137
10	Indian Journal of Pure & Applied Mathematics	24	500	34	1049	0.333
11	Proceedings of the Indian Academy of Sciences-Animal Sciences	24	524	44	1093	1.956

Table 3. Contd.

11	Proceedings of the Indian Academy of Sciences-Animal Sciences	24	524	44	1093	1.956
12	Bulletin of Materials Science	23	547	95	1188	0.783
13	Journal of Applied Electrochemistry	23	570	281	1469	1.697
14	Oxidation Communications	21	591	3	1472	0.24
15	Indian Journal of Pure & Applied Physics	20	611	27	1499	0.246
16	Journal of the Indian Chemical Society	20	631	65	1564	0.382
17	International Journal of Engineering Science	19	650	187	1751	1.36
18	Journal of Chemical Research-S	19	669	52	1803	0.04
19	Surface Technology	19	688	64	1867	1.793
20	Tetrahedron Letters	18	706	222	2089	2.66
21	Indian Journal of Technology	16	722	24	2113	
22	International Journal of Heat and Mass Transfer	16	738	227	2340	1.947
23	Journal of the Electrochemical Society	15	753	275	2615	2.241
24	Indian Journal of Biochemistry & Biophysics	14	767	12	2627	0.574
25	Materials Research Bulletin	14	781	114	2741	1.879
26	Proceedings of the Indian Academy of Sciences Section B	14	795	18	2759	-
27	Journal of Power Sources	13	808	177	2936	3.792
28	Experientia	12	820	21	2957	
29	Journal of Molecular Catalysis A-Chemical	12	832	26	2983	3.135
30	Letters In Peptide Science	12	844	52	3035	-
31	National Academy Science Letters-India	12	856	13	3048	0.173
32	Pramana-Journal of Physics	12	868	12	3060	0.349
33	Indian Journal of Chemistry	11	879	48	3108	-
34	Indian Journal of Physics and Proceedings of the Indian Association For the Cultivation of Science	11	890	11	3119	0.226
35	Proceedings of the Indian Academy of Sciences-Chemical Sciences	11	901	33	3152	0.993
36	Synthesis and Reactivity In Inorganic and Metal-Organic Chemistry	11	912	31	3183	0.569
37	Caryologia	10	922	38	3221	0.45
38	Indian Journal of Chemical Technology	10	932	41	3262	0.267
39	International Journal of Chemical Kinetics	10	942	54	3316	1.619
40	Journal of Alloys and Compounds	10	952	11	3327	2.135
41	Journal of Biosciences	10	962	24	3351	1.956
42	Journal of Environmental Biology	10	972	20	3371	-
43	Transition Metal Chemistry	10	982	4	3375	1.223
44-49	six journals having 9 articles each	54	1036	414	3789	-
50-58	Nine journals having 8 articles each	72	1108	544	4333	-
59-66	Eight journals having 7 articles each	56	1164	264	4597	-
67-82	Fifteen journals having 6 articles each	96	1260	688	5285	-
83-99	Seventeen journals having 5 articles each	85	1345	644	5929	-
100-143	Forty four journals having 4 articles each	176	1521	871	6800	-
144-184	Forty one journals having 3 articles each	123	1644	465	7265	-
185-297	113 journals with 2 articles each	226	1870	843	8108	-
298-615	318 journals with one article each	318	2188	1293	9401	-

*Impact factor 2010.

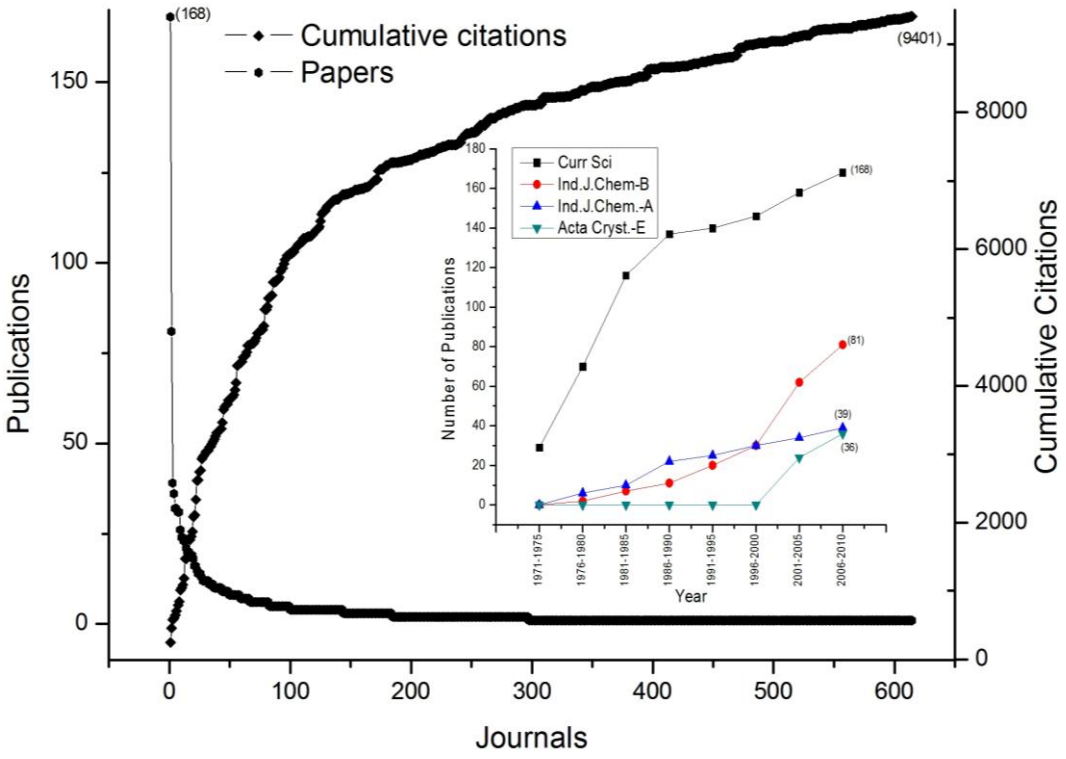

Figure 5. Bradford-Zipf's bibliography of publications of Bangalore University (Inset publication growth in four core journals).

Table 4. Distribution of papers and journals according to zones.

Zone	No. of journals	No. of papers	Bradford multiplier
First	21	722	-
Second	106	1457	5.05
Third	488	2188	4.6

collaborative research activity in the university is very small, accounting for 10% share. The excellence in research is confined to selecting few authors, where the top 10 authors account for about 703(32.13%) of the total publications and 4408(46.89%) of the total citation counts.

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