
Scientometric Analysis of India's Research Output on Wireless Communication (2001 – 2012)

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Abstract

The present study examines the research output in wireless communication contributed by the Indian scientists during 2001 – 2012 as reflected in the SCOPUS database. A total of 1128 records are retrieved and exported to the MS - Excel. Then the data analyzed with the IBM SPSS Statistics 19. Scientometrics tools such as, Relative Growth Rate and Doubling Time, Degree of Collaboration and Co-Authorship Index have been employed. Type of document has been analyzed. Further, we identified top 10 most preferred journals by the Indian scientists and highly productive Indian institutions

Keywords

Wireless communication, India, Scopus, Scientometrics.

Electronic access

The journal is available at www.jalis.in



Journal of Advances in Library and Information Science
ISSN: 2277-2219 Vol. 2. No.3. 2013. pp. 105-111

INTRODUCTION

Scientometrics is a Science of measuring and analyzing the science which studies the quantitative aspects of science. A.F.J. Van Raan (1997) [1] described as scientometric research is devoted to quantitative studies of science and technology. Vinkler P (2010) [2] defined scientometrics as a scientific field dealing with all aspects of people, or group of people, matters and phenomena in science and their relationships which do not restrict scientometrics to information aspects only. Wireless Communication is the fastest growing segment in the field communications industry. History of wireless communications backs to 1800s when Marconi established a link between a land based station and tugboat. During the last decade, there was an exponential growth in the cellular systems and currently there are around two billion users worldwide. Wireless communication is described as transmitting / receiving voice and data using electromagnetic waves in open space. Mobile, portable and fixed are the types of wireless communication. Cellular systems, wireless LANs, satellite systems and wireless PANSs are the current wireless systems. The most advantage of wireless communication systems is that a mobile user can make a call anywhere and anytime.

The present study investigates the Scientometrics analysis of the wireless communication literature contributed by Indian scientists during the year 2001 to 2012. The major objectives of the present study are to examine the growth of literature using RGR and Doubling Time, Pattern of Co-authorship using Co-Authorship Index, extent of collaboration, type of document, most preferred journals by Indian scientists, most productive Indian institutions and analysis of highly cited papers.

REVIEW OF RELATED LITERATURE

Many bibliometric / scientometric studies have been reported in the field of science and engineering research in India. Few of the studies have been reviewed and presented below. Rajendran P et. al (2005) [3] conducted bibliometric study on Fiber Optics literature published in Ei- Tech Index database covering the period 1999-2003. Growth of literature by year wise, country wise production, authorship pattern, bibliographic forms, ranking of core journals, nature of research, have been analysed. Kademani B S, et al. (2006) [4] conducted a scientometric study on Thorium research in India

with a sample of 2399 papers published during 1970 – 2004 and reported that the authorship trend was towards multi authored papers as 85.7% of the papers were multi authored. Mohan L, et al. (2010) [5] analyzed the research trends in nanoscience and nanotechnology in India published during 1982 – 2008 and found that there were a total of 19718 individual keywords occurred in the 8326 papers. Anil Sagar, et al. (2010) [6] made a scientometric analysis of all Tsunami related publications during 1997 – 2008 and found that the CAI for mega authored papers for the countries Japan, India, Italy and France was higher than the world average. Har Gaur and Gupta B M (2010) [7] carried out a scientometric analysis on Indian dental sciences research during 1999 – 2008 and list out the top 30 productive journals of Indian and foreign origin together contributed 78.19% share to the total cumulative publications output by India in dental sciences. Rajendran P, et al. (2011) [8] studied the research articles published in Journal of Scientific and Industrial Research. The study analyzed the publication pattern and authorship collaboration in Indian authors.

Materials and Methods

The data has been extracted from SCOPUS international multidisciplinary database for the present study and the following search strategy has been used in the combined field of Title, Abstract & Keywords.

TITLE-ABS-KEY("wireless communication") AND PUBYEAR > 2000 AND PUBYEAR < 2013 AND (LIMIT-TO(AFFILCOUNTRY, "India"))

The above search criteria yielded 1128 records which are attributed to at least one Indian address in the affiliation field and downloaded. The information relating to title, authors, affiliations, document type, number of citations, source title and keywords for each publication are exported to Ms-Excel then analyzed with the IBM SPSS Statistics 19. Further the following Bibliometrics / Scientometrics tools have been employed.

- RGR and Dt
- Degree of Collaboration (DC)
- Co-authorship Index (CAI)

Limitations

The present study is limited to a period of 12 years from 2001 to 2012 based on the records as reflected in the SCOPUS database.

ANALYSIS & DISCUSSION

Document Type

The distribution of various forms of communication of Indian scientists has been presented in table 1. It is observed from table that the Indian scientists prefer to publish their research findings in the type of conference paper. A total of 1128 research literatures have been contributed by the Indian scientists to the world wireless communication research during 2001 – 2012 as reflected in the SCOPUS database. Out of 1128 publications, 808 (71.63%) are appeared as conference paper and 284 (25.18%) as article. Other forms of communication such as review, editorial, article in press and erratum are accumulated to 3.19% only.

Table 1: Distribution of Document Type

S.No	Type	No. of articles	%
1	Conference Paper	808	71.63
2	Article	284	25.18
3	Review	26	2.30
4	Editorial	5	0.44
5	Article in Press	4	0.35
6	Short Survey	1	0.09
	Total	1128	100

Growth of Wireless Communication Research

The growth of literature of Indian wireless communication research is being measured with the Scientometrics indicators Relative Growth Rate (RGR) and Doubling Time (Dt). The RGR is obtained with the following formula used by Karpagam R, et al (2011) [9].

$$R(a) = \frac{(W_2 - W_1)}{(T_2 - T_1)}$$

- R (a) = Relative Growth Rate over the specific period of interval
- W1 = log w1 (Natural log of initial number of publications)
- W2 = log w2 (Natural log of final number of publications)
- T2 – T1 = Unit difference between the initial and final time
- R (a) = RER per unit of publications per unit of time (yr)

The Dt is obtained with the following formula.

$$Dt = \frac{0.693}{R}$$

$$\text{Doubling time for publications } Dt(a) = \frac{0.693}{R(a)}$$

The data pertaining to the growth of literature has been presented in table 2. To calculate the mean RGR and mean Dt, the study period (2001 – 2012) has been divided into two block periods, i.e. 2001 – 2006 and 2007 – 2012. The publication output of Indian scientists is increased from 8 in 2001 to 252 in 2012 with an average of 94 papers per year. It is observed from table 2 that the mean RGR is

decreased from 0.55 in the first block to 0.37 in the second block. On the other hand, mean Dt is increased from 1.39 in the first block to 1.96 in the second block.

RGR is decreased from 0.56 in the year 2002 to 0.26 in the year 2012 and the corresponding Dt is gradually increased from 1.24 to 2.67. As Dt is the period of time required to double in terms of quantity, it is seen from table 2 that the required time to double is 1.70 average.

Table 2 : Relative Growth Rate and Doubling Time

Year	# Papers	cum	log _e p1	log _e p2	R (a)	Mean R (a)	Dt	Mean Dt
2001	8	8		2.08				
2002	6	14	2.08	2.64	0.56		1.24	
2003	17	31	2.64	3.43	0.79		0.88	
2004	28	59	3.43	4.08	0.65		1.07	
2005	27	86	4.08	4.45	0.37		1.87	
2006	38	124	4.45	4.82	0.37	0.55	1.87	1.39
2007	75	199	4.82	5.29	0.47		1.47	
2008	102	301	5.29	5.71	0.42		1.65	
2009	114	415	5.71	6.03	0.32		2.17	
2010	163	578	6.03	6.36	0.33		2.10	
2011	298	876	6.36	6.77	0.41		1.69	
2012	252	1128	6.77	7.03	0.26	0.37	2.67	1.96
Total	1128					0.45		1.70

Authorship Pattern

Table 3 shows that two authored publications were highest with 42.55% and lowest by more than six authored with 1.69%. Majority of papers were with 2 to 4 authors.

Table 3: Authorship Pattern

S.No	No. of Authors	No. of Papers	%
1	Single Author	62	5.50
2	Two authors	480	42.55
3	Three authors	336	29.79
4	Four Authors	149	13.21
5	Five authors	60	5.32
6	More than Five authors	41	3.64
	Total	1128	100

Degree of Collaboration

The extent of degree of collaboration by year wise has been calculated with the following formula suggested by Subramanyam (1993) [10] and results are presented in table 4.

$$DC = \frac{N_m}{N_s + N_m}$$

Where DC =Degree of Collaboration

N_s = Number of single authored papers
 N_m = Number of multi authored papers

The year wise degree of collaboration falls between 0.83 and 1 with an average of 0.95 during the study period.

Table 4: Degree of Collaboration

Year	Single Author	Multi Author	Total	Degree of Collaboration
2001	1	7	8	0.88
2002	1	5	6	0.83
2003	0	17	17	1.00
2004	3	25	28	0.89
2005	0	27	27	1.00
2006	3	35	38	0.92
2007	5	70	75	0.93
2008	5	97	102	0.95
2009	10	104	114	0.91
2010	14	149	163	0.91
2011	12	286	298	0.96
2012	8	244	252	0.97
Total	62	1066	1128	0.95

Pattern of Co-Authorship

Pattern of Co-Authorship is being measured by Co-Authorship Index, which is obtained by calculating proportionately the publications by single, two authors and multi authored papers. CAI is determined with the following formula suggested by Garg & Padhi (2001) [11].

$$CAI = \frac{N_{ij}/N_{io}}{N_{oj}/N_{oo}} \times 100$$

Here,

N_{ij} = Number of publications for the particular authorship pattern in the particular block

N_{io} = Total output in the particular block

N_{oj} = Total output for the particular authorship pattern

N_{oo} = Total output

CAI = 100 reflects that the number of publications corresponds to the world average, CAI > 100 reflects higher than the world average and CAI < 100 reflects lower than the world average within a co-authorship pattern.

In order to calculate the co-authorship pattern in India, the study period has been divided into two block periods, i.e. 2001 – 2005 and 2006 – 2010. Table 5 reveals that the CAI increased for double authors from 74 in first block to 103 in second blocks. On the other hand, it is decreased from first block to second block for single and multi-authors.

Table 5: Pattern of Co-Authorship

Block	Single author	Two authors	More than two authors	Total
2001 - 2006	8 (117)	39 (74)	77 (120)	124
2007 - 2012	54 (98)	441 (103)	509 (98)	1004
Total	62	480	586	1128

() indicates CAI

Most Preferred Journals by Indian Scientists

Most preferred journals by the Indian scientists in the field wireless communication during the study are presented in table 6. Eighteen journals published at least 5 papers during the period accounting to 17%. Out of these eighteen journals, only three journals are originated from India. It is observed that Indian scientists are prefer foreign journals than Indian journals and papers published by Indian scientists form a part of the world research. Most preferred journals are “Communications in Computer and Information Science” (51), “European Journal of Scientific Research” (23) and “IETE Technical Review” (14).

Table 6: Most preferred journals

S. No	Title	Country of Origin	No. of Papers	Percentage
1	Communications in Computer and Information Science	Germany	51	4.52
2	European Journal of Scientific Research	UK	23	2.04
3	IETE Technical Review (Institution of Electronics and Telecommunication Engineers, India)	India	14	1.24
4	Wireless Personal Communications	Netherland	14	1.24
5	Journal of Theoretical and Applied Information Technology	Pakistan	12	1.06
6	Microwave and Optical Technology Letters	USA	12	1.06
7	IETE Journal of Research	India	7	0.62
8	Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	Germany	7	0.62
9	Research Journal of Applied Sciences, Engineering and Technology	UK	7	0.62
10	IEEE Vehicular Technology Conference	USA	6	0.53
11	Indian Journal of Radio and Space Physics	India	6	0.53
12	Information Technology Journal	Pakistan	6	0.53
13	World Academy of Science, Engineering and Technology	USA	6	0.53
14	IEEE Transactions on Information Theory	USA	5	0.44
15	International Journal of RF and Microwave Computer-Aided Engineering	USA	5	0.44
16	Journal of Computer Science	USA	5	0.44
17	Procedia Engineering	Netherland	5	0.44
18	WSEAS Transactions on Communications	Greece	5	0.44

Ranking of most producing institutions

Table 7 provides the ranking list of top most productive institutes in the field of wireless communication during the study period. The 16 top institutes published 257 papers accounting to 23% of country's output. Out of these 16 institutes, 7 are national importance, 8 are universities and 1 is an engineering college. Most productive institutes are Anna University, IIT Madras and SRM University.

Highly Cited Papers

The characteristics of 10 highly cited papers in the field of Indian wireless communication research are provided in table 8. Out of 10 papers, six are single country papers (India) and 4 are international collaborative papers. These 10 papers received 925 citations cumulatively with 48% of all citations. Out of 10 papers, eight as article and one each as review and conference paper published. One paper contributed with single author and remaining 9 papers with co-authors.

Table 7 – Ranking of Institutions

Institute	Numbers	Rank
Anna University	32	1
IIT Madras	20	2
SRM University	19	3
NIT Rourkela	19	3
Cochin University of Science and Technology	18	4
Jadavpur University	17	5
IIT Kharagpur	17	5
IISc	16	6
Jaypee University of Information technology	16	6
IIT Delhi	14	7
IIT Guwahati	14	7
IIT Bombay	12	8
Amrita University	12	8
Sathyabama University	11	9
ThaparUniveristy	10	10
SSN College of Engineering	10	10

Table 8 – Highly cited papers

S.No	Paper	Cited by	Document Type	Country of Authors
1	Dighe P.A., Mallik R.K., Jamuar S.S. (2003) Analysis of transmit-receive diversity in Rayleigh fading. IEEE Transactions on Communications, 51 (4) : 694 – 703.	254	Article	India
2	Sethuraman B.A., SundarRajan B., Shashidhar V. (2003). Full-diversity, high-rate space-time block codes from division algebras. IEEE Transactions on Information Theory, 49 (10) : 2596 – 2616.	249	Article	India
3	Sebastian M.T., Jantunen H. (2008). Low loss dielectric materials for LTCC applications: A review. International Materials Reviews, 53 (2) : 57 – 90.	130	Review	India, Finland
4	Simko M., Hartwig C., Lantow M., Lupke M., Mattsson M.-O., Rahman Q., Rollwitz J. (2006). Hsp70 expression and free radical release after exposure to non-thermal radio-frequency electromagnetic fields and ultrafine particles in human Mono Mac 6 cells. Toxicology Letters, 161 (1) : 73 – 82.	51	Article	Germany, India
5	Pandian P.S., Mohanavelu K., Safer K.P., Kotresh T.M., Shakunthala D.T., Gopal P., Padaki V.C. (2008). Smart Vest: Wearable multi-parameter remote physiological monitoring system. Medical Engineering and Physics, 30 (4) : 466 – 477.	50	Article	India
6	Sairam K.V.S.S.S.S., Gunasekaran N., Rama Reddy S. (2002). Bluetooth in wireless communication. IEEE Communications Magazine, 40 (6) : 90 – 96.	49	Article	India
7	Ghosh A. (2004). Estimating coverage holes and enhancing coverage in mixed sensor networks. Proceedings - Conference on Local Computer Networks, LCN.	48	Conference Paper	India
8	Iyer A., Rosenberg C., Karnik A. (2009). What is the right model for wireless channel interference?. IEEE Transactions on Wireless Communications, 8 (5) : 2662 – 2671.	41	Article	Canada, India
9	Krishna D.D., Gopikrishna M., Aanandan C.K., Mohanan P., Vasudevan K. (2008). Compact dual band slot loaded circular microstrip antenna with a superstrate. Progress in Electromagnetics Research, 83 : 245 – 255.	27	Article	India
10	Chakka R., Van Do T. (2007). The MM $\sum_k = 1$ K CPPk / GE / c / L G-queue with heterogeneous servers: Steady state solution and an application to performance evaluation. Performance Evaluation, 64 (3) : 191 – 209.	26	Article	India, Hungary

CONCLUSION

Indian scientists published 1128 research papers in wireless communication during 2001 – 2012 with an average of 94 papers per year and most preferred type is conference paper. Analysis of authorship pattern reveals that Indian scientists prefer to do research with co-author than solo. Co-authorship pattern also

indicates that Indian scientists are willing to work with co-author (two authors). Degree of collaboration is 0.95 for the study period which reveals that there exists a high level of collaboration among the authors. Anna University is the leading institution in this research field and IITs also contributed significant number of papers. Communications in Computer and Information

Science is the top journal preferred by Indian scientists to publish their research findings.

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