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India's Science and Technology output, 1989-2014: A Scientometric Analysis

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Abstract

The present study determines the extent of India's Publication growth in Science and Technology. The data was extracted from the Thomson Reuters' Web of Science for the period 1989-2014. The study covers a year wise growth of Science and Technology publications; Relative Growth Rate (RGR), Doubling Time (DT), Activity Index (AI) of different countries; international collaboration, productive Indian Institutes, prolific authors in Science and Technology field. The results reveal that (i) India's publication effort in Science and Technology research corresponds to the world's average (ii) The USA topped the list among the highly productive countries with 4, 32,093 publications (iii) The highest

number of publications were published by Bhabha Atomic Research Centre, Mumbai (4,117 publications) (iv) Among the journals preferred, *Current Science* (India) ranked first with 14,245 publications etc.

Keywords: Activity Index (AI), Doubling Time (Dt), Relative Growth Rate (RGR), Scientometrics, Science & Technology output

Introduction

Since independence, India has developed large infrastructure for Science and Technology (Gupta et al., 2013). Recognizing the importance of Science and Technology in the Economic and Industrial development, the Government of India reemphasized the need to view them together in its Science and Technology Policy 2003 following the Science Policy Resolution of 1958 and the Technology Policy Resolution of 1983(Gupta et al., 2013). The policy has recognized the central role of Science and Technology system in the economic as well as industrial development of the country in raising the quality of life of its people, in creating national wealth, in utilizing the natural resources, in protecting the environment and in ensuring the national security (Gupta and Gupta, 2011).

The expenditure on Science and Technology has gone up substantially from the first five-year plan (1951 to 1956) to the tenth five-year plan (2002-2007). The union government accounts for major portion (around 70 to 75 percent) of the total expenditure on Science and Technology. As a result, there has been a significant expansion in the education sector (Kademani et al., 2007). In this regard, the research has been carried out through a chain of research laboratories/ research institutes, as well as higher education institutes. These Research laboratories/institutes were established as per the five year plans from first year plan (1951-1956) to twelfth five year plan (2012-2017)(Dept. of Science & Technology, 2014).

After the Economic Liberalization in 1991 and 1992, India started making an affirmation in the universal publication pursuit. India, to a large amount symbolizes the Science and Technology activity of emerging economies. In this paper, the authors have used many scientometrics indicators to evaluate (since evaluation is one of the key components of any Science and Technology activity) India's publications growth in Science and Technology using number of publications produced by the scientists, collaborative works with foreign authors, growth models etc.

The analysis of publications provides some insights into the complex dynamics of research activity and enables policy makers and science administrators in framing policies and directions in which Science and Technology has to be conducted (Kademani, et. al., 2007).

Major Science and Technology Policies in India

The Table 1 indicates the major Science and Technology policies implemented in India from 1983-2003.

Table 1:Major Science and Technology Policies in India

Sl. No	Science and Technology Policies	Year
1	Technology Policy Statement	1983
2	Computer Policy	1984
3	Textile Policy	1984
4	Electronics Policy	1984
5	Setting up of Centre for the Development of Telematics	1985
6	Technology Information Forecasting and Assessments Council (TIFAC) and Technology Mission launched in water	1985
7	Telecommunications, oil-seeds etc.	1987
8	New Industrial Policy Statement	1991
9	New Industrial Policy for Small Scale Sector	1991
10	Liberal Policies on MNCs and FDI	1991
11	Automatic permission to import technology up to Rs 10 million	1991
12	National Policy on Education (1986 modified)	1992
13	New Fertilizer Pricing Policy	1992
14	New reforms in CSIR other science agencies	1995
15	Setting up of the autonomous Technology Development Board to assist firms in the commercialization of technology form the national laboratories	1996
16	Phokran Nuclear Explosion II launching of indigenous space satellites	1998
17	USA making S&T collaboration with several Indian R&D institutions	1998

18	India developing new models of super computers	1998
19	Five-year tax holiday for commercial R&D companies	1998
20	Excise duty waiver for three years on goods produced based on indigenously developed technology and patented in any of the European countries	1998
21	Income tax relief on R&D expenditure	1998
22	New Patents policy confirming to WTO	1999
23	Exclusive marketing rights for five years to companies as part of WTO	1999
24	Information Technology Bill	2000
25	Creation of a new Ministry of Information Technology	2000
26	Introduction of Protection of Plant Varieties and Farmer's Right Bill in Parliament	2000
27	Science and Technology Policy	2003

Contribution of Five Year Plans and the Growth of Science & Technology Sector

The draft of the Seventh Five Year plan (1985-1990) was approved on Nov, 9, 1985 by the National Development Council. One of the main objectives of the plan was the incorporation of Science and Technology into the foremost stream of development planning. The most noteworthy growth in the Eighth Five Year plan (1992-1997) has been the establishment of a series of national laboratories and research centers in various parts of the country. The Special Actions Plans (SAPs) like new implementing measures were evolved in the Ninth Five Year Plan (1997-2002) to fulfill its target within the stipulated time with the required resources. These SAPs covered Science and Technology sector also. The Tenth Five Year Plan (2002-2007) focused on promoting Post-Graduate Education and Research.

The special tasks for Scientific and Industrial research was sponsored through the DSIR (Department of Scientific and Industrial Research) and CSIR (Council of Scientific and Industrial Research) to seek support in industry through a vast range of training, research sponsorship, and joint research schemes.

India made substantial investments in the R&D (Research and Development) during the Eleventh Five Year Plan (2007-2012) laying a strong foundation for building a vibrant and dynamic S&T sector in the country. The share of scientific publications emanating from

universities increased from fifteen percent (15%) in 2003 to thirty one (31%) per cent in 2012, almost doubled in the period of ten years.

The Eleventh Five year Plan (2007-2012) period has made a historical development in Indian Science research. Near about 29 foremost space missions were fruitfully accomplished which covered 13 Launch Vehicle missions with the Polar Satellite Launch Vehicle (PSLV) and the Geosynchronous Satellite Launch Vehicle (GSLV) and 16 satellite missions. The most significant and world's recognized achievement of the Eleventh five Plan period was the successful launching of India's first unmanned moon mission Chandrayaan-1in the month of October 2008. High-resolution data of excellent quality from Indian scientific instruments on board Chandrayaan-1 has led to the identification of new lunar features and characteristics and detection of water molecules around the moon jointly with the International Agency.

In the Twelfth Five Year Plan (2012-2017)the global share of publications is estimated to be increased by 5 per cent, global ranking of scientific publication is estimated to be in top five ranking, global ranking in number Patent Cooperation Treaties (PCTs) target is in the top tenth position, the estimated target of Ph.D outputs in the whole Science sector is 12,500 per year,public–private sharing of investments is 50:50 in Science and Technological research. Since India has invested heavily in Science and Technology sector (through different five year plans), the time is ripe to relook into the journey it has travelled and the achievements we have made in the Science and Technology sector in terms of publications.

Need for the Study

The growth of scientific research has become a major concern for the scientists as well as for the policy makers. The publication profile is one of the major indicators of the scientific activity of a country. Scientometrics studies have been providing some insights into the complex dynamics of research activity and it enables the researchers, scientists, policy makers and administrators to provide proper funding and ample of sources.

Objectives of the study

The main objective of the study is to present the growth of literature and make the quantitative assessment of Science and Technology research in India. The specific objectives of the study are to:

- study the Indian and Global research output in Science and Technology;
- determine the year wise growth of publications in India in Science and Technology;
- identify the Relative Growth Rate and Doubling Time of publications;
- know the extent of international collaboration with foreign authors;
- find out the highly productive Indian Institutes in Science and Technology;
- present the journals preferred by the authors; and
- calculate the Activity Index for India for the study period.

Methodology

Scientometrics is an application of quantitative methods to the history of science (Rajendran et al., 2011). The present study covers the Growth and Activity of Research in Science and Technology in India. The study covers publication productivity of India in Science and Technology for the period of 1989 to 2014. A total of twenty-six year data has been collected as reflected in Thomson Reuter's Web of Science database. The keyword used for the search was "**(**SU= SCIENCE TECHNOLOGY) AND (CU= INDIA) AND (PY= 1989-2014)" for measuring the research output on Science and Technology research in India. The data was retrieved during the third and fourth week of April, 2015.

Relative Growth Rate (RGR) and Doubling Time (Dt)

The Relative Growth Rate (RGR) is the increase in number of articles per unit of time. This definition is derived from the definition of relative growth rates in the study of

growth analysis of individual plants and effectively applied in the field of Botany (Hunt, 1978 and 1982) (Poorter and Garnier, 1996)(Hoffmann and Poorter, 2002). If the number of articles of a subject gets doubled during a given period then the difference between the logarithms of numbers at the beginning and end of the period must be logarithms of number 2. If natural logarithm is used this difference has a value of 0.693. The mean RGR of articles over the specific period of interval is represented as;

$$R_t(P) = \frac{1}{t}[\log_e p(t) - \log_e p(0)]$$

R_t= Relative Growth Rate of the Articles Over the specific period of Time

$log_e p(t)$=Logarithm of initial number of Articles

$log_e p(0)$=Logarithm of Final number of Articles

Doubling Time (DT) = 0.693/R

Activity Index (AI)

In the present context, Activity Index for India has been calculated for different years to see how India's research activity changed over a period of time using the formula, which is suggested by Price(1981) and used by Karki and Garg (1997)in their study on alkaloid chemistry research in India.

Mathematically: AI = {(Ii / Io) / (Wi / Wo)} x100

Where Ii = Indian output in the year i

Io = Total Indian output

Wi = World output in the year i

Wo= Total world output

Results and Analysis

The total number of publications extracted in the field of Science and Technology is 59,465for the period 1989-2014 as reflected in the Web of Science database and 4,79,429

citations have received during the period. The World's output is 15,75,365during the period for Science and Technology research.

Year wise Publications

The Table 2 presents the year wise publications of India and the World. It reveals that a total of 59,465 publications were published during 1989-2014 which received 4,79,429 citations. The highest number of publications i.e. 5851 was published in the year 2014. The highest number of citations was received i.e. 35,290 for the year 2009, followed by 34,711 citations in 2007 and 32,881 citations were received in 2008 respectively. During these three-year period, India successfully launched the first unmanned moon mission Chandrayaan-1 (Planning Commission, 2007).

The average Activity Index of first 13 years i.e. 1989 to 2001 is 82.27. During the next thirteen years (2002to 2014) the average Activity Index is increased to 107.59. After 2002, the average value of the Activity Index has shown an increasing trend. This may be due to the establishment of number of national laboratories and research institutes in different parts of the country (during Eighth Five Year Plan, 1992-1997). However, in the next five year plan i.e. 1997-2002, a Special Action Plans (SAP) were set up to reach the target. Special Action Plans contributed to fulfill the targets of remaining tasks of Eighth five year plan and Ninth Five Year Plan. The results indicate that India's publication effort in Science and Technology research corresponds precisely to the world's average.

Table2: Year wise Publications

Publication Year	Number of Publications	Percentage	Citations	Average Citations Per Paper	World's Publications	Activity Index
1989	1,327	2.23	7,396	5.57	39,168	89.76
1990	1,139	1.92	6,668	5.85	39,394	76.60
1991	1,160	1.95	6,985	6.02	39,829	77.16
1992	1,173	1.97	6,634	5.66	39,574	78.52
1993	1,290	2.17	6,795	5.27	39,556	86.40
1994	1,254	2.11	7,388	5.89	41,249	80.54
1995	1,293	2.17	7,138	5.52	43,234	79.23
1996	1,267	2.13	12,426	9.81	45,561	73.67
1997	1,210	2.03	9,141	7.55	45,086	71.10
1998	1,431	2.41	14,216	9.93	46,098	82.24
1999	1,562	2.63	18,515	11.85	44,379	93.24
2000	1,437	2.42	15,562	10.83	43,264	87.99
2001	1,623	2.73	20,897	12.88	43,782	98.21
2002	1,538	2.59	21,352	13.88	45,477	89.60
2003	1,860	3.13	29,740	15.99	48,581	101.43
2004	1,907	3.21	24,299	12.74	52,478	96.27
2005	2,101	3.53	28,509	13.57	56,011	99.37
2006	2,437	4.10	28,933	11.87	57,945	111.42
2007	2,917	4.91	34,711	11.90	67,270	114.88
2008	3,070	5.16	32,881	10.71	70,979	114.59
2009	3,182	5.35	35,290	11.09	76,393	110.35
2010	3,495	5.88	31,532	9.02	83,160	111.34
2011	4,257	7.16	29,679	6.97	96,497	116.87
2012	4,417	7.43	22,888	5.18	1,09,527	106.84
2013	5,267	8.86	15,191	2.88	1,26,442	110.35
2014	5,851	9.84	4,663	0.80	1,34,431	115.31
	59,465	**100.00**	**4,79,429**	**8.06**	**15,75,365**	

Highly Productive Countries in Science and Technology Research

The Table 3reflects the top ten countries with the highest publications in Science and Technology research for the period 1989-2014. The share of these countries publication is 72.48 % of the total world's publications (15, 75,365) for the period. Among the top ten countries, the USA topped the list with 4,32,093 publications, followed by China with 1,35,458 publications, Japan with 1,04,894 publications, Germany with 95,574 publications,

UK with 89,257, France with 71,894, India with 59,465, Italy with 55,047, Canada with 50,613 and Spain with 47,493 publications ranked Second to tenth respectively.

Table 3: Highly Productive Countries in Science and Technology research

YEAR	USA	CHINA	JAPAN	GERMANY	UK	FRANCE	INDIA	ITALY	CANADA	SPAIN
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1989	11,574	792	1,914	230	2,475	968	1,327	562	1,069	210
1990	11,775	715	1,737	1,687	2,515	980	1,139	609	1,172	267
1991	11,968	847	2,207	1,994	2,590	1,229	1,160	684	1,111	341
1992	12,005	787	2,565	1,965	2,441	1,260	1,173	895	1,157	426
1993	12,103	925	2,841	1,884	2,352	1,383	1,290	812	1,196	469
1994	12,578	803	2,961	2,136	2,502	1,634	1,254	997	1,266	582
1995	12,543	859	3,267	2,285	2,498	1,697	1,293	1,120	1,305	699
1996	12,404	1,098	3,241	2,526	2,460	1,825	1,267	1,243	1,345	839
1997	11,764	1,175	3,214	2,497	2,625	1,920	1,210	1,153	1,280	942
1998	12,488	1,389	3,451	2,731	2,697	2,167	1,431	1,315	1,263	983
1999	11,918	1,348	3,218	2,714	2,620	1,971	1,562	1,263	1,166	1,029
2000	11,999	1,471	3,394	2,818	2,791	2,194	1,437	1,282	1,255	1,081
2001	12,411	1,716	3,719	3,005	2,459	2,214	1,623	1,479	1,176	1,147
2002	13,211	1,813	3,712	3,047	2,639	2,079	1,538	1,682	1,319	1,325
2003	13,820	2,176	4,040	3,087	2,770	2,376	1,860	1,870	1,411	1,548
2004	15,195	2,467	4,090	3,274	2,795	2,399	1,907	2,066	1,605	1,654
2005	15,777	3,079	4,072	3,438	3,075	2,727	2,101	2,057	1,801	1,803
2006	15,575	4,076	4,370	3,727	2,999	3,034	2,437	2,256	1,808	1,983
2007	18,509	5,508	4,757	4,207	3,471	3,268	2,917	2,868	2,230	2,485
2008	18,813	6,702	4,798	4,454	3,817	3,635	3,070	2,963	2,362	2,607
2009	19,784	7,725	5,344	4,978	3,959	3,925	3,182	3,289	2,547	2,925
2010	23,109	9,181	4,940	5,110	4,382	4,076	3,495	3,457	3,002	3,152
2011	25,835	12,273	6,103	6,662	5,298	4,990	4,257	4,162	3,423	3,909
2012	29,434	16,259	6,149	7,512	6,198	5,529	4,417	4,384	4,117	4,683
2013	32,564	22,681	7,456	8,718	7,430	6,253	5,267	5,343	4,555	5,031
2014	32,937	27,593	7,334	8,888	7,399	6,161	5,851	5,236	4,672	5,373
Total	**4,32,093**	**1,35,458**	**1,04,894**	**95,574**	**89,257**	**71,894**	**59,465**	**55,047**	**50,613**	**47,493**

Figure 1 & 2 show India's and global research output in Science and Technology research in terms of publications during 1989-2014. It is observed thatthere is an exponential growth of publications in Science and Technology for both India and the World. The R^2value for India (0.780) is greater than the World's (R^2=0.725) value.

Fig. 1 Indian Publication output in Science and Technology

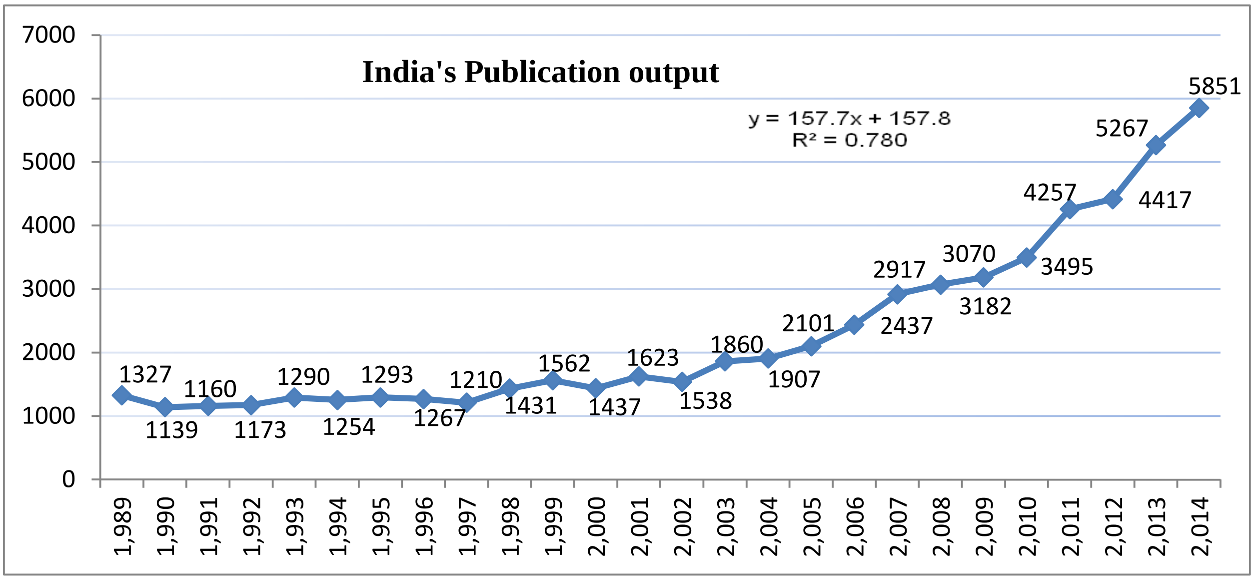
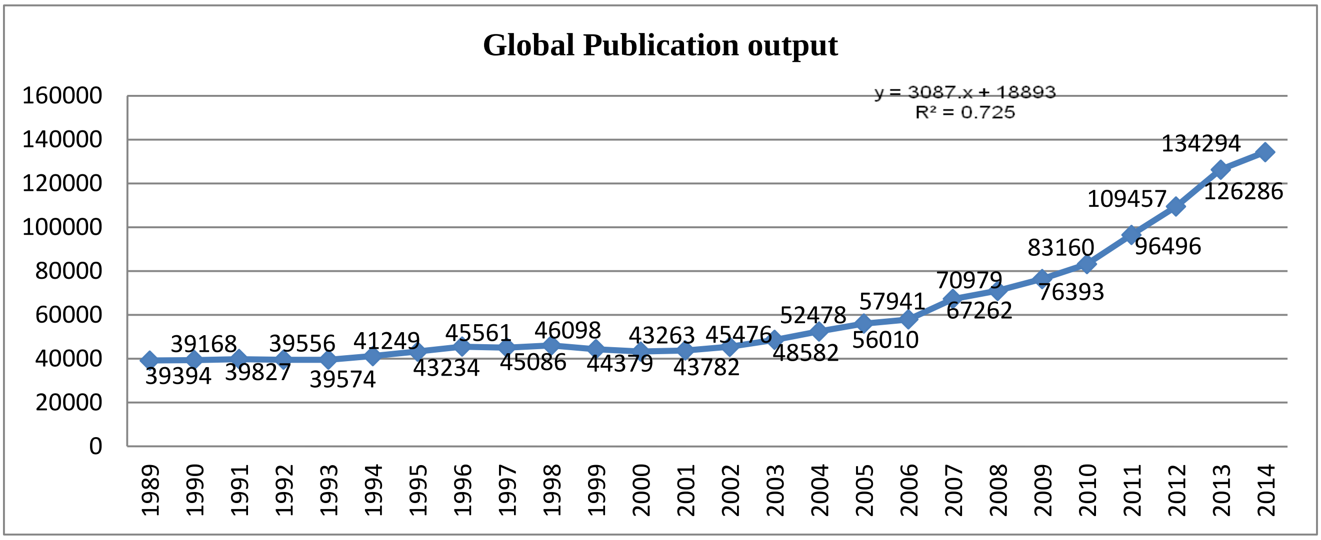


Fig. 2 Global Research output in Science and Technology



Relative Growth Rate and Doubling Time

The RGR and Doubling Time of publications in Science and Technology are presented in table 4. It is noticed that the RGR of publications decreased from 0.62 in 1990 to 0.10 in 2014. The mean RGR for the first twelve years (i. e. 1990 to 2001) shows the growth rate of 0.21, whereas, the mean RGR for the next thirteen years (2002 to 2014) was reduced to 0.10. The corresponding Doubling time for different years gradually increased from 1.12 (1990) to 6.69 (2014). The mean doubling time for the first twelve years (i. e. 1990 to 2001)

was only 4.42, which was increased to 7.28 during the next thirteen years i. e. from 2002 to 2014.

Table 4:Relative Growth Rate and Doubling Time

Year	No. of articles	Cumulative no. of articles	Log$_e$ 1p	Log$_e$ 2p	R (P)	Mean R (P)	Dt.	Mean Dt.
1989	1327	1,327		7.19				
1990	1,139	2,466	7.19	7.81	0.62		1.12	
1991	1,160	3,626	7.81	8.20	0.39		1.80	
1992	1,173	4,799	8.20	8.48	0.28		2.47	
1993	1,290	6,089	8.48	8.72	0.24	**0.21**	2.91	**4.42**
1994	1,254	7,343	8.72	8.90	0.19		3.70	
1995	1,293	8,636	8.90	9.06	0.16		4.27	
1996	1,267	9,903	9.06	9.20	0.14		5.06	
1997	1,210	11,113	9.20	9.32	0.12		6.01	
1998	1,431	12,544	9.32	9.44	0.12		5.72	
1999	1,562	14,106	9.44	9.56	0.12		5.90	
2000	1,437	15,543	9.56	9.65	0.10		7.14	
2001	1,623	17,166	9.65	9.75	0.10		6.98	
2002	1,538	18,704	9.75	9.84	0.09		8.08	
2003	1,860	20,564	9.84	9.93	0.09		7.31	
2004	1,907	22,471	9.93	10.02	0.09		7.81	
2005	2,101	24,572	10.02	10.11	0.09		7.75	
2006	2,437	27,009	10.11	10.20	0.09	**0.10**	7.33	**7.28**
2007	2,917	29,926	10.20	10.31	0.10		6.76	
2008	3,070	32,996	10.31	10.41	0.10		7.10	
2009	3,182	36,178	10.41	10.50	0.09		7.53	
2010	3,495	39,673	10.50	10.59	0.09		7.51	
2011	4,257	43,930	10.59	10.69	0.10		6.80	
2012	4,417	48,347	10.69	10.79	0.10		7.23	
2013	5,267	53,614	10.79	10.89	0.10		6.70	
2014	5,851	59,465	10.89	10.99	0.10		6.69	
	59, 465							

Collaborative Countries

The impact of research of any country can be examined by making collaboration and citation count of the articles received over a period of time. The Table 5 shows the top ten collaborative countries in Science and Technology research with India. The top ten countries appeared in the table reveal that India has regularly conducted combined conferences, workshops, seminars, major scholarship and makes research agreements and MoU (Memorandum of Understanding) for various science research innovations as well as

institutions. India has published the highest number of articles with the USA i.e. 2900 and has received highest citations i.e.85, 027. The highest average citations per paper i.e. 46.94% were received for publications collaborated with Canada (421 publications). The lowest average citations per paper i.e. 18.84 % were received from South Korea (a total number of 630 publications were collaborated).

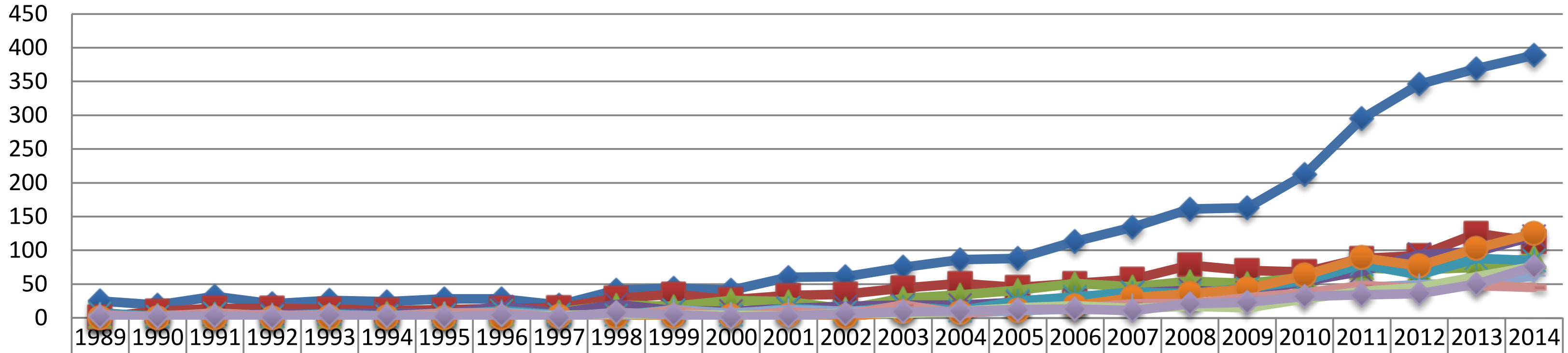
Table 5: Top Ten Collaborative countries

Country	Publications	Percentage	Citations	Average Citations Per Paper	h-Index
USA	2900	4.877	85027	29.32	126
Germany	1145	1.926	32169	28.10	77
Japan	821	1.381	28516	34.73	63
UK	774	1.302	29666	38.33	73
France	665	1.118	25031	37.64	60
South Korea	630	1.059	11868	18.84	45
Canada	421	0.708	19761	46.94	49
Italy	415	0.698	17451	42.05	45
China	384	0.646	14435	37.59	53
Australia	372	0.626	11268	30.29	49

The Department of Science and Technology, Government of India has initiated short-term and long-term research programmes with these top collaborative countries. In December 1997, The USA made MoU (Memorandum of Understanding) on scientific research in the areas of Earth and Atmospheric Sciences signed between the Department of Science and Technology &the Department of Space, Government of India and National Oceanic and Atmospheric Administration & National Aeronautics and Space Administration, USA.As an outcome of this agreement, an Indo-US Science and Technology Forum has been established as an autonomous society registered in India under Societies Registration Act XXI of 1860 (Dept. of Science & Technology, 1999-2014).

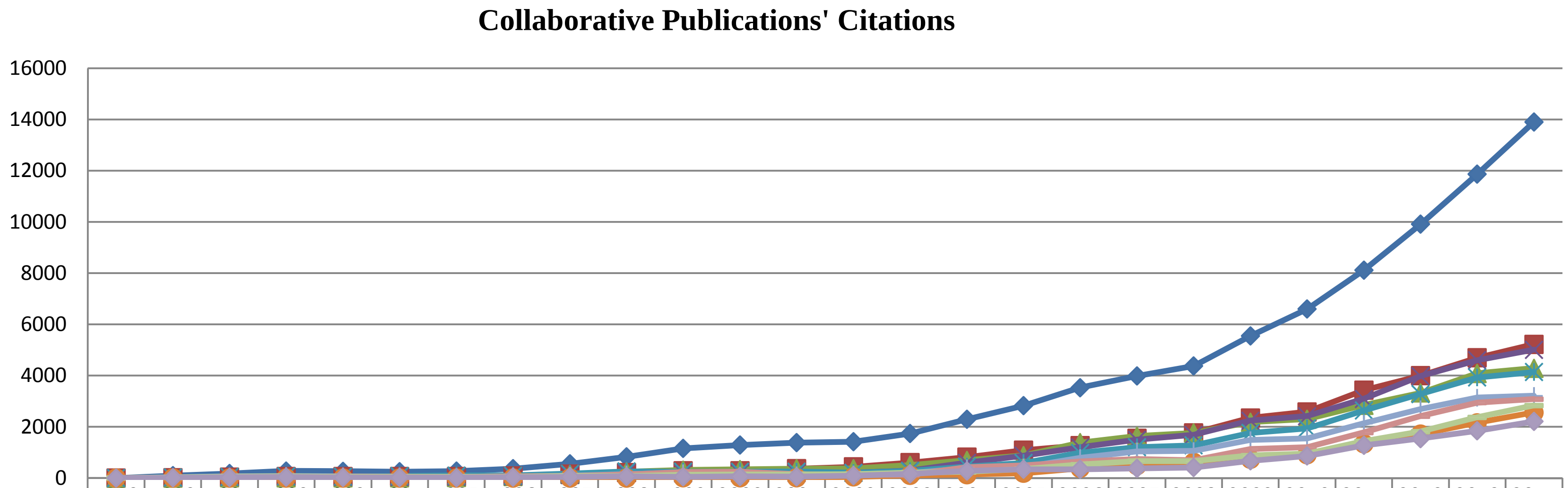
Fig. 3: Top Ten Collaborative countries

Collaborative Publication output



	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
USA	25	19	32	21	26	24	28	28	19	41	44	41	60	61	75	86	88	113	134	161	163	212	295	346	369	389
GERMANY	1	10	14	14	13	11	12	14	15	29	35	27	33	35	44	51	45	51	57	78	70	68	88	92	125	113
JAPAN	2	4	5	3	3	7	6	6	9	19	17	26	24	13	29	34	41	51	46	54	51	60	74	71	75	90
UK	7	2	5	6	6	7	6	17	7	20	11	10	14	17	19	19	23	27	37	41	37	54	69	94	98	121
FRANCE	7	2	7	3	6	3	4	11	5	4	12	4	15	9	17	11	25	31	38	36	44	55	79	64	88	85
SOUTH KOREA	0	0	0	0	1	1	0	0	2	2	3	3	4	2	9	8	11	18	30	36	43	63	89	77	103	125
CANADA	5	0	4	5	1	3	7	8	4	2	12	7	12	10	11	7	11	13	19	18	22	32	45	49	52	62
ITALY	4	2	7	3	5	2	7	6	1	4	11	2	9	5	19	6	14	14	21	21	30	37	48	44	48	45
CHINA	1	1	2	0	3	1	3	1	3	6	5	4	3	7	6	10	15	18	14	17	15	28	39	45	61	76
AUSTRALIA	2	2	3	1	4	3	2	4	1	8	5	1	3	6	9	10	12	13	11	21	23	32	34	36	50	76

Fig. 4: Citations receivedfor Collaborative Publications



	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
USA	5	98	179	278	271	253	277	367	559	828	1163	1291	1385	1424	1742	2296	2829	3534	3989	4380	5553	6603	8119	9913	11865	13904
GERMANY	0	18	40	64	66	68	70	94	155	222	289	289	367	438	605	816	1090	1277	1561	1766	2351	2588	3435	3999	4698	5224
JAPAN	0	3	13	14	17	22	29	65	146	254	315	340	370	376	506	694	882	1388	1639	1766	2184	2301	2847	3328	4089	4291
UK	2	16	38	61	43	38	48	66	124	207	187	197	195	207	298	600	876	1203	1499	1688	2242	2423	3098	3986	4602	5011
FRANCE	2	31	56	81	63	84	105	101	174	261	251	250	255	211	279	455	597	988	1212	1283	1763	1945	2640	3288	3931	4141
SOUTH KOREA	0	0	0	0	1	1	1	1	2	4	12	16	22	52	110	136	190	379	487	618	736	919	1337	1715	2162	2562
CANADA	0	41	70	84	76	59	45	65	100	152	198	105	113	148	196	381	424	790	1045	1061	1485	1552	2138	2696	3141	3216
ITALY	0	21	37	56	51	55	52	70	84	141	233	243	155	131	131	423	494	654	742	695	1139	1201	1781	2422	2949	3082
CHINA	0	29	56	72	46	42	48	46	84	78	128	139	142	156	215	247	354	532	664	658	884	956	1438	1816	2374	2836
AUSTRALIA	0	12	32	46	27	26	23	40	48	70	52	66	55	96	169	279	344	346	384	418	675	865	1283	1545	1846	2215

Productive Institutions in Science and Technology

The table6 shows the most productive institutions of top twenty five organizations in Science and Technology research in India. The highest number of papers were published by Bhabha Atomic Research Centre, Mumbai with the publication percentage of 6.92 (4,117Publications) followed by, Indian Institute of Science (IISc), Bengaluru with the percentage of 4.28 (2,547publications) and Central Food Technological Research Institute India with the percentage of 3.20 (1,902Publications) were ranked Second and Third respectively. The study reveals that most of the organizations (among top twenty five) are based in New Delhi, Mumbai and Kolkata.

Table6: Productive Institutions in Science and Technology

Sl. No	Organization	Place	State	Publications	%
1	Bhabha Atomic Research Center	Mumbai	Maharashtra	4117	6.92
2	Indian Institute of Science (IISc), Bangaluru	Bengaluru	Karnataka	2547	4.28
3	Central Food Technological Research Institute, India (CFTRI)	Mysore	Karnataka	1902	3.20
4	Indian Institute of Technology IIT,Kharagpur	Kharagpur	West Bengal	1484	2.50
5	Indira Gandhi Centre for Atomic Research	Kalpakkam	Tamil Nadu	1218	2.05
6	Banaras Hindu University	Varanasi	Uttar Pradesh	1213	2.04
7	Indian Institute of Technology IIT Bombay	Mumbai	Maharashtra	973	1.64
8	Indian Institute of Technology IIT Madras	Chennai	Tamil Nadu	945	1.59
9	University of Delhi	New Delhi	New Delhi	937	1.58
10	Tata Institute of Fundamental Research (TIFR)	Mumbai	Maharashtra	877	1.47
11	Indian Institute of Technology IIT Delhi	New Delhi	New Delhi	843	1.42
12	Indian Institute of Technology IIT Kanpur	Kanpur	Uttar Pradesh	782	1.32
13	Guru Nanak Dev University (GND)	Amritsar	Punjab	636	1.07
14	University of Pune*	Pune	Maharashtra	627	1.05
15	Jawaharlal Nehru Center for Advanced Scientific Research	Bengaluru	Karnataka	607	1.02
16	Indian Agricultural Research Institute	New Delhi	New Delhi	579	0.97
17	National Chemistry Laboratory	Pune	Maharashtra	576	0.97
18	Jadavpur University, Jadavpur	Kolkata	West Bengal	559	0.94
19	Indian Institute of Technology IIT Roorkee	Roorkee	Uttarakhand	544	0.91
20	Ministry of Earth Sciences (MoES) India	New Delhi	New Delhi	543	0.91
21	University of Calcutta	Kolkata	West Bengal	528	0.89
22	Indian Association for the Cultivation of Science	Jadavpur	West Bengal	524	0.88
23	Saha Institute of Nuclear Physics	Kolkata	West Bengal	520	0.87
24	Punjab Agriculture University	Ludhiana	Punjab	501	0.84

25	National Dairy Research Institute India	Karnal	Haryana	495	0.83

* University of Pune is renamed as Savitribai Phule Pune University

Journals Preferred in Science and Technology

The table 7 presents the top twenty-five Science and Technology journals preferred by the Indian scientists. It is found that the *Current Science*(India) with the highest publications i.e. 14,245 ranked first, followed by *Journal of Food Science and Technology*(India)with 3,074 publications (9,411 citations), *PLOS One, (*USA)with 2,556 publications (15,002 citations),*National Academy Science Letters India*(India)with 1,623 publications (1,474 citations), *Materials Science and Engineering a Structural Materials Properties Microstructure and Processing*(USA)with 1401 publications (19,756 citations) ranked second to fifth respectively. Of the total 59,465 papers, 36,654 (62%) publications appeared in the top twenty five journals. Out of twenty-five journals, eight journals are from USA and Netherlands respectively, seven journals are from India and two are from UK.

The Impact Factor is a measure of the frequency with which the average article in a Journal has been cited in a particular year (Thomson Reuters' 1994). The Impact factor of the *Journal of Physical Chemistry* from India is high, i.e. 4.835, followed by *PLOS One*from USA with 3.534, *Food Chemistry* journal from UK has impact factor 3.25. These three journals occupy first to third position with respect to impact factor.

Table 7:Journals Preferred in Science and Technology

Sl. No	Preferred Journals	TP	% of TP	TC	Countries	Impact factor
1	*Current Science*	14,245	23.951	61,292	India	0.833
2	*Journal of Food Science and Technology Mysore*	3,074	5.169	9,411	India	2.024
3	*PLOS One*	2,556	4.298	15,002	USA	3.534
4	*National Academy Science Letters India*	1,623	2.729	1,474	India	0.24
5	*Materials science and Engineering a Structural Materials Properties Microstructure and Processing*	1,401	2.356	19,756	USA	2.409
6	*Nuclear Instruments Methods in Physics Research Section B Beam Interactions with*	1,127	1.895	9,092	India	1.186

	Materials and Atoms					
7	*Defense Science Journal*	1,116	1.876	1,509	India	0.31
8	*Journal of Nanoscience and Nanotechnology*	1,082	1.819	6,379	USA	1.339
9	*Journal of Physical Chemistry C*	1,026	1.725	18,989	India	4.835
10	*Journal of RADIOANALYTICAL and Nuclear Chemistry*	1,001	1.683	3,703	Netherlands	1.415
11	*International Journal of Remote Sensing*	796	1.338	7,992	USA	1.359
12	*Food Chemistry*	743	1.249	15,127	U K	3.259
13	*Annals of Arid Zone*	687	1.155	565	India	0.01
14	*Journal of Earth System Science*	652	1.096	2,814	USA	0.794
15	*Journal of Nuclear Materials*	642	1.079	5,432	USA	2.016
16	*Radiation Physics and Chemistry*	633	1.064	4,151	USA	1.189
17	*Nuclear Instruments Methods in Physics Research Section a Accelerators Spectrometers Detectors and Associated Equipment*	587	0.987	13,171	U K	1.316
18	*Food and Chemical Toxicology*	534	0.898	8,539	Netherlands	2.61
19	*Journal of Agricultural and Food Chemistry*	528	0.888	9,370	USA	3.107
20	*Applied Radiation and Isotopes*	475	0.799	3,261	Netherlands	1.056
21	*ScriptaMaterialia*	436	0.733	6,175	Netherlands	2.968
22	*Microelectronics and Reliability*	432	0.726	915	Netherlands	1.214
23	*Nanotechnology*	426	0.716	8,231	India	2.332
24	*Journal of the Science of Food and Agriculture*	421	0.708	4,057	Netherlands	1.879
25	*Radiation Effects and Defects in Solids*	411	0.691	1,441	Netherlands	0.603

* TP=Total Publications TC= Total Publications

Discussions and Conclusions

The present study covers the Growth and Activity of research in Science and Technology in India. The study covers a total period of twenty six years (form 1989 to 2014) as per Thomson Reuter's Web of Science database. It is evident from the study that the highest numbers of publications were published in the year 2014 followed by 5,267 publications during 2013. The year 2009 has received the highest citations i.e. 35,290 (for 3,182 publications), followed by, 34,711 citations were received (for 2,917 publications) during 2007. The R^2 value (R^2= 0.780) of India is greater than the world (R^2= 0.725) for Science and Technology. Among the collaborative countries, the USA topped the list with 2,900 publications, followed by Germany with 1,145 publications. The journal, *Current*

Science (from India) topped the list with 14,245 publications, followed by *Journal of Food Science and Technology* (India) with 3,074 publications.

Everything is not, however, fine and rosy about India's science education system. Despite the fact that India today has the second largest education system, it has still to meet the basic needs and aspirations to its billion people. C.V. Raman (INSA, 2001)one of the India's most eminent scientists and also the recipient of Nobel Prize said, "There is only one solution for India's economic problems and that is Science, more science and still more science". The Research in pure science in India is also on the decline, says Varghese (2006).

The number of brilliant students opting for research in major disciplines like Physics and Chemistry appears to be sharply declining (Balram, 2002). The reasons may be the research aptitude in students is not properly developed and cultivated from the beginning there is a mismatch between theory and practice and the impression among students is that a career in basic science is not encouraging and lucrative. However, the developed notions are managing the problem by attracting brilliant scholars from other countries. If this trend continues, India will face a shortage in R & D personal very soon (Varghese, 2006).The academic ambience persisting in many universities does not encourage the research pursuits of faculties. The outcome of Universities' research and its management (through Institutional Repositories) in universities is another very serious problem faced by many Indian universities (Varghese, 2006).

It is evident from the study that the scientific research in India mainly carried out either from the academic or the research institutions. The publication activity by different industries is almost absent. Out of the top twenty five highly productive institutes, there is no single industrial research centre appearing in the list unlike in China, South Korea and other developed countries where small scale industries have established R & D units for further research. This will improve the efficacy of the industries in terms of products and

publications as well. We could find the similar situation even in some of the large scale industries. Hence, the situation is ripe for small scale industries to establish R & D units, thereby maintaining the quality of the products and improve the productivity in terms of research publications.

Among the highly productive institutions, the Bhabha Atomic Research Centre (BARC), Mumbai ranked first with 4,117 publications (6.92 %) followed by Indian Institute of Science (IISc), Bengaluru with 2,547 publications. Out of the top twenty five institutions, universities figure is only six, which is quite discouraging. The statistics from the University Grants Commission (UGC) reveals that there are 329 state universities (as on 31st March, 2015), 207 private universities (as on 23rd April 2015) and 46 central universities (as on 20th May, 2015) (leaving the deemed to be universities, since there is a mushroom growth of these universities). It would be better if the respective state Governments should stop opening new universities at least for a decade from now so as to strengthen the already established universities in all respects (Hadagali, 2014).

There are 10,043 degree colleges as per UGC Act, 1956 under section 2 (f) & 12 (B) (as on 31st May, 2015). There is no single college appearing in the list of productive institutes. The National Council of Applied Economic Research (NCAER), in its report, reveals that three percent of school children want to pursue a career in science (Shukla, 2005). After graduation, students in India drift to other job-oriented courses. Careful analysis is necessary for elucidating the reason for the decline and to find proper measures for strengthening science education and research (Shukla, 2005).

A study conducted by Gupta et al. (2002) on India's collaboration in Science and technology with Southeast Asian countries points out that sufficient infrastructure and human resources availability are the main reasons for the strong dominance of India's bilateral collaborative research with other countries. The degree of collaboration at the international

level is not encouraging to that of expected level. The extent of International collaboration was inversely proportional to the size of a country's scientific enterprise and extra-scientific factors such as Geography, Politics and Language (Prakasan et al., 2014).

Collaborative research is generally expected to provide a right platform to depict the best expertise available in both the countries. A study by Prakasan et al. (2014) reveals that India had only 4.56 % internationally collaborative publications in 1991 and it has risen to 22.77 % in 2010. USA, Germany, Japan, England and France were the most favourite collaborative countries. India has been regularly undertaking research programmes with these countries. India is ranked third in GDP (Gross Domestic Product) based on Purchase Power Parity (7.997 $ current international, billions) and ranked seventh in GDP of current prices (2,308 US $, billions) as per IMF World Economic Outlook (IMF, April 2015). In view of this futuristic research programmes in mind, India needs to be proactive in continuous MoUs and other research programmes more with developing countries as well as with the neighboring countries.

However, on the other hand, the UGC has provided access to most of the e-resources to the various colleges (through N-List programme) which helps the teachers and researchers to access e-resources at their desktops. If there is a contribution of two papers per college every year the number goes up very high. The respective State Govts. are striving hard to provide necessary infrastructure but the rate of speed in adopting latest technologies is very slow compared to those of developed and some of the developing countries. The Government of India and the respective State Govts. have initiated various programmes at the school levels to encourage basic science education in India which are still to gear up. In TOTO, India will definitely occupy first three positions in terms of research publications if all the teachers and researchers working in universities and colleges put hands together along with personnel working in R & D institutions.

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