7-20-2019

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ABSTRACT

The present paper provides a bird's view about the Materials Science research at the global level by applying various Scientometric indices and indicators. The study uses Science Citation Index of ISI Thomson Reuters' Web of Science for the period from 2002 to 2016 (for a period of fifteen years) of top fifteen countries in the field of Materials Science. The parameters used in this study are Relative Growth Rate (RGR), Doubling Time (Dt.), Activity Index (AI), Publication Efficiency Index (PEI), Relative Comparative Advantage for Publication (RCAP). The findings of the study reveal that the percentage share of Materials Science publications of the World is 5.61 out of the total scientific publications of the World; the study indicates that China topped the table with 2,87,736 publications, followed by the USA (2,17,422); there is an exponential growth of publication for the world (R^2 = 0.967) in Materials Science field; the Annual Growth Rate (RGR) is highest for Iran (through it ranked fifteenth in terms of publications), i.e. 27.00; Activity Index is more than one for nine countries which indicates that the research efforts of these countries correspond to the world's average; It is evident from the study that USA (1.48), England (1.19), Australia (1.14), Germany (1.09) and France (1.07) have more than one PEI which clearly indicates that there is an impact of publications in Materials Science by these countries is more than the research

effort devoted during 2002 to 2016; China topped the list with the highest mean value of Relative Comparative Advantage for Publication (RCAP) i.e. 2.23. RCAP value of China, South Korea, Taiwan, India, Iran, Japan, Russia and France are more than one. The data indicate that these countries are specialised in the field of Materials Science.

Keywords: Activity Index, Materials Science, Publication Efficiency Index, Relative Comparative Advantage for Publication, Relative Growth Rate, Scientometrics,

Introduction

Monitoring and evaluating the various facets of the scientific enterprise is a necessary and integral part of the science policy. The developments in R & D activities presuppose the knowledge of the activities and performance of the innovation system. The developments of new indicators on Science, Technology and Innovation (STI) have grown substantially at the global level during the last two decades.

However, the analysis of data is the most skilled task in the research process. It calls for the researchers' own judgment and skill. Analysis means the critical examination of the assembled and grouped data for studying the characteristics of the subject under study and determining the patterns of relationships among the variables relating to it. Both quantitative and qualitative methods are used to achieve this. However, Science research most often requires quantitative analysis involving the application of various statistical techniques. Scientometrics is one of the techniques which are a set of mathematical and statistical methods used to analyze and measure the quantity and quality of books, articles and other forms of publications. It is considered as a recognized exercise to measure the research output in terms of publications. Hence the present study is conducted on the Scientometric analysis of Materials Science research.

Materials Science is an interdisciplinary field involving the properties of matter and its applications to various areas of Science and Engineering. This scientific field investigates the relationship between the structure of Materials at Atomic or Molecular scales and their macroscopic properties. It incorporates elements of applied Physics and Chemistry. In recent years, Materials Science has become a major field of research as it is focused on Nanoscience and Nanotechnology. Materials used in High-Tec applications, usually designed for the maximum performance and normally expensive

e.g. Titanium alloys for supersonic airplanes, Magnetic alloys for computer disks, special ceramics for the heat shield of the space shuttle, etc. There is a lot of research conducted worldwide in Materials Science. There is a necessity of quantifying the research conducted in the field of Materials Science by applying various Scientometrics indicators along with newly introduced and practiced indices, indicators.

Review of Literature

A few global studies on materials science and its allied subjects have been carried out. Garfield and Pudovkina (2003) demonstrate in their paper how to identify the core journals of materials science, ceramics, and nanoceramics. The data was extracted from Web of Science and a total 10,000 papers were used for further analysis on Nano-Crystals and Nano-Ceramics. The HistCite maps and tables demonstrate the chronological development of the Materials Science. Walke and Dhawan (2007) analyse the growth and publications' size of the Indian publications in materials science for the period from 1993 to 2001. Further, the authors observed that the Materials Science research in India is growing steadily about seven % per year. The collaborative research has been given due importance and is growing faster (368.2 per cent) than the country growth in materials science research (7.09 per cent).

Kademani et al. (2013) study reflects the extensive worldwide study on materials science. The data was retrieved from the Web of Science database for the period from 2006 to 2010 on materials science. The growth and development of world literature on materials science in terms of publications output and citations output was presented. The study reveals that an exponential growth of literature was observed except in 2010 which may be attributed to time-lag in input of records in the database. Ho (2014) in his paper uses the Science Citation Index-Expanded to identify and analyse the characteristics of the highly cited articles in materials science for the period from 1999 to 2011. The results of Y-index, a new indicator showed that Massachusetts Institute of Technology, USA had high articles publication potential as well as published the most first author and corresponding author articles. Geim and Novoselov who are the 2010 Nobel laureates, published the most potential articles in materials science. Velmurugan (2018) emphasizes on the publications productivity on materials science retrieved through the web of science bibliographic database for a period from 2006 to 2015. It is noted that the maximum number, i.e. 98.6% of literature output with

12,682 global citations have published by Indian scientists on Material Science during the period of study.

Among the materials science field nanoscience and nanotechnology have emerged as prominent areas. Braun et al. (1997) have carried out a study on the growth trends in nanoscience and nanotechnology. Kademani et al. (2006) have studied literature on thorium at the global level using Science Citation Index as a data source for the period from 1982 to 2004. The study further reveals that the bilateral collaboration accounted for 80.55 percent of the total collaborative papers. The spurt in the literature output was reported during 1991-2004.There were 94 countries involved in the research in materials science field. The USA is the top producing country with 1000 authorships (21.11%), followed by India with 498 authorships (10.51%). A similar study on nanotechnology and nanoscience was also carried out by Kostoff et al. (2007) using Science Citation Index and Social Science Citation Index databases.

Sagar et al. (2010) have carried out a study on Cobalt-60 as per the International Nuclear Information Systems (INIS). A total of 5874 publications were published for a period from 2000 to 2007. The study reveals that China topped the list with 960 (14.96 %) publications. The study reveals that the authorship and collaboration trend is towards multi authored papers. The researchers in China, Japan, the Russian Federation and the USA were tend to work in larger groups. Hiremath and Hadagali (2014) analyse the results world literature on Biomaterials research as reflected in Web of Science database for the period from 1999 to 2013. The study reveals that among the different countries, USA topped the list with 12,025 publications and its share is 25.251 % of the total publications. It is also revealed from the study that among the top forty two authors, fifteen authors belong to China, which is predominantly high compared to other countries. Sindagi and Anandhalli (2018) in their paper analyse the world literature on nanotechnology. The total research publications (8000) on nanotechnology were published in the seventeen different languages. 17.04 % of world's share was published in three journals i.e. Advanced Powder Technology, Microelectronic Engineering, and Journal of Nanoscience and Nanotechnology.

Scope and Limitations of the Study

The present study is confined to Materials Science research publications as reflected in Thomson Reuters' Web of Science database for the period of fifteen years from 2002 to 2016.

Objectives of the Study

The main objective of the present study is to provide the growth of literature on Materials Science research for the period from 2002 to 2016. The specific objectives of the study are to:

1. identify the annual growth of publications in the field of Materials Science at the global level;
2. study the Relative Growth Rate (RGR) and Doubling Time (Dt.) in the field of Materials Science.
3. find out the research performance of highly productive countries in the field of Materials Science;
4. use indices like Activity Index (AI), Publication Efficiency Index (PEI), Relative Comparative Advantage for Publication (RCAP).

Methodology

The data on Materials Science research has been collected from the Science Citation Index of ISI Thomson Reuters' Web of Science. The string used to retrieve the data on Materials Science Research is as follows:

SU= (Materials Science) AND PY= (2002-2016)

The ISI Web of Science is an integrated, Web based platform designed to support all levels of scientific and scholarly research within the academic, corporate, government or non-profit organizations. The data collected then is fed into MS-Excel and put into tabular forms.

Data Analysis and Interpretation

Distribution of Publications: Scientific vs. Materials Science

The table 1 depicts the status of Scientific Publications and that of Materials Science publications of the World. The study reveals that the percentage share of

Materials Science' publications of the World is 5.61 out of the total scientific publications of the world. The world's Materials Science publications are 12, 42,775.

Table 1: Distribution of Publications: Scientific vs. Materials Science

Year	Scientific Publications (World)	Percentage (%)	Materials Science Publications (World)	Percentage (%)
2002	1034960	4.67	51021	4.11
2003	1082219	4.88	53690	4.32
2004	1170092	5.28	61179	4.92
2005	1240004	5.60	62981	5.07
2006	1295368	5.84	67492	5.43
2007	1360669	6.14	71007	5.71
2008	1412111	6.37	75368	6.06
2009	1481516	6.68	78861	6.35
2010	1515982	6.84	80199	6.45
2011	1596237	7.20	88723	7.14
2012	1678782	7.57	92804	7.47
2013	1769840	7.99	103137	8.30
2014	1816832	8.20	112171	9.03
2015	1837430	8.29	119577	9.62
2016	1871884	8.45	124565	10.02
	2,21,63,926	**100**	**12,42,775**	**100**
	Percentage Share of Materials Science Publication (World)	5.61		

Table 2: Research output of top fifteen countries in the field of Materials Science

Year	China	USA	Japan	Germany	South Korea	India	France	England	Italy	Taiwan	Spain	Canada	Russia	Australia	Iran
2002	5389	9199	7191	4425	2452	1838	3428	2849	1560	1097	1487	1171	1945	827	119
2003	6680	9758	7390	4163	2714	2019	3205	2860	1605	1302	1343	1278	1880	840	189
2004	7762	10976	7786	4834	3603	2187	3589	3101	1960	1545	1643	1503	2103	991	240
2005	10127	11219	7254	4678	3854	2479	3449	2924	1648	1597	1554	1721	1800	1026	271
2006	11161	11888	7529	4626	4341	2786	3657	3040	1668	2289	1753	1903	1868	1158	442
2007	12848	13032	7363	5116	3774	3393	3784	3132	1970	2059	1909	1931	1806	1195	579
2008	15003	13183	6705	4934	4312	3801	4219	3180	2065	2298	1954	1998	1795	1390	835
2009	16841	13891	6745	5209	4845	4343	4120	3367	2097	2574	2095	2153	1774	1519	1338
2010	17246	14861	6083	5409	5238	4501	4010	3307	2292	2614	2197	2191	1611	1746	1613
2011	20556	15939	6517	6232	6308	4872	4402	3465	2559	2929	2437	2318	1853	1913	1900
2012	23290	16410	6067	6006	6571	5104	4402	3569	2502	2741	2685	2364	1873	2166	2156
2013	27751	17339	6554	6501	7316	6228	4859	3869	2969	3130	2826	2545	2042	2482	2543
2014	33418	18882	6565	6995	7902	6705	4768	4070	3098	3037	3126	2772	2349	2844	2811
2015	38406	20064	6298	7391	8203	7206	5097	4612	3243	2732	3189	2944	2972	3124	3094
2016	41258	20781	6649	7557	8645	7772	5143	4985	3506	2630	3361	2995	3051	3327	3632
Total	**2,87,736**	**2,17,422**	**1,02,696**	**84,076**	**80,078**	**65,234**	**62,132**	**52,330**	**34,742**	**34,574**	**33,559**	**31,787**	**30,722**	**26,548**	**21,762**
AVG	19182	14495	6846	5605	5339	4349	4142	3489	2316	2305	2237	2119	2048	1770	1451

The table 2 reveals the research output of top fifteen countries in Materials Science. The study indicates that China topped the table with 2,87,736 publications, followed by the USA with 2,17,422 publications, Japan with 1,02,696 publications, Germany with 84,076 publications, South Korea with 80,078 publications ranked second to fifth respectively. India ranked sixth in the table with 65,234 publications. Among the top fifteen highly productive countries, eight countries belong to the developed countries and seven are developing countries. The contribution in Materials Science publications from the developing countries is enormous. The average publication per year is the highest for China (19,182 publications) and the lowest for Iran (145 publications). India's contribution to the Materials Science discipline from 2002 to 2016 is 5.25%. The table 2 also provides the publications trend in Materials Science subject.

Table 3: Relative Growth Rate (RGR) and Doubling Time (Dt.) of Materials Science Research

Years	Materials Science Publications	Cumulative No. of Publications	w1	w2	RGR (w2-w1)	Dt.
2002	51021	51021		10.84		
2003	53690	104711	10.84	11.56	0.72	0.96
2004	61179	165890	11.56	12.02	0.46	1.51
2005	62981	228871	12.02	12.34	0.32	2.15
2006	67492	296363	12.34	12.60	0.26	2.68
2007	71007	367370	12.60	12.82	0.21	3.23
2008	75368	442738	12.82	13.00	0.19	3.71
2009	78861	521599	13.00	13.17	0.16	4.23
2010	80199	601798	13.17	13.31	0.14	4.84
2011	88723	690521	13.31	13.45	0.14	5.04
2012	92804	783325	13.45	13.57	0.13	5.50
2013	103137	886462	13.57	13.70	0.12	5.60
2014	112171	998633	13.70	13.82	0.12	5.82
2015	119577	1118210	13.82	13.93	0.11	6.13
2016	124565	1242775	13.93	14.03	0.11	6.56
Total	**1242775**				**3.19**	**57.95**
				Mean	**0.21**	**3.86**

*RGR = Relative Growth Rate, Dt. = Doubling Time

The RGR is the increase in number of articles/ pages/ reports/ patents per unit of time. This definition is taken from the study of growth analysis of individual plants and successfully applied in the field of Botany (Hunt, 1978) which in turn had its origin

from the study of the rate of interest in the financial investments by Blackman (1919).The RGR and Doubling time of publications in Materials Science are presented in table 3. It is noticed that the RGR of Publications decreased from 0.72 in 2003 to 0.11 in 2016. The mean RGR for fifteen years' period is 0.21.

If the number of articles or pages of a particular subject field doubles during a given period than the difference between the logarithms of numbers at the beginning and end of the period must be logarithms of number 2. If the natural logarithm is used this difference has a value of 0.693. Thus the corresponding doubling time for each specific period of interval and for research output can be calculated. The corresponding Doubling time for different years gradually increased from 0.96 (2003) to 6.56 (2016). The mean Doubling time for the selected period (2002 to 2016) is 3.86.

Figure 1: Relative Growth Rate (RGR)

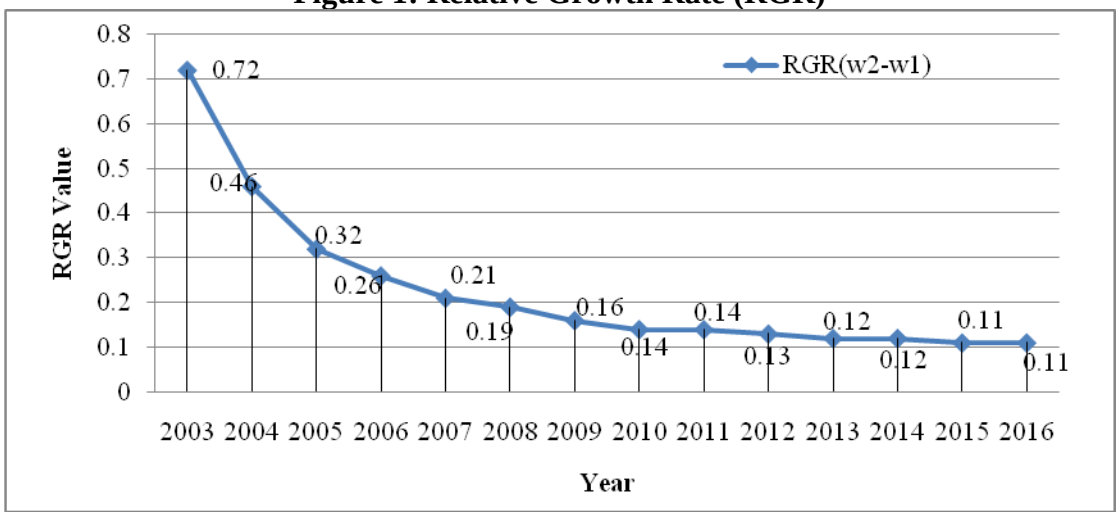

Figure 2: Doubling Time (Dt.)

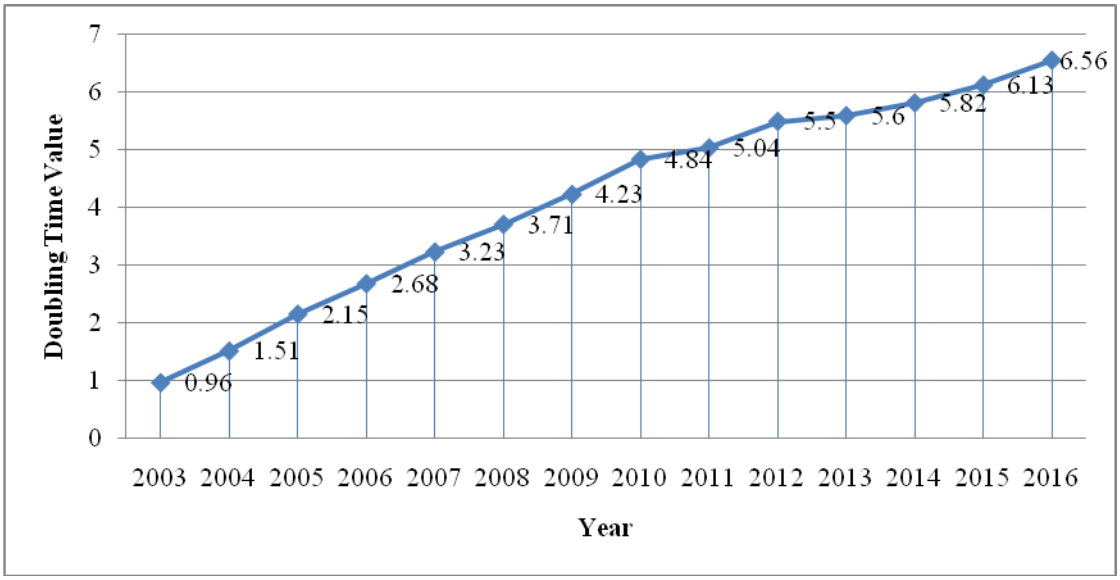
Doubling Time Value
7
6
5
4
3
2
1
0
0.96
1.51
2.15
2.68
3.23
3.71
4.23
4.84
5.04
5.5
5.6
5.82
6.13
6.56
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Year

Table 4: Citations received by the top fifteen Countries in the field of Materials Science

Year	USA	China	Germany	Japan	South Korea	England	France	India	Canada	Italy	Spain	Australia	Taiwan	Russia	Iran
2002	346190	108296	109495	149355	52947	75289	81522	38587	35812	32405	33332	22098	25943	18479	1961
2003	417238	140323	119923	145315	62459	79913	86146	45652	34307	38922	37461	21924	28971	21025	5198
2004	438047	155148	124197	151862	72397	84749	86168	47552	46184	39338	35055	29913	36408	23065	4562
2005	415616	200143	135100	156216	74794	84088	92537	52620	50091	44515	40492	29170	37342	16761	5765
2006	447280	232986	127116	146323	80335	92891	95672	55697	57378	39909	42695	34496	40661	19945	7935
2007	512246	292755	147041	146527	85939	119021	95773	69019	57476	45191	52980	38233	42003	22746	12687
2008	516333	345852	132882	132075	92297	95736	103301	74169	52158	47195	46665	51988	43091	18446	16754
2009	493443	377003	146231	134971	100756	95739	97673	80865	55071	50246	46869	49992	51174	17184	24519
2010	548137	409332	143374	124298	116890	88670	89179	73908	51649	55541	51292	51644	45788	15650	29624
2011	479385	433187	131941	112931	114510	79290	82324	73639	51992	49703	50658	51469	45838	15019	28517
2012	416390	449859	109666	88418	108899	68133	71301	66062	39534	43242	46136	50538	43721	13593	25334
2013	347831	425699	94000	73611	98012	65081	63143	67219	34744	42957	39144	43560	34144	14649	24980
2014	280454	400848	80962	57884	81695	55469	44454	51700	29402	34788	33619	39401	26907	14114	21876
2015	180994	290782	55503	36975	54472	36586	29867	35717	19980	25330	22706	29691	14141	10663	16475
2016	69341	119887	20893	15486	20562	15047	11945	15207	7961	9897	8906	12015	5460	4460	9194
Total	**59,08,925**	**43,82,100**	**16,78,324**	**16,72,247**	**12,16,964**	**11,35,702**	**11,31,005**	**8,47,613**	**6,23,739**	**5,99,179**	**5,88,010**	**5,56,132**	**5,21,592**	**2,45,799**	**2,35,381**
AVG	393928	292140	111888	111483	81131	75713	75400	56508	41583	39945	39201	37075	34773	16387	15692

*AVG=Average citations per year

The quality of the publications depends upon the number of citations received by the paper, country or an author. The table 4 provides the number of citations received by the top fifteen countries in Materials Science. The USA topped the list with 59,08,925 citations, followed by China with 43,82,100 citations, Germany with 16,78,324 citations, Japan with 16,72,247 citations and South Korea with 12,16,964 citations ranked second to fifth respectively. India ranked eighth with 8,47,613 citations to its credit. The Average citations per year is the highest for the USA with 3,93,928 citations and the lowest for Iran with 15,692 citations.

Table 5: RGR, AGR, & DT. of top fifteen countries in Materials Science Research

Country	ACP	RGR	DT	AGR	Percentage Share of the total Scientific Publications	Materials Science Publications rank out of the total Science Publications
China	15.23	0.27	2.85	14.79	12.485	4
USA	27.18	0.21	3.96	5.63	3.391	13
Japan	16.28	0.18	5.54	-0.36	7.421	4
Germany	19.96	0.20	4.25	3.84	5.329	6
South Korea	15.20	0.23	3.50	9.19	12.304	4
India	12.99	0.24	3.24	10.24	9.702	4
France	18.20	0.19	4.41	2.91	5.691	4
England	21.70	0.19	4.36	3.90	3.586	11
Italy	17.25	0.21	3.95	5.95	3.649	10
Taiwan	15.09	0.23	3.91	6.82	9.935	4
Spain	17.52	0.21	3.82	5.85	4.513	**6**
Canada	19.62	0.22	3.89	6.57	3.432	10
Russia	8.00	0.18	4.67	3.53	6.778	3
Australia	20.95	0.23	3.25	9.87	3.926	9
Iran	10.82	0.35	2.11	27.00	8.453	4

*ACP=Average Citation per Paper, RGR=Relative Growth Rate, AGR=Annual Growth Rate,
DT=Doubling Time,

The table 5 reveals the RGR, AGR, DT. and ACP of the top fifteen countries in Materials Science. The Average Citation per Paper is highest for USA (27.18 ACP), England (21.70 ACP), Australia (20.95 ACP), Germany (19.96 ACP) and Canada (19.62 ACP) respectively. The RGR is the lowest for Japan and Russia (0.18) and the highest for Iran (0.35). The Doubling time of Japan is highest (5.51) and lowest for Iran

(2.11). However, the Annual Growth rate (AGR) is the highest for Iran, i.e. 27.00 and the lowest for Japan (-0.36). It is also observed from the table that the percentage share of the total scientific publications is the highest for China (12.485%), followed by South Korea (12.304%) and the lowest for USA (3.391 %).

The data also reveals that China topped the table with the 12.485 % share of Materials Science publications out of the total scientific publications of the country and the priority area of research, followed by South Korea with 12.304 % and the fourth priority subject of research out of the other scientific research areas. India with the share of 9.702 % and the fourth priority areas of research in India. Though the USA and England have the highest scores of ACP but the least in share of percentage (USA 3.391%, England 3.586%) out of their total scientific publications.

The Activity Index (AI) is being used to compare a country's publication output with the world research output, the AI suggested by Frame (1977) and elaborated by Schubert and Braun (1986). This indicator can be used to characterize the relative research effort of a country to a particular subject discipline (Hu and Rousseau, 2009; Chen and Guan, 2011). AI is a relative performance indicator, which takes into account the effect of the publication performance of a country in a particular subject to the world performance. If AI=1, which indicates that the country's research efforts in a field corresponds precisely to the world's average. If AI>1, it means the county employs more strength than the world average. The table 6 depicts the Activity Index of top fifteen countries in Materials Science. Among the top fifteen countries, nine countries' AI is more than 1 which indicates that nine countries' (Japan – 1.093, Russia – 1.043, France – 1.035, England – 1.031, USA – 1.008, Germany – 1.006, Italy – 1.004, Taiwan – 1.003, Canada – 1.003) research efforts correspond to the world's average. The AI of Spain, South Korea, India and China (0.996, 0.973, 0.957, 0.951) are between 0.951 and 0.996. The AI is high in the initial years from 2002 to 2016 for Japan, Russia, France, England, USA, Germany and Italy. For other countries the Activity Index (AI) is fluctuating year by year.

The PEI indicator is another derivative of the above mentioned Activity Index (Price, 1981), and was used by Garg and Padhi (2001) and Guan and Ma (2004) in their studies as a measure of research quality. The PEI is an indicator that defines if the impact of research output by the top performing countries in scientific publications and

citations. IF PEI>1, it indicates that the impact of publications in a given field by a particular country is more than the research effort devoted to it during the period considered. It is evident from the table 7 that USA (1.48), England (1.19), Australia (1.14), Germany (1.09) and France (1.07) have more than 1 PEI which clearly indicates that there is an impact of publications in Materials Science by these countries is more than the research effort devoted during 2002 to 2016. The PEI of France (0.99), Spain (0.96) and Italy (0.94) are nearer to one which also corresponds to the world's average. The PEI is least for Russia (0.44) and Iran (0.59). The PEI is always above 1 for all the years for USA, England and Australia (except 2003 year).

Table 6: Activity Index (AI) of top fifteen countries in Materials Science

Year	Japan	Russia	France	England	USA	Germany	Italy	Taiwan	Canada	Spain	South Korea	India	China	Australia	Iran
2002	1.71	1.54	1.34	1.33	1.03	1.28	1.09	0.77	0.9	1.08	0.75	0.69	0.46	0.76	0.13
2003	1.67	1.42	1.19	1.27	1.04	1.15	1.07	0.87	0.93	0.93	0.78	0.72	0.54	0.73	0.2
2004	1.54	1.39	1.17	1.2	1.03	1.17	1.15	0.91	0.96	0.99	0.91	0.68	0.55	0.76	0.22
2005	1.39	1.16	1.1	1.1	1.02	1.1	0.94	0.91	1.07	0.91	0.95	0.75	0.69	0.76	0.25
2006	1.35	1.12	1.08	1.07	1.01	1.01	0.88	1.22	1.1	0.96	1	0.79	0.71	0.8	0.37
2007	1.25	1.03	1.07	1.05	1.05	1.07	0.99	1.04	1.06	1	0.82	0.91	0.78	0.79	0.47
2008	1.08	0.96	1.12	1	1	0.97	0.98	1.1	1.04	0.96	0.89	0.96	0.86	0.86	0.63
2009	1.04	0.91	1.04	1.01	1.01	0.98	0.95	1.17	1.07	0.98	0.95	1.05	0.92	0.9	0.97
2010	0.92	0.81	1	0.98	1.06	1	1.02	1.17	1.07	1.01	1.01	1.07	0.93	1.02	1.15
2011	0.89	0.84	0.99	0.93	1.03	1.04	1.03	1.19	1.02	1.02	1.1	1.05	1	1.01	1.22
2012	0.79	0.82	0.95	0.91	1.01	0.96	0.96	1.06	1	1.07	1.1	1.05	1.08	1.09	1.33
2013	0.77	0.8	0.94	0.89	0.96	0.93	1.03	1.09	0.96	1.01	1.1	1.15	1.16	1.13	1.41
2014	0.71	0.85	0.85	0.86	0.96	0.92	0.99	0.97	0.97	1.03	1.09	1.14	1.29	1.19	1.43
2015	0.64	1.01	0.85	0.92	0.96	0.91	0.97	0.82	0.96	0.99	1.06	1.15	1.39	1.22	1.48
2016	0.65	0.99	0.83	0.95	0.95	0.9	1.01	0.76	0.94	1	1.08	1.19	1.43	1.25	1.67
AI	**1.093**	**1.043**	**1.035**	**1.031**	**1.008**	**1.026**	**1.004**	**1.003**	**1.003**	**0.996**	**0.973**	**0.957**	**0.951**	**0.919**	**0.862**

*AI=Activity Index

Table 7: Publication Efficiency Index (PEI) of top fifteen Countries in Materials Science

Year	USA	England	Australia	Germany	Canada	France	Spain	Italy	Japan	China	South Korea	Taiwan	India	Iran	Russia
2002	1.50	1.05	1.06	0.98	1.22	0.95	0.89	0.83	0.83	0.80	0.86	0.94	0.83	0.65	0.38
2003	1.57	1.03	0.96	1.06	0.99	0.99	1.03	0.89	0.72	0.77	0.85	0.82	0.83	1.01	0.41
2004	1.56	1.07	1.18	1.01	1.20	0.94	0.84	0.79	0.76	0.78	0.79	0.92	0.85	0.74	0.43
2005	1.44	1.11	1.10	1.12	1.13	1.04	1.01	1.05	0.83	0.77	0.75	0.91	0.82	0.82	0.36
2006	1.49	1.21	1.18	1.09	1.19	1.03	0.96	0.95	0.77	0.82	0.73	0.70	0.79	0.71	0.42
2007	1.44	1.40	1.18	1.06	1.09	0.93	1.02	0.84	0.73	0.84	0.84	0.75	0.75	0.80	0.46
2008	1.50	1.15	1.43	1.03	1.00	0.94	0.91	0.87	0.75	0.88	0.82	0.72	0.75	0.77	0.39
2009	1.42	1.14	1.32	1.12	1.02	0.95	0.90	0.96	0.80	0.90	0.83	0.80	0.75	0.73	0.39
2010	1.46	1.06	1.17	1.05	0.93	0.88	0.92	0.96	0.81	0.94	0.88	0.69	0.65	0.73	0.38
2011	1.41	1.07	1.26	0.99	1.05	0.87	0.97	0.91	0.81	0.99	0.85	0.73	0.71	0.70	0.38
2012	1.36	1.02	1.25	0.98	0.90	0.87	0.92	0.93	0.78	1.03	0.89	0.85	0.69	0.63	0.39
2013	1.35	1.13	1.18	0.97	0.92	0.88	0.93	0.97	0.76	1.03	0.90	0.73	0.73	0.66	0.48
2014	1.30	1.19	1.21	1.01	0.93	0.81	0.94	0.98	0.77	1.05	0.90	0.77	0.67	0.68	0.52
2015	1.24	1.09	1.31	1.04	0.94	0.81	0.98	1.08	0.81	1.04	0.92	0.71	0.68	0.73	0.49
2016	1.21	1.09	1.31	1.00	0.96	0.84	0.96	1.02	0.84	1.05	0.86	0.75	0.71	0.92	0.53
PEI (Value)	**1.48**	**1.19**	**1.14**	**1.09**	**1.07**	**0.99**	**0.96**	**0.94**	**0.89**	**0.832**	**0.830**	**0.82**	**0.71**	**0.59**	**0.44**

*PEI=Publication Efficiency Index

Table 8: Relative Comparative Advantage for Publication (RCAP) of top fifteen Countries in Materials Science

Year	China	South Korea	Taiwan	India	Iran	Japan	Russia	France	Germany	Spain	Australia	Italy	England	Canada	USA
2002	2.64	2.56	1.80	1.80	1.00	1.70	1.45	1.25	1.12	1.05	0.67	0.77	0.79	0.58	0.56
2003	2.64	2.40	1.91	1.78	1.17	1.67	1.45	1.14	1.04	0.90	0.63	0.73	0.76	0.59	0.56
2004	2.38	2.54	1.91	1.68	1.09	1.64	1.51	1.15	1.06	0.94	0.65	0.77	0.74	0.60	0.55
2005	2.65	2.56	1.81	1.76	0.95	1.58	1.33	1.10	1.02	0.85	0.64	0.64	0.69	0.65	0.57
2006	2.34	2.54	2.22	1.72	1.16	1.54	1.37	1.08	0.94	0.85	0.65	0.59	0.67	0.65	0.57
2007	2.47	2.12	1.88	1.79	1.05	1.55	1.26	1.08	0.98	0.84	0.64	0.64	0.66	0.64	0.61
2008	2.44	2.07	1.83	1.67	1.19	1.38	1.13	1.10	0.91	0.79	0.67	0.63	0.66	0.62	0.60
2009	2.39	2.09	1.89	1.86	1.53	1.36	1.11	1.03	0.91	0.77	0.68	0.61	0.67	0.64	0.61
2010	2.22	2.11	1.86	1.80	1.58	1.25	1.03	1.01	0.94	0.78	0.75	0.65	0.64	0.65	0.66
2011	2.17	2.23	1.85	1.70	1.37	1.26	1.07	1.00	0.99	0.76	0.70	0.67	0.61	0.62	0.64
2012	2.15	2.10	1.69	1.69	1.46	1.15	1.12	0.98	0.92	0.79	0.72	0.63	0.60	0.60	0.63
2013	2.04	2.17	1.81	1.75	1.57	1.16	1.07	0.98	0.92	0.75	0.71	0.67	0.58	0.59	0.61
2014	2.02	2.06	1.66	1.64	1.53	1.10	1.13	0.91	0.92	0.78	0.71	0.63	0.57	0.59	0.61
2015	1.98	1.97	1.50	1.62	1.53	1.05	1.22	0.91	0.91	0.74	0.70	0.61	0.58	0.59	0.63
2016	1.91	2.03	1.44	1.61	1.57	1.08	1.19	0.89	0.90	0.76	0.70	0.64	0.61	0.59	0.64
RCAP Value	**2.23**	**2.19**	**1.77**	**1.73**	**1.51**	**1.32**	**1.21**	**1.01**	**0.95**	**0.80**	**0.70**	**0.65**	**0.64**	**0.61**	**0.60**

*RCAP= Relative Comparative Advantage for Publication

The table 8 compares the Relative Comparative Advantage for Publication (RCAP) growth of Materials Science among the top fifteen highly productive countries of the World. The analysis shows that China tops the list with highest mean value of RCAP i.e. 2.23 but the values showed the declining trend from 2002 to 2016 except 2005 (2.65). South Korea stands second in RCAP value with 2.19, followed by, Taiwan with 1.77 average values. India stands in fourth position (1.73) and USA (0.60) ranked last among the top fifteen countries. RCAP value of China, South Korea, Taiwan, India, Iran, Japan, Russia and France are more than 1(RCAP>1). The data indicate that these countries are specialized in the field of Materials Science. China, South Korea, Taiwan and India have a gradual increase in the relative impact. These Asian countries have shown improvement in both the publications and citations in Materials Science during the study period (2002 – 2016).

Findings and Conclusion

The present study highlights the key issues of Materials Science research development as reflected in Web of Science database for the period from 2002 to 2016. It is observed from the study that the percentage share of materials Science publications of the world is 5.61 out of the total scientific publications of the world. The contribution in materials science publications from the developing countries is enormous. China topped the table with 2,87,736 publications, followed by the USA with 2,17,422 publications. The Relative Growth Rate (RGR) of publications decreased from 0.72 in 2003 to 0.11 in 2016. The mean RGR for fifteen years' period is 0.21. The corresponding doubling time for different years gradually increased from 0.96 (2003) to 6.56 (2016). The Average Citations per Paper is highest for USA (27.18), followed by England (21.70).

The Activity Index (AI) of nine countries, i.e. Japan (1.093), Russia (1.043), France (1.035), England (1.031), USA (1.008), Germany (1.006), Italy (1.004), Taiwan (1.003) and Canada (1.003) is more than one. The Publication Efficiency Index (PEI) is more than one for USA (1.48), England (1.19), Australia (1.14), Germany (1.09) and France (1.07). The study also indicates that China topped the list with the highest mean value of Relative Comparative Advantage for Publication (RCAP), i.e. 2.23, followed by South Korea (2.19).

Scientometrics is one of the techniques which are a set of mathematical and statistical methods used to analyze and measure the quantity and quality of books, articles and other forms of publications. Predominantly, the Scientometric indicators help organizations / governments to make decisions, framing the policy, appointments, promotions and funding. However, these indicators also used as measuring techniques for the research and detect the misallocation / misappropriation. Such studies will enable the authorities of the organization / institutions to provide adequate facilities to assess the research activities in a systematic manner.

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