Thin Film Research output in BRICS Countries: A Scientometric Dimension

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Abstract - *The present scientometric study highlighted the contributions made by BRICS countries in the field of Thin Film research, as reflected in the Web of Science (WoS) database during the year 2001-2019. BRICS countries have contributed 65,741 publications, accounting for approximately one-third of the world's publications indexed in the Web of Science (WoS) database. China made the highest contribution of 62.93% (41,369) among the BRICS countries. China not only catches up with the USA but overtakes by contributing 2.11 % more publications. India is leading among all the BRICS countries with Compound Annual Growth Rate 9.88. Results indicate that BRICS has already made a significant contribution in the field of thin films, this is evidence that BRICS countries emerging as the global leader in R&D output as rightly predicted by Kumar & Asheulova (2011).*

Keywords: Thin Film, Citation Analysis, BRICS Countries, Relative Quality Index, Transformative Activity Index.

Introduction

Among the emerging countries, the BRICS countries (Brazil, Russia, India, China, and South Africa) are making a significant contribution to the world economy. These five countries are among the most important emerging nationwide economies, notably by their fast development. The aim of the BRICS relationship is a collaboration to progress the economies of the member countries.The BRIC association formed since the late 2000s and since the year 2009 its pioneers meet frequently at official summits, held in one of the countries. South Africa country joined the Association in the year 2010.

Scientometrics is a complex of quantitative methods that are used to research and investigate science progression.The term Scientometrics was introduced and came into prominence with the founding of the periodical call as a "Scientometrics". Scientometrics is the study of research progress in scientific andtechnical progress, the quantitative research study of science guidelines investigate, which focuses on a large multiplicity of quantitative measurements. This study reveals the nature of research publications in the field of Thin Film.Thin film has been intensively existing as one of the promising areas of sources of green energy due to the possibility of low cost and high efficiency. Thin film cells have been

implemented in various materials, such as amorphous CdTe, silicon, Ga Se2, Cu and organic and other compounds. Thin films meant to be layered, their thickness is ranging from micrometer to nanometer. There are several different notations of thin films in science and engineering. For example, the meaning of thin film possibly will be denoted as a laminated viscous layer of fluid (Ryan & Xiaosong, 2015).Thin film devices take part in an essential position in the growth of current science when used to produce separate resistors. The thin film provides better performance and reliability compared to the type of combination, and offer low-cost comparable performance compared to specific wire resistors. However, it is in the area of integrated circuits that incorporate thin-film resistors.

This study explains both theoretical and empirical discussions relating to research publications in the field of Thin Film published by the BRICS countries. Scientometric techniques are used to analyze quantitatively the Thin Film research to draw inferences in the growth of the subject.

Review of Literature

Venkatesan & Thanuskodi,(2014) in this paper, the authors attempted to quantitatively analyze the growth and development of energy in the global output as reflected in the *WebofScience* (WOS) database from 1980- 2013. Total records got 2016 papers and Nuclear Science Technology got topped 836 documents with 41 percent, and number of journal articles documented as 1851 with 92 percent. Institutions from 24 various countries, first Ranked with (31) 2 percent papers got from Korea Atom Energy Research Institute. Period of fifteen years the USA is less in nuclear research publication and USA 1st Ranked with 25 Percent followed by Germany with 11 Percent, and India ranking 12 with 3 Percent. In general, the results of this study have been revealed Nuclear Energy Generation research literature has gradually increased.

Singh & Hasan, (2015) this article evaluated the trend of the research results of the countries of the Development Group as BRICS from 1994 to 2013 and analyzed 25,52,490 publications from BRICS countries.As many as 12.43 percents ofpapers have been indexed in the year 2013 as compared to 1.51 percentinthe year 1994. Chinese publications were in maximum collaboration9.38 percent, followed by Germany with 3.24 percent, England with2.39 percent, Japan with 2.19 percentand France with 2.02 percent. ActaCrystallographica Section E Structure Reports Onlinewith 19,334 (0.76 percent) is the highest-ranked journal, followed by Physical Review B with 17623 (0.69 percent) and PLOS Onewith 16,930 (0.66 percent). Over twenty years in the study, the tendency of research trends in China has been drastically increased.

Savanur. K. P. (2018) in this paper, the author had analyzed the research output of economicspublications by BRICS countries during the twenty-six years from 1991 to 2016. It was found that BRICS share has been consecutively increasing in the total output in the world contribution. The increment has occurred from 2.54 percentile in 1991 to 18.81 percentile in the year 2016 decrease to 4.02 percentile and 4.8 percentile in the year 2002 and 2003 respectively (cited from p.16). This paper shows the total Citations received to the BRICS articles contributed to 8% of the total citations of the Global publications.

Verma & Margam, (2019) in this paper, the authors attempted to do the correlation study of an altimetricscore and citations received by the highly cited publications on Digital library compared inBrazil and India from 1989 to 2017.The findings of this study reveal that highly

cited publications of India on DL received more online altmetric attention as compared to Brazil.

Kumar & Asheulova (2011) in this study, the authors analyzed the growth of publications in BRIC countries compared with the United States in terms of world publications output during 1980-2009. The major result of the study indicates that China may be ab emerging leader in scientific publication followed by India among the BIRC countries (cited from p.228).

Objectives of the study

1. To analyze the growth rate of Thin Film publications published by BRICS countries.
2. To find out collaboration co-efficient pattern followed by BRICS countries to publish research papers on Thin Film
3. To know Co-authorship index
4. To understand TAI followed by authors to Publish Thin Film research
5. To scrutinize the country-wise distribution of Thin Film literature published by BRICS countries.
6. To understand the citation pattern of Thin Film literature

Scope and limitations of the study

The present scientometric study aimed to examine quantitatively the growth of literature in the field of Thin film contributions made by the BRICS countries (Brazil, Russia, India, China, and South Africa), as reflected in the *Web of Science* (WoS) database published during the years 2001-2019.

Thin Film is a multidisciplinary subject area which includes Physics, Chemistry, Engineering, Science and Technology, Materials Science, Synthesis, Deposition. In the present study, we have restricted the thin film subject with limited topics such as Copper thin film, Indium thin film, Solar thin film, Semiconducting thin film, Crystal thin film, Photoconductivity thin film, Silicon thin film, GaAs, NaCl, Diamond, Perovskite, YBa2Cu3O7.

Methodology

The present study focused on Thin film research output published by BRICS countries from 2001 to 2019 till August. Data for the study collected from the Web of Science database presently publishing from Clarivatepublishers. The query was designed in keeping view of the various topics in the thin-film research and the BRICScountries. Bibliographic data was downloaded. The various bibliographic fields like author, source title, year, citations, type of documents, etc. were exported to and analyzed using MS Excel software. Further, the datasets were analyzed using the scientometric indicators like Compound Annual Growth Rate, collaboration index, co-authorship index, transformative activity index, relative citation impact to conclude.

Analysis and Discussion

Year-Wise Growth Rate of Research Publications

The research output and growth rate of the BRICS countries in thin film research field from 2001 to 2019 is shown in Table 1.

Table-1: Year-wise growth rate of research publications

Year	Country					USA	BRICS Output	World Output
	Brazil	China	India	Russia	South Africa			
2001	96	526	185	229	19	1314	1055	6233
2002	88	582	272	162	14	1347	1118	6481
2003	100	751	308	189	21	1461	1369	7100
2004	134	987	342	198	21	1593	1682	7984
2005	104	1267	378	180	17	1814	1946	8571
2006	126	1486	497	199	15	1843	2323	9599
2007	131	1681	581	189	16	1819	2598	9903
2008	138	1929	678	249	13	1867	3007	10506
2009	145	2052	747	223	41	1988	3208	11157
2010	117	2062	776	232	36	2052	3223	11246
2011	129	2431	850	202	33	2180	3645	12205
2012	141	2504	909	237	44	2206	3835	12506
2013	163	2833	1091	250	37	2267	4374	13587
2014	195	3202	1366	287	70	2388	5120	14409
2015	160	3597	1442	368	63	2484	5630	15780
2016	**198**	**3739**	1568	**432**	110	2507	6047	16021
2017	171	3674	1444	361	93	2450	5743	14422
2018	194	3671	**1580**	393	**116**	2116	5954	14087
2019	120	2395	1009	240	100	1284	3864	8893
Total Publications	**2650**	**41369**	**16023**	**4820**	**879**	**36980**	**65741**	**210690**
Percentage of Publications	4.03	62.93	24.37	7.33	1.34	56.25		
CAGR	1.25	8.79	9.88	0.26	9.67	-0.13		

CAGR: Compound Annual Growth Rate

In the tenure of 2001-2019 all around the world, 210690 publications have been published on Thin Film research, in which BRICS countries have contributed 65,741 publications, accounting for approximately 31 percent of the world's publications indexed in WoS database.

China made the highest contribution of 62.93% (41,369) leaving other BRICS countries far behind and progressing at a faster rate in the research and development activities.

Kumar &Asheulova (2011) argued that …China has a sharp rise that dwarfs other BRIC nations and may catch up with the United States in the near future... China produced ~ 13 percent papers of the total world publications in all fields of science, second to the United States, which has ~ 24 percent share of the global publication share (p.231). In our study, it is evident to note that China not only catches up with the USA but overtake by contributing 19.66 percent of the world's thin film research as compared to the USA 17.55 percent of the world's contribution. India has published 24.37% (16,023) research publications. (Bouabid, Paul-Hus &Lariviere, 2016) got similar results, China's scientific output exceeded that of the USA in Engineering and Technology in the 2010-2012. There was a steady growth of Indian publications during the period of study. South Africa has the lowest numberof publications among BRICS countries with 879 publications making 1.34% percent of the total. The year 2016 is been considered as the peak year for China where it has contributed the maximum

number of research publications i.e. 3739 (5.68 %), similarly, India's peak year is 2018 where it has contributed with 1580 (2.4 %) publications. CAGR shows that India is leading among all the BRICS countries with Compound Annual Growth Rate 9.88, followed by China with 8.79, where Russia stands in the bottom with 0.26. An interesting point is other than BRICS countries USA is also contributing to the field of Thin Film which is also remarkable as compared to other leading BRICS countries such as China, India.It's interesting to note that the USA contributed 17.55 percent to the world's output in the field of thin films and the Compound Annual Growth Rate is -0.13.

The growth rate is measured using the formula of CAGR or Compound Annual growth rate ["http://en.wikipedia.org/wiki/Compound_annual_growth_rate"] (09.09.2013). It gives the average rate of increase per year. The value is appropriate for comparing the growth rates between different countries.

$$CAGR = \left\{ \left[\frac{Ending\ \ Value}{Beginning\ \ Value} \right]^{\frac{1}{n-1}} - 1 \right\}$$

Where n is the number of years. In our case n=16.

India has maximum growth rate of 9.88 followed by China with 9.67. Russia has the lowest growth rate with 0.26 and Brazil with only 1.25.

The total publications share of BRICS countries in the field of thin film has shown steady growth as indicated in table-1. The increment occurred from 0.5% in 2001 to 31.2 % in the year 2019 (till August). Therefore BRICS as an emerging economy in the world had shared almost one-third of the total publications in the field of thin film as indexed in the WoS database.

Figure-1: Year-wisee growth of Thin Film publications of BRICS

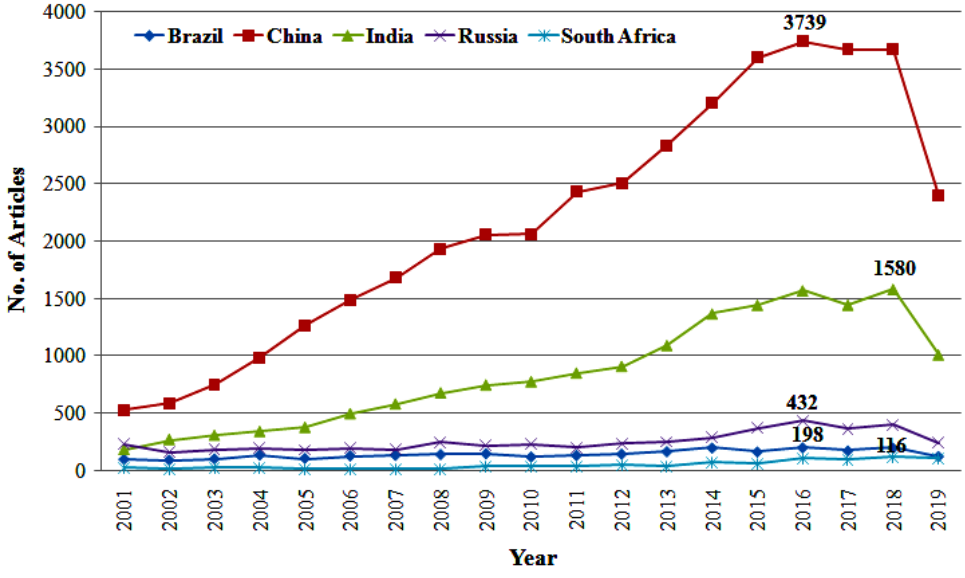


Table-2: Evaluationof research publications & Citations between BRICSand the world

Year	BRICS Output	World Output	Percentage share of BRICS	Year	Citation Received by BRICS	Citations of the World	Percentage Share of BRICS
2001	1055	6233	16.93	2001	21702	197704	10.98
2002	1118	6481	17.25	2002	27526	224052	12.29
2003	1369	7100	19.28	2003	37369	265285	14.09
2004	1682	7984	21.07	2004	42706	286608	14.90
2005	1946	8571	22.70	2005	47979	282547	16.98
2006	2323	9599	24.20	2006	57638	282547	20.40
2007	2598	9903	26.23	2007	64371	311158	20.69
2008	3007	10506	28.62	2008	72523	297640	24.37
2009	3208	11157	28.75	2009	70853	346048	20.47
2010	3223	11246	28.66	2010	75201	317205	23.71
2011	3645	12205	29.86	2011	79337	323492	24.53
2012	3835	12506	30.67	2012	74401	294216	25.29
2013	4374	13587	32.19	2013	73176	272281	26.88
2014	5120	14409	35.53	2014	83223	261628	31.81
2015	5630	15780	35.68	2015	73107	220380	33.17
2016	6047	16021	37.74	2016	59121	162990	36.27
2017	5743	14422	39.82	2017	50002	125702	39.78
2018	5954	14087	42.27	2018	23492	55452	42.36
2019	3864	8893	43.45	2019	2432	5038	48.27
Total	**65741**	**210690**	**31.20**	**Total**	**1036159**	**4531973**	**22.86**

Table No. 2 reveals the contrast between the World and the BRICS country's research output and respective citations received in the field of Thin Film during 2001-2019. During this said tenure BRICS Countries have published 65741 (31.2 %) research papers, whereas 210690 research publications in the field of Thin Film published throughout the world, in which highest number of papers published in the year 2016 with 16021, whereas in the case of BRICS countries same year is considered as the peak year of the publications i.e. 2016 with 6047 (2.87 %) research papers. Out of 4531973 total citations to the world's total research output in thin film research, BRICS countries' research publications have been cited 1036159 (22.86 %) times. Citations always indicate the quality and/or impact of the research, in this study, it is revealed that BRICS countries played a major role in the field of thin film research not only in terms of utmost publications i.e. one-third of world share but also in a total number of citation received, i.e. 22.86 %.

Measure of Collaboration

Collaboration is an intense form of communication that allows for effective communication as well as the sharing of competence and other resources (Meiln and Persson, 1996).***Collaborative Coefficient*** (CC) that integrates some of the merits from both of the 'Collaborative Index' and 'Degree of Collaboration'(Ajiferuke&Burell, 1988). The Collaboration Coefficient (CC) counted by the method which is suggested by theAjiferukeet al. in their paper published in the year 1988 as mention below:

$$\text{Collaborative Coefficient} = 1 - \frac{\sum_{j=1}^{A} \frac{f_j}{j}}{N}$$

Where,

j = the number authors in an article i.e. 1, 2, 3 ……

f_j = the number of j authored articles

N = the total number of articles published in a year, and

A = the total number of authors per articles

Modified Collaborative Coefficient

The assessment to give a better understanding of modifiedCollaboration coefficient during the period of study, the modified collaboration coefficient (MCC) counted by the formula which is suggested by(Savanur and Srikanth, 2010) as given below:

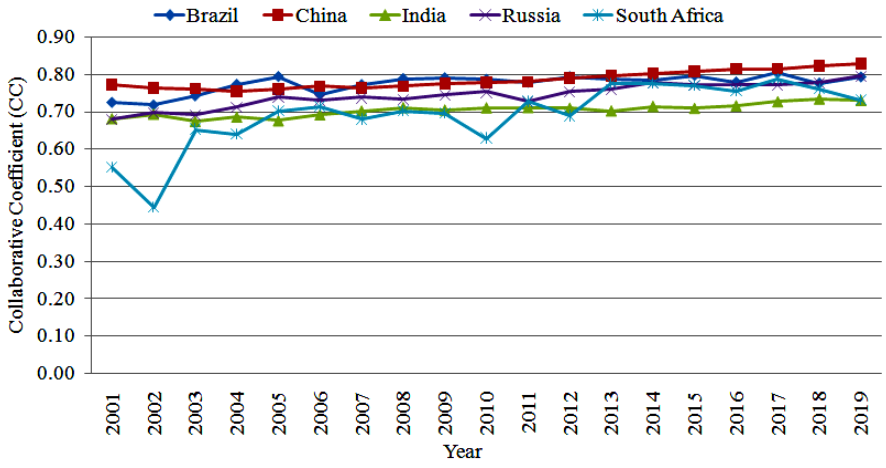
$$\text{Modified Collaborative Coefficient} = \frac{A}{A-1}\left\{1 - \frac{\sum_{j=1}^{A}\frac{f_j}{j}}{N}\right\}$$

Table-3 provides the Pattern of authorship and collaboration of the BRICS countries and the year-wise collaboration rate is depicted in figure-2. The average collaboration coefficient 3.66 has beencounted during the year 2001-2019, It can be experimental China and Brazil have maximum collaboration rate of 0.78, followed by Russia 0.74, and India only get 0.70, South Africa has the lowest collaborative rate 0.69, the great deal of (83.40%) papers ofChina in the field of Thin Film weremore than three-authoredand followed by Russia 73.68%, Chinese single-authored paperswere the lowest 0.71 followed by Brazil 0.79. Brazil and China have been recorded a higher collaboration rate of 0.68, followed by India with 0.61 and Russia with 0.59for all BRICScountries seem to be better collaboration among the authors. (Elango & Rajendran, 2013).

Table-3: Collaboration rate of the Thin Film BRICS countries

Country	1 Authored	2 Authored	3 Authored	>3 Aut	Total	CC	MCC
Brazil	21	186	308	2135	2650	0.78	0.78
China	268	1890	4007	35204	41369	0.78	0.79
India	232	2797	3487	9507	16023	0.70	0.71
Russia	189	424	582	3625	4820	0.74	0.75
South Africa	33	102	146	598	879	0.69	0.72

Figure-2: Collaborative Coefficient (CC) Thin Film of BRICS Countries



Co-Authorship Pattern of the BRICS Countries

Co-Authorship Index is obtained by calculates proportionately the publications by single, double, multi and more multi-authored articles. Co-Authorship Index is calculatedwith the following formula suggested by (Garg&Padhi, 2001).

$$CAI = \left(\frac{N_{ij}}{N_{oj}}\right) \div \left(\frac{N_{io}}{N_{oo}}\right) X100$$

Here…,

N_{ij} = Number papers having j authors in block i;.

N_{io} = Total output of block i;.

N_{oj} = Number of papers having j authors for all blocks;.

N_{oo} = Total number of papers for all authors and all blocks; $j = 1, 2, 3, \geq 3$.

CAI<100 indicates that the number of papers is lower than the average.

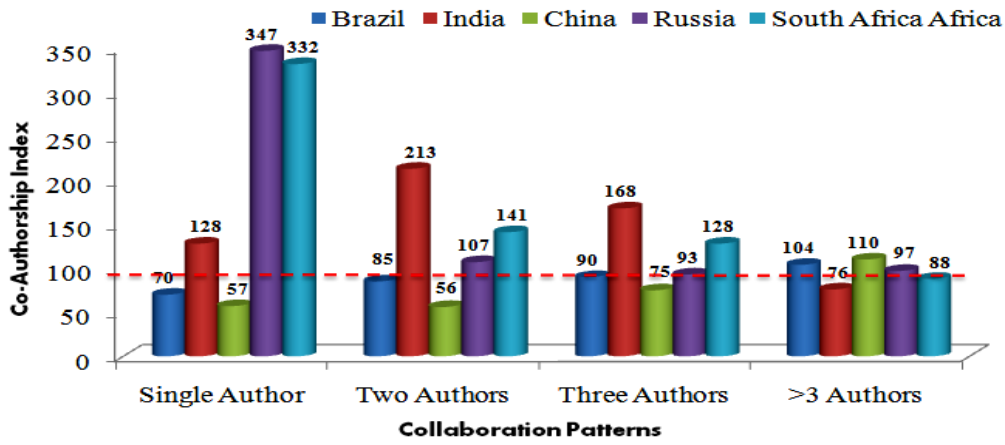
> 100 "reflects higher than the Global average and CAI <100 reflects lower than the Global average within a Co-authorship Pattern" (cited from p.6), Elango&Rajendran, 2013.

Table-4 Co-authorship pattern of the BRICS Countries

Country	Single Author	CAI	Two Authors	CAI	Three Authors	CAI	>3 Authors	CAI	No. of Records
Brazil	21	70	186	85	308	90	2135	104	**2650**
India	232	128	2797	213	3487	168	9507	76	**16023**
China	268	57	1890	56	4007	75	35204	110	**41369**
Russia	189	347	424	107	582	93	3625	97	**4820**
S. Africa	33	332	102	141	146	128	598	88	**879**
Total	**743**		**5399**		**8530**		**51069**		**65741**

Table-4 provides the co-authorship pattern of Thin Film BRICS countries and these values depicted in the following Figure - 3. It is clear from the table that, in all the BRICS countries, the CAI value for Brazil and China was more than 100 (average) in all authorship categories which shows that they preferred to work in small and big teams.The Co-Authorship Index value for India and Russia and South Africa was more than 100 (average) in Single and two-authored papers, in three-authored papersIndia and South Africa score more than 100 (average), it seems that they werehigher more preferred to work in small and large teams.

Figure -3: Collaboration patterns reflected by Thin Film Co-Authorship Index



Transformative Activity Index (TAI)

The ***Transformative Activity Index*** suggested by Guan & Ma, in the year 2004 mathematical formula of TAI given below, which is applied to the research output of BRICS countries published on Thin Film during 2001-2019.

$$TAI = \frac{C_i/C_o}{W_i/W_o} X\ 100$$

Here,

~ C_i = Number of publications for a particular country in a particular year,

~ C_o = Total output for a particular country during the study period;

~ W_i = Number of publications for all the countries in a particular year;

~ W_o = Total output for all the countries during the study period;

Table-5 shows the publication output of thin film research of the BRICS countries during the two blocks i.e.2001-2009 and 2010-2019. By using the dataset, TAI for the two blocks has been calculated.

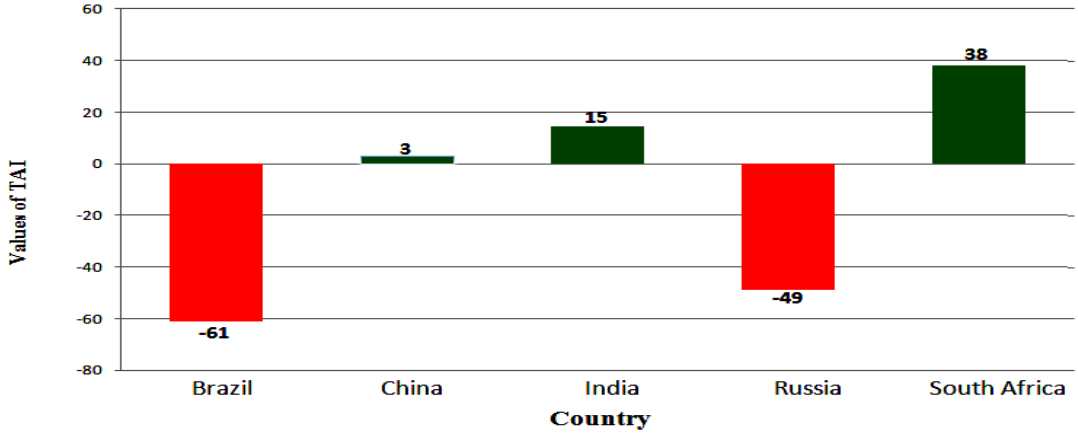
It is clear from the table-5 that the publication activities in Brazil and Russia have been decreasing considerably. The remaining countries South Africa, India and China show an increasing trend in their publication activity as shown by the values of TAI.

Table-5: Transformative Activity Index of the BRICS Countries

Country	2001-2009	TAI	2010-2019	TAI	2001-2019	Change in TAI
Brazil	1062	144	1588	83	2650	-61
China	11261	98	30108	101	41369	3
India	3988	89	12035	104	16023	15
Russia	1818	135	3002	86	4820	-49
South Africa	177	72	702	111	879	38
	18306		**47435**		**65741**	

Chaitra, Jeyshankar, & Abu (2014)found similar results in their study on Lung Cancer research in G7 and BRIC countries. Among the BRICS countries, Russia showed decreasing trend in their publication activity.

Figure – 4: Change in the values of the TAI Thin Film for BRICS countries



Citation Profile of Thin Film Research for the BRICS Countries

Table-6: Citation profile in Thin Film by BRICS countries

Citations Range	Brazil	China	India	Russia	South Africa	Total	%
0	271	5138	1910	831	151	8301	16.54
1	186	3761	1382	602	74	6005	11.97
2	198	3222	1238	483	76	5217	10.40
3	165	2616	1015	382	61	4239	8.45
4	145	2308	940	276	45	3714	7.40
5	134	2070	817	243	39	3303	6.58
6-10	531	6839	2950	814	163	11297	22.51
11-100	981	14484	5581	1140	265	22451	44.74
101-1000	39	916	188	46	5	1194	2.38
>1000	0	15	2	3	0	20	0.04
Total	2650	41369	16023	4820	879	65741	
Total Citations	38964	708618	225449	53320	9808	1036159	
Average Citation	14.70	17.13	14.07	11.06	11.16	15.76	
H-Index	73	229	124	77	41	245	

A citation shows the quality of work, thus Thin Film research articles have been received 1036159 citations from across the world, during 2001-19, where the highest number of citations been received by Chinese publications with 708618, which followed by Indian publications which have received 225449 citations. Brazil and Russia published fewer research papers as compared to other leading BRICScountries such as China, India, but the quality of the work reflected with the number of citations that they have received. Table number 6 replicates that, 20 research papers have been receiving more than 1000 citations.

Absolute Citation Impact and Relative Citation Impact

(LalithaKumari, 2009), Analyzed the results of Indian research and the impact on synthetic organic chemistry during the period 1998 to 2004, extracting data from selected journals of synthetic organic chemistry.It was noted that for the Indian publications, the Impact of the absolute citation and the impact of the relative citation are lower than the global average and that China exceeded India in these during the study period.

$$RCI = \frac{A\ country's\ share\ of\ total\ citations}{A\ country'sshare\ of\ total\ publications}$$

Relative Citation Impact (RCI) =1 indicates that the countries citation rate is equal to the average citation rate, RCI>1 indicates that the countries citation rate is highest than the average citation rate and also implies the high impact of research in that country and Relative Citation Impact (RCI) <1 indicates that the countries citation rate is lower than the average citation rate and also implies that the research efforts are highest than its impact.

Table-7: Absolute Citation Impactand Relative Citation Impact BRICS Countries

Country	Papers	BRICS share (%) Papers	Citations	BRICS share (%) Citations	ACI	RCI
Brazil	2650	4.03	38964	3.76	14.70	0.93
China	41369	62.93	708618	68.39	17.13	1.09
India	16023	24.37	225449	21.76	14.07	0.89
Russia	4820	7.33	53320	5.15	11.06	0.70
South Africa	879	1.34	9808	0.95	11.16	0.71
	65741		**1036159**			

The Absolute Citation Impact and Relative Citation Impact values of BRICS countries shown in table-7. China has the maximum ratio of average citation per paper (CPP) 17.13%, which signifies the quality of research undertaken in the country, followed by Brazil with 14.70% and India 14.07 % Absolute Citation Impact, South Africa with 11.16% and Russia ACI value 11.06%. Russia being the lowest Absolute Citation Impact value with 11.06%. Among the BRICS countries, China is the only country whose Relative Citation Impact value is more than 1.09% indicating the higher citation impact. Brazil's RCI value is almostto average citation impact i.e. 0.99%, Russia and South Africa close to RCI 0.70% citation rate.

Relative Quality Index (RQI) of BRICS Countries

A value of RQI> 1 indicates a quality higher than the average, while a value of RQI <1 indicates a quality lower than the average, The *Relative Quality Index* (RQI) suggested by (Nagpaul,P.S, 1985) is the relationship between the proportion of high-quality articles (NHQ%) and the proportion of the number of articles (TNP%). RQI is used by (Garg, K C; Padhi, P, 2002) for quality intercomparison.

$$NHQ\% = \frac{Number\ of\ High\ Quality\ papers\ for\ a\ \ Country\ or\ an\ Institution}{Total\ Number\ of\ Quality\ Papers} x\ 100$$

$$TNP\% = \frac{Total\ Publications\ output\ of\ a\ Country\ or\ \ an\ Institution}{Total\ Publications\ output\ of\ all\ Country\ or\ Institution} x\ 100$$

$$RQI = \frac{NHQ\%}{TNP\%}$$

Table-8: Country wise Relative Quality Index (RQI)

Countries	TNP	TNC	CPP	NHQ	TNP%	NHQ%	RQI
Brazil	2650	38964	14.70	291	4.03	4.91	1.22
China	41369	708618	17.13	3645	62.93	61.46	0.98
India	16023	225449	14.07	1445	24.37	24.36	1.00
Russia	4820	53320	11.06	481	7.33	8.11	1.11
South Africa	879	9808	11.16	69	1.34	1.16	0.87
	65741	**1036159**		**5931**			

TNP-Total No. of Papers, TNC-Total No. of Citation, CPP-Citations per Paper, NHQ-No. of High Quality Papers, TNP%-Total No. of Paper Percentage, NHQ%- No. of High Quality Paper Percentage, RQI-Relative Quality Index

A value of RQI> 1 indicates a quality higher than the average, while a value of RQI <1 indicates a quality lower than the average. Table-9 indicates the *relative quality index*of the BRICS countries studied during the study period of 2001 to 2019.

The Relative Quality Index of BRICS countries is tabulated in the Table-8, the BRICS countries contributed 65,741 research output (31.2 % of world's contribution) on thin films which have been cited 10,36,159 times (22.86 % of citations received by world's thin film publications) with 15.76 citations per paper.Among the BRICS countriesBrazil, Russia and India's RQI is 1.22, 1.11 and 1.0 respectively which indicate the quality higher than the average, and China is almost close to one i.e. 0.98, whereas South Africa's RQI is 0.87 which indicate below the average.

Conclusion

The present scientometric study highlighted the contributions made by BRICS countries in the field of Thin Film research, as reflected in the Web of Science (WoS) database during the year 2001-2019. This empirical data illustrate that the scientific publications of the emerging countries like a collaboration of BRICS showed a positive swing.The collaboration of BRICS countries started making a significant impact in the world of science and technology by increasing their R&D output. It is evident from this analysis that BRICS countries have contributed over one-third of the world's publication share in the field of thin films and more interestingly, China not only catches up with the USA but overtake by contributing 2.11 % more publications with 8.79 Compound Annual Growth Rate. India is following China with the highest annual growth rate of 9.88. Russia, Brazil, and South Africa are expected to increase as compared to the existing trends. From this analysis, BRICS has already made a significant contribution in the field of thin films, this is evidence that BRICS countries emerging as the global leader in R&D output as rightly predicted by Kumar &Asheulova (2011) and studies may be conducted to testand verify whether the similar trends continued in other scientific fields also.

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