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India's Research Contribution in Physical Sciences during 2000-2019: A Bibliometric Study

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Abstract

This study provides an overview of the research productivity of scientists/researchers/faculty from across India, in terms of the number of research publications contributed in the Physical Science discipline. The study attempted to analyze bibliometric indicators of published research that have been indexed in *Scopus* database. There are 1116847 documents published during the period of twenty years i.e. 2000-2019. The study revealed that there is a consistent growth in number of documents published. It has been observed that there are 543728 documents published during 2015-2019 which is higher than the total publication during 2000-2014. The subject discipline, 'Engineering' has been emerged as a major discipline in which more research publications are published. The study noted encouraging trends in collaborative research work with their foreign counterparts.

Keywords: Bibliometric Study, Physical Sciences, India, International Collaboration, Research Output, Research Productivity

1. Introduction

Research is an important exercise for enhancing the social life of human beings. Research is an iterative process that requires to be done on a frequent interval with research questions, research data and research methods that results into creation of new knowledge and improvement in existing knowledge. Well organized research is vital for the development of

the nation that leads towards the policy formation to compete with other nations at the global level. Research brings societal changes in society which results in the upliftment of the society. Conducting research is a step towards new knowledge discovery and if it is not communicated to others, it will be treated as intellectual exercise which is done to get some knowledge. One of the important aspects of the research is to communicate to the other researchers or peers who are working in the same or a relevant area avoiding duplication of work. There is some research that requires huge funding and getting funds is only possible if it is communicated to others. Many research activities are being done at various levels in the society but, due to some reason they are not communicated/popularized in the domain. Scholarly communication is one of the mediums for communicating research output. Scholarly communication includes journal articles, artifacts, books, review articles, patents, etc. The performance of the research institutions should be evaluated at regular intervals to judge its implications on the society. Research publications are one of the essential criteria for performance evaluation of the researchers and academic institutions. Research publication is a scholarly communication in a relevant field of knowledge. An attempt has been made to find out India's research contribution in the Physical Science during the period of twenty years i.e. 2000- 2019.

2. Objectives

First and foremost objective of this study is to analyze the research performance of India in physical science at national and global context, as reflected in its publication output during 2000-2019. Especially, the study focuses on the following objectives:

- To find out the research output of India in Physical Science, the growth of research publication, rank and global publications share and impact;
- the patterns of international collaboration and major collaborative partners;
- the distribution of Indian Physical science publications by subjects;
- productivity and impact of leading institutions of India in physical sciences;

- most productive authors; and
- the patterns of research communication in most productive journals.

3. Review of Literature

The literature review is a paramount prerequisite for any research work. Review of literature enables researchers to understand the consequences of past research activities carried out in respective fields. The present study endeavors to review highly relevant literature gathered from various sources. Numerous surveys have been conducted by researchers in various subjects to measure research output of institutions - quantitative and qualitative. Many bibliometric analysis has also been done for individual research institutes. An attempt has been made to review the literature published in scholarly communications related to research output on various topics, on studies conducted on institutions with special reference to physical sciences.

(Ho, 1998) has conducted a study on measuring research output of three faculties namely business, education and humanities & social sciences, in six Hong Kong universities. The data for this study on research and publications output of each of the university was collected from the annual reports for the year 1990-1995. The results revealed that the research output of academics in Hong Kong was at par with other countries in many aspect and demand for more research publications from the researchers might enhance the figure but pressing researchers for more research publications may raise the figure but would not increase qualitative output in long run.

In a study on scientometric analysis of research output in the subject computer science for the period 1994-2001, (Gupta & Dhawan, 2005) have observed that there was a wide gap between the quantitative and qualitative performance of research in computers and control science research in India. They had further observed that this gap was wide because, significant

proportion of the country's publication output was reported in non-SCI-covered journals. They discussed that it was a matter of concern as share in high impact factor journals was only marginal and this disparity once again highlighted the gap between the quantitative and qualitative research performance in computer science.

(Okafor & Dike, 2010) have analysed the research output of academics in science and engineering faculties of Federal Government-owned universities in Nigeria. The researchers in this study have tried to find out research output during 1997-2006 for which stratified random sampling technique was used to select six Federal universities in Southern Nigeria. Total of 435 questionnaires were circulated, out of which 353 were received by the researcher. The study has revealed that, 30.6% of the researchers published between 0-4 journal articles and only 2.7% of them had published 30 or more journal articles during the period of study. It has also observed that 42.1% researchers did not have even a single article in foreign journals.

According to (Gupta & Bala, 2011) India scored 12th position among the productivity of medicine during the years 1999-2008. They have observed that India has published the highest collaborative research publication with the USA. It was also noted that there was an urgent requirement to formulate a national health research plan in order to increase the research output and improve the quality of research in the field of medical sciences.

(Kumar & Dora, 2012) have carried out research productivity analysis of Management Institutes with special reference to Indian Institute of Management, Ahmedabad for the period of twelve years i.e. 1999-2010. The study attempted to make research productivity analysis of IIMA using Scopus and Web of Science as databases as source of data. The study revealed that there is a considerable increase in the number of research papers published by IIMA over the years 1999 to 2010. They also observed that there was significant increase in collaborative research and decrease in solo authorship. They have also noticed that, during the study period, there was significant decline in interdisciplinary research.

(Maharana, 2012) has conducted a study to analyse the growth, contribution and impact of research carried out by the researchers of Orissa University of Agricultural Technology, based on the publications indexed in Scopus database for the period 2008-2012. The study revealed that the average annual publications range from 33 to 34 papers, with 0.96 degree of collaboration. Study also revealed that the Indian Journal of Animal Research is the most preferred research journal among the university research community during the study period.

(Diem & Wolter, 2013) have used bibliometric parameters for measuring research performance of individual researchers in the field of education in Switzerland. They used two separate databases namely Web of Science and Google Scholar to understand the specificities of publication practices by the researchers in the field education. They have observed that both the databases showed a quite inadequate distribution of the individual research output. It has also been observed that, both the databases posed problems when used to benchmark individual research performance.

(Pandita et al., 2014) analysed the research output of selected Indian Medical Research Institutions during 2007-2011. The study revealed that there was steady increase in the research publications in medical sciences having average annual growth of 58.90% which is remarkable. AIIMS, New Delhi showed a mixed trend with slight increase and decrease in the publications over the years. It was also observed that during the study period difference in the growth rate among four medical institutions when analyzed individually.

(Pandita & Singh, 2017) conducted research to find out the trend of doctoral research activities in social sciences by the higher education institutions in India for the period of 2010-2014. The study has been conducted by gathering secondary data from the bibliography of doctoral dissertations, published on an annual basis by the Association of Indian Universities for the period of research. The study revealed that 5788 doctoral degrees were awarded across 171 institutes of higher education institutes in India in as many as in 17 different social science disciplines, with an average of 340.47 doctoral degrees in each subject field. It was also observed that education, commerce, and economics are the three main subject disciplines in

which maximum doctoral degrees have been awarded, while in Tourism subject less degrees have been awarded.

This review of literature has presented various aspects of research productivity/output analysis for different institutions and subjects. The literature survey reveals that research productivity analysis is not a new phenomenon and has been done by many researchers for individual institutions. It has also been conducted for the various subjects. It is also observed that the coverage and scope of different bibliometric study varies from three to five years, ten and forty years. Review of literature also depicts that considerable studies have been published on research output analysis of various Indian institutions. However, there is no similar study carried out to analyse Indian research contribution in physical sciences.

4. Methodology and Source of Data

The study is based on the research publications data in Indian context for twenty years (2000-2019). In order to understand the actual research productivity of India in Physical sciences, an exhaustive and in-depth research productivity analysis needs to be carried out which will ultimately provide valuable input to funding agencies for making policy-oriented decisions. The present study intends to analyze research productivity of all such subject disciplines which are interdisciplinary in nature. The present bibliometric study is based on the research publication data as indexed in the *Scopus* database for the 20 years i.e. 2000-2019.

5. Scope and Limitation

Generally, research trends in most of the subject disciplines will change in every five years. In the subject area of science and technology, the research trends may change slightly early compared to other subject disciplines. It has been noted that technology has impacted the entire knowledge world over the years. In view of this, researchers have considered a period of twenty years i.e. 2000-2019 for studying the research trends in physical science in India. The

research data has been derived from one of the commercial indexing and abstracting databases, popularly known as *Scopus*.

Bibliometric data for the present study have been downloaded from (Scopus, 2020) database on August 05, 2020 for a period of twenty years, between 2000 and 2019. The *Scopus* provides comprehensive bibliometric statistics for research contributions of various countries and institutions in different types of documents. An analysis of bibliometric data, retrieved from the *Scopus* have been done on various aspects such as growth of research over a period (2000- 2019), international collaboration, most productive authors, preferred funding agencies, etc. The *Scopus* does not provide citation data for more than 20000 publications and India's research publication for the said period is 1116847. Therefore, the citation data pertaining to India's research contribution in Physical Sciences has not been analyzed. Thus, this happens to be a minor limitation of the present study.

6. Analysis and Interpretation of Data

The data retrieved from the *Scopus* database have been analysed by various aspects to get the exact idea of research for the physical sciences in India.

As depicted in the table 1 and figure 1 below, the growth of research publications has grown constantly over a period of twenty years. The highest increase could be noticed in 2019 with a 11.54 % increase in the number of research publications.

Table 1: Year Wise Publication in Physical Sciences

| Year | Total No. Publication | Per cent | Average (%) |
|------|-----------------------|----------|-------------|
| 1999 | 13476 | - | - |

| | | | |
|-----------|---------|-------|-------|
| 2000 | 14344 | 1.28 | 4.35 |
| 2001 | 15341 | 1.37 | 6.95 |
| 2002 | 17380 | 1.56 | 13.29 |
| 2003 | 19406 | 1.74 | 11.66 |
| 2004 | 21241 | 1.9 | 9.46 |
| 2005 | 24938 | 2.23 | 17.41 |
| 2006 | 29349 | 2.63 | 17.69 |
| 2007 | 32282 | 2.89 | 9.99 |
| 2008 | 37260 | 3.34 | 15.42 |
| 2009 | 41719 | 3.74 | 11.97 |
| 2010 | 47388 | 4.24 | 13.59 |
| 2011 | 58100 | 5.2 | 22.6 |
| 2012 | 63709 | 5.7 | 9.65 |
| 2013 | 69213 | 6.2 | 8.64 |
| 2014 | 81449 | 7.29 | 17.68 |
| 2015 | 90161 | 8.07 | 10.7 |
| 2016 | 98130 | 8.79 | 8.84 |
| 2017 | 103549 | 9.27 | 5.52 |
| 2018 | 122997 | 11.01 | 18.78 |
| 2019 | 128891 | 11.54 | 4.79 |
| 2000-2019 | 1116847 | 100 | - |

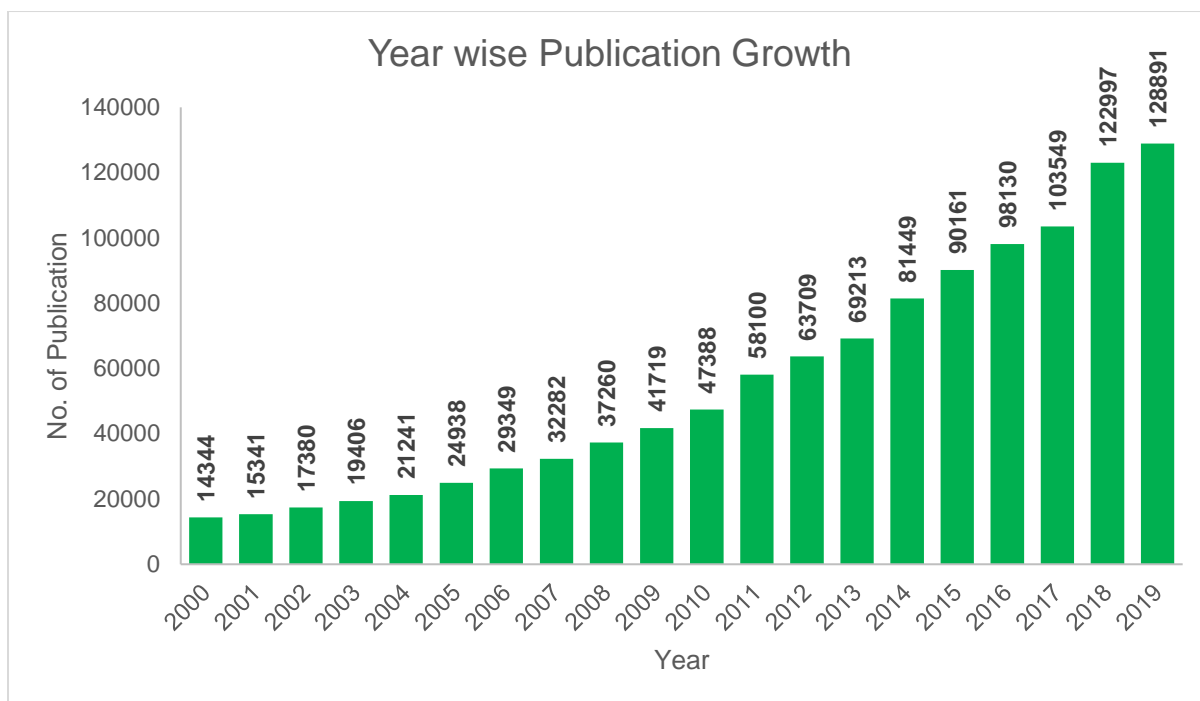


Figure 1: Year Wise Growth of Publication During 2000 to 2019

As depicted in figure 2 below, there is an exponential growth in number of publications in the five years block of 2015-2019. There may be many reasons for the increasing number of publications including wide awareness of research publications, incentives for research publications, career prospects and requirements of the funding agency, etc.

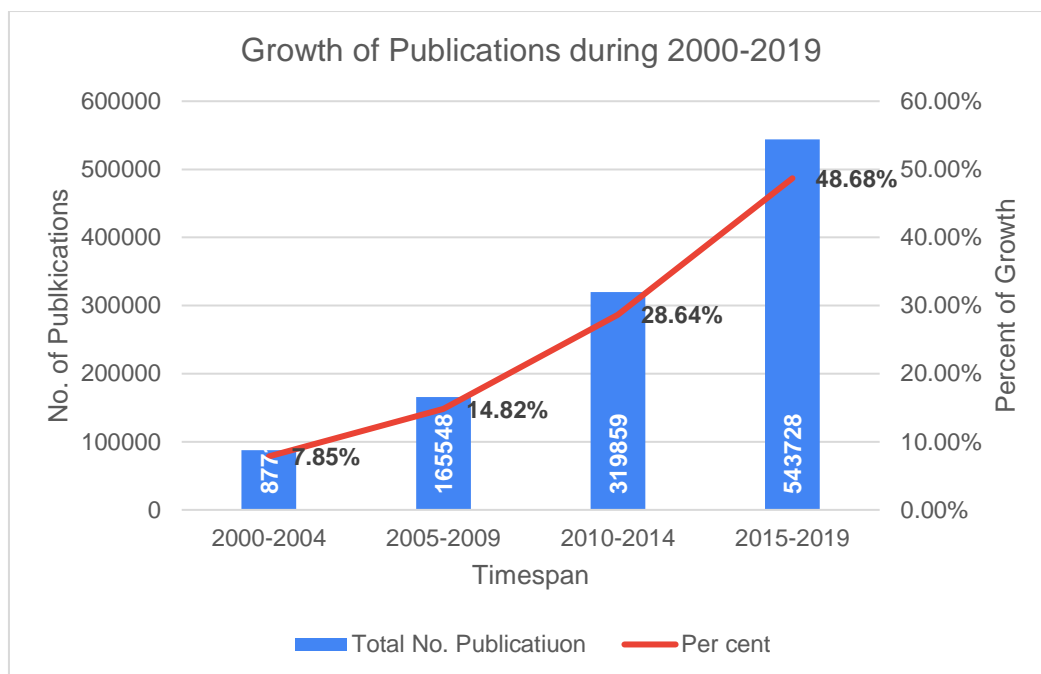


Fig. 2: Comparison of Five Years Block

As depicted in figure 2 above, there are 573119 documents that have been published in the fifteen years period i.e. 2000-2014 and in the last five years period i.e. 543728 documents have been published in Physical Science across the country. It may be observed from the data that 48.68% documents are published in the five years period (2015-2019) which is much higher compared to the fifteen years period (2000-2014).

The number of research publications grows constantly and steadily over the years. However, it could be noticed from the figure 3 below that the highest average growth of 22.60% in the year 2011.

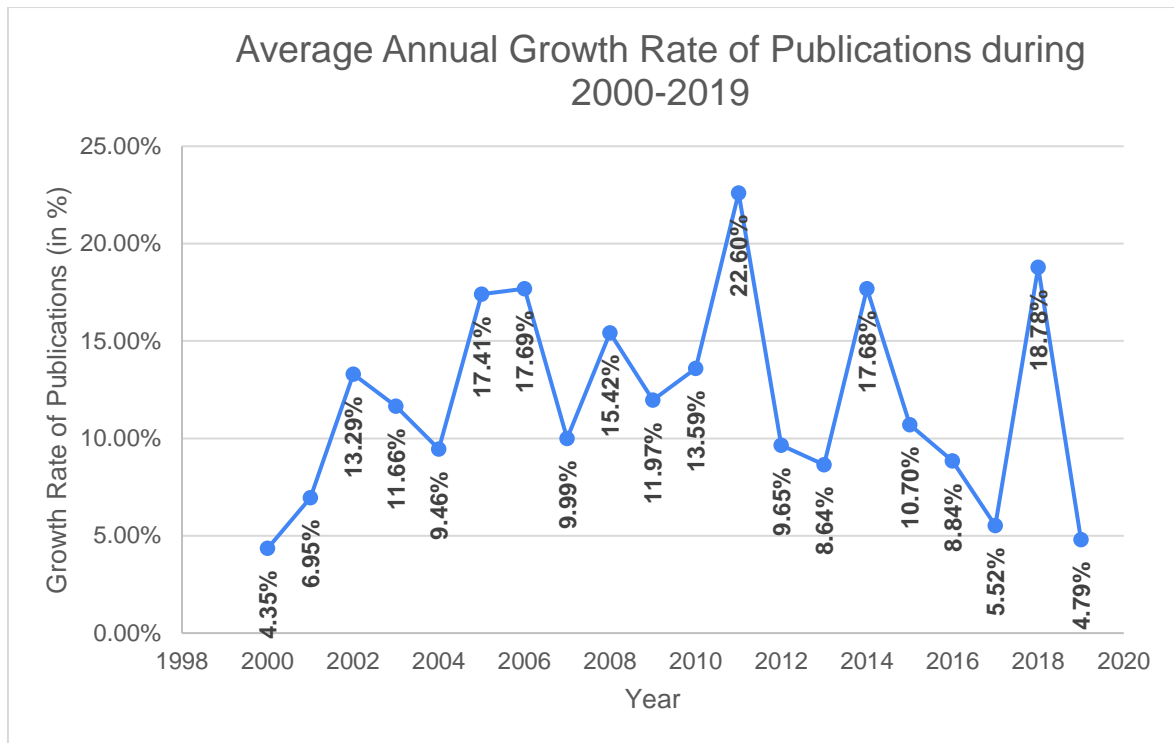


Figure 3: Average Growth Year Wise

As depicted in figure 4 below, the researchers are publishing research publications in different types of documents. These include article, conference paper, book chapter, review, etc. It may be observed from the data that 68.10% of total scholarly communications have been published in the form of Article.

Table 2: Types of Documents

| Document type | No. of Publication | Per cent |
|------------------|--------------------|----------|
| Article | 759993 | 68.10 |
| Conference Paper | 292442 | 26.13 |
| Book Chapter | 24404 | 2.18 |
| Review | 21554 | 1.93 |

| | | |
|--------------------------|----------------|---------------|
| Editorial | 5742 | 0.51 |
| Note | 2915 | 0.26 |
| Erratum | 2744 | 0.25 |
| Book | 1986 | 0.18 |
| Letter | 1463 | 0.13 |
| Short Survey | 1055 | 0.09 |
| Data Paper | 183 | 0.02 |
| Retracted | 83 | 0.01 |
| Abstract Report | 30 | 0.00 |
| Business Article | 20 | 0.00 |
| Conference Review | 3 | 0.00 |
| Undefined | 2230 | 0.20 |
| Total Publication | 1116847 | 100.00 |

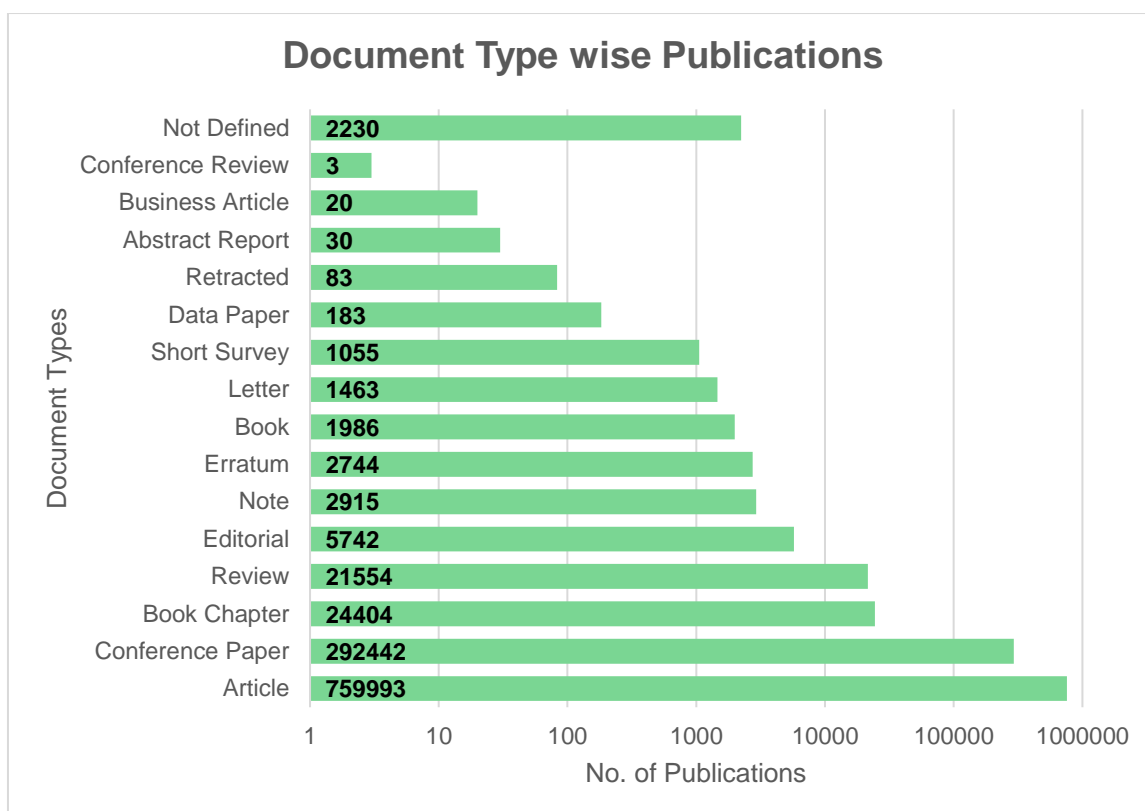


Figure 4: Types of documents (2000-2019)

The Government of India is spending millions of Rupees for higher education & research. There are many independent research organizations involved in hardcore research activity. The data revealed that IISc, Bangalore has the highest research publications in the Physical Sciences with 3.01% share in total publications published during 2000-2019. The table 3 depicts the share of top 25 institutions conducting most of the research in Physical Sciences.

Table 3: Affiliation of Researcher

| Sr. No. | Affiliation | No. of Paper | Per Cent |
|---------|--|--------------|----------|
| 1 | Indian Institute of Science, Bengaluru | 33524 | 3.01 |
| 2 | Indian Institute of Technology Kharagpur | 29194 | 2.62 |
| 3 | Indian Institute of Technology, Bombay | 26861 | 2.41 |

| | | | |
|----|---|--------|-------|
| 4 | Indian Institute of Technology Madras | 26734 | 2.40 |
| 5 | Indian Institute of Technology Delhi | 26184 | 2.35 |
| 6 | Bhabha Atomic Research Centre | 22512 | 2.02 |
| 7 | Anna University | 20677 | 1.86 |
| 8 | Indian Institute of Technology Kanpur | 20544 | 1.84 |
| 9 | Jadavpur University | 19383 | 1.74 |
| 10 | Indian Institute of Technology Roorkee | 19142 | 1.72 |
| 11 | Vellore Institute of Technology, Vellore | 16395 | 1.47 |
| 12 | University of Delhi | 15339 | 1.38 |
| 13 | Indian Institute of Technology Guwahati | 13028 | 1.17 |
| 14 | Council of Scientific and Industrial Research India | 12894 | 1.16 |
| 15 | Tata Institute of Fundamental Research, Mumbai | 12774 | 1.15 |
| 16 | Banaras Hindu University | 11376 | 1.02 |
| 17 | University of Calcutta | 10300 | 0.92 |
| 18 | Indian Institute of Chemical Technology | 10032 | 0.90 |
| 19 | Panjab University | 9568 | 0.86 |
| 20 | Aligarh Muslim University | 9309 | 0.84 |
| 21 | Indian Institute of Technology Indian School of Mines, Dhanbad | 8718 | 0.78 |
| 22 | National Institute of Technology Rourkela | 8444 | 0.76 |
| 23 | National Chemical Laboratory India | 8271 | 0.74 |
| 24 | Indian Space Research Organization | 7982 | 0.72 |
| 25 | Indian Association for the Cultivation of Science | 7894 | 0.71 |
| 26 | Others | 709768 | 63.55 |

The major subjects in Physical Sciences include Engineering, Computer Science, Physics and Astronomy, Chemistry, Material Science and Mathematics. There are many research publications which are interdisciplinary in nature. It may be observed from the figure 6 below that the subject 'Engineering' having 419044 publications with 37.52% share among the other subjects.

Table 4: Subject Area in Physical Sciences

| Sr. No. | Subject area | No. of Paper | Per Cent |
|---------|--|--------------|----------|
| 1 | Engineering | 419044 | 37.52 |
| 2 | Computer Science | 283534 | 25.39 |
| 3 | Physics and Astronomy | 258338 | 23.13 |
| 4 | Chemistry | 238637 | 21.37 |
| 5 | Materials Science | 232379 | 20.81 |
| 6 | Mathematics | 124610 | 11.16 |
| 7 | Environmental Science | 117663 | 10.54 |
| 8 | Chemical Engineering | 114996 | 10.3 |
| 9 | Energy | 74851 | 6.7 |
| 10 | Biochemistry, Genetics and Molecular Biology | 73577 | 6.59 |
| 11 | Earth and Planetary Sciences | 65894 | 5.9 |
| 12 | Agricultural and Biological Sciences | 48680 | 4.36 |
| 13 | Pharmacology, Toxicology and Pharmaceutics | 42629 | 3.82 |
| 14 | Social Sciences | 29451 | 2.64 |
| 15 | Business, Management and Accounting | 26023 | 2.33 |
| 16 | Medicine | 23029 | 2.06 |

| | | | |
|----|-------------------------------------|-------|------|
| 17 | Decision Sciences | 19581 | 1.75 |
| 18 | Immunology and Microbiology | 11534 | 1.03 |
| 19 | Economics, Econometrics and Finance | 5164 | 0.46 |
| 20 | Health Professions | 3087 | 0.28 |
| 21 | Multidisciplinary | 2692 | 0.24 |
| 22 | Arts and Humanities | 2529 | 0.23 |
| 23 | Neuroscience | 1472 | 0.13 |
| 24 | Psychology | 981 | 0.09 |
| 25 | Nursing | 284 | 0.03 |
| 26 | Dentistry | 226 | 0.02 |
| 27 | Veterinary | 185 | 0.02 |

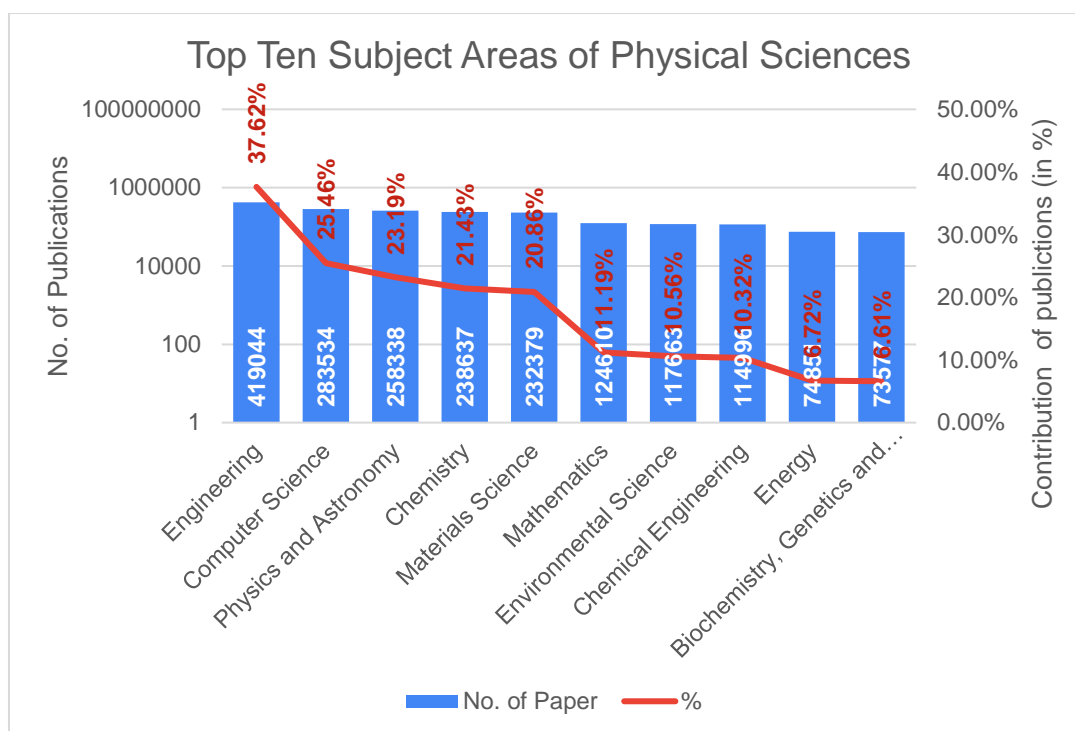


Figure 6: Top Ten Subject Area in Physical Science

It is highly desirable to publish scholarly communications in indexed or peer reviewed publications. The table 5 shows that there are 14929 publications with a share of 1.34% are published in API Conference Proceedings and 11119 publications with a share of 1.00% are published in the Advances in Intelligent Systems and Computing.

Table 5: Top Twenty Source of Publications

| Sr. No. | Source/Publisher | No. of Paper | % |
|---------|--|--------------|------|
| 1 | AIP Conference Proceedings | 14929 | 1.34 |
| 2 | Advances in Intelligent Systems and Computing | 11119 | 1.00 |
| 3 | International Journal of Applied Engineering Research | 10905 | 0.98 |
| 4 | Lecture Notes in Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics | 8810 | 0.79 |
| 5 | RSC Advances | 7668 | 0.69 |
| 6 | International Journal of Recent Technology and Engineering | 6780 | 0.61 |
| 7 | International Journal of Innovative Technology and Exploring Engineering | 6699 | 0.60 |
| 8 | Asian Journal of Chemistry | 6541 | 0.59 |
| 9 | Materials Today Proceedings | 6151 | 0.55 |
| 10 | Communications in Computer and Information Science | 5707 | 0.51 |

| | | | |
|----|---|--------|-------|
| 11 | Tetrahedron Letters | 5076 | 0.45 |
| 12 | Acta Crystallographica Section E Structure Reports Online | 4560 | 0.41 |
| 13 | ACM International Conference Proceeding Series | 4249 | 0.38 |
| 14 | Journal of Advanced Research in Dynamical and Control Systems | 4217 | 0.38 |
| 15 | Journal of Alloys and Compounds | 4019 | 0.36 |
| 16 | Proceedings of SPIE The International Society for Optical Engineering | 3924 | 0.35 |
| 17 | IOP Conference Series Materials Science and Engineering | 3887 | 0.35 |
| 18 | Journal of the Indian Chemical Society | 3858 | 0.35 |
| 19 | SAE Technical Papers | 3745 | 0.34 |
| 20 | Spectrochimica Acta Part A Molecular and Biomolecular Spectroscopy | 3718 | 0.33 |
| 21 | Others | 990285 | 88.67 |

The bibliometric data retrieved from the Scopus database revealed that India's contribution in Physical Sciences for a period of 2000-2019 with its global counterpart remains constant. Table 6 and figure 7 shows that India's major counterparts are US, Germany and UK with 58454, 22689 and 19611 publications, respectively.

Table 6: Country-wise distribution of publications (International Collaboration)

| Country/Territory | No. of Paper | Country/Territory | No. of Paper |
|-------------------|--------------|--------------------|--------------|
| India | 1115282 | Australia | 10052 |
| United States | 58454 | Saudi Arabia | 8723 |
| Germany | 22689 | Spain | 8149 |
| United Kingdom | 19611 | Malaysia | 7767 |
| South Korea | 17845 | Russian Federation | 7726 |
| France | 14975 | Taiwan | 7537 |
| Japan | 14758 | Switzerland | 6237 |
| China | 13181 | Poland | 5849 |
| Italy | 10644 | Brazil | 5717 |
| Canada | 10233 | Other countries | 121528 |

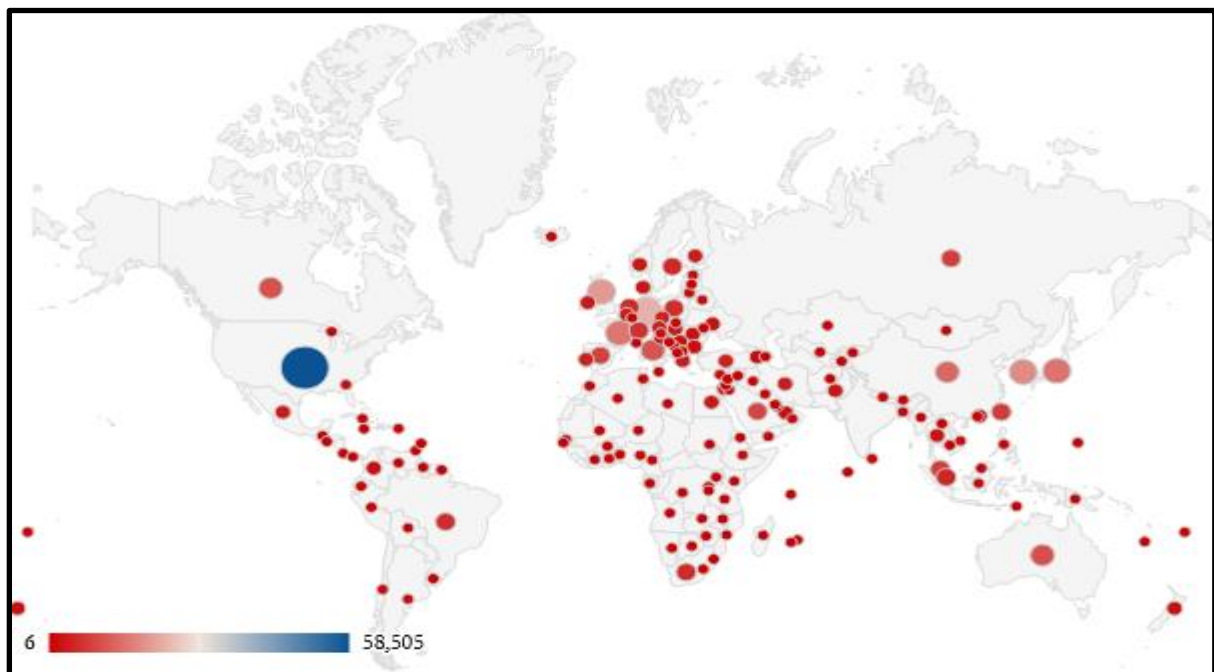


Figure 7: Geographical presentation of publications

It is important to note that the funds for conducting research is vital for uninterrupted research. There are many agencies in India that provide research funding in different disciplines. UGC, ICCSR, ICMR, CSIR, DST, ICMR, etc., are some of the major funding agencies in India. As depicted in figure 8 the UGC, CSIR and DST are the major Government agencies for research to apply for funds. It may be observed from the data that the UGC, with 2.98%, CSIR with 1.61% and DST with 1.5% funding are the major sources of funding for research in India for the Physical Sciences.

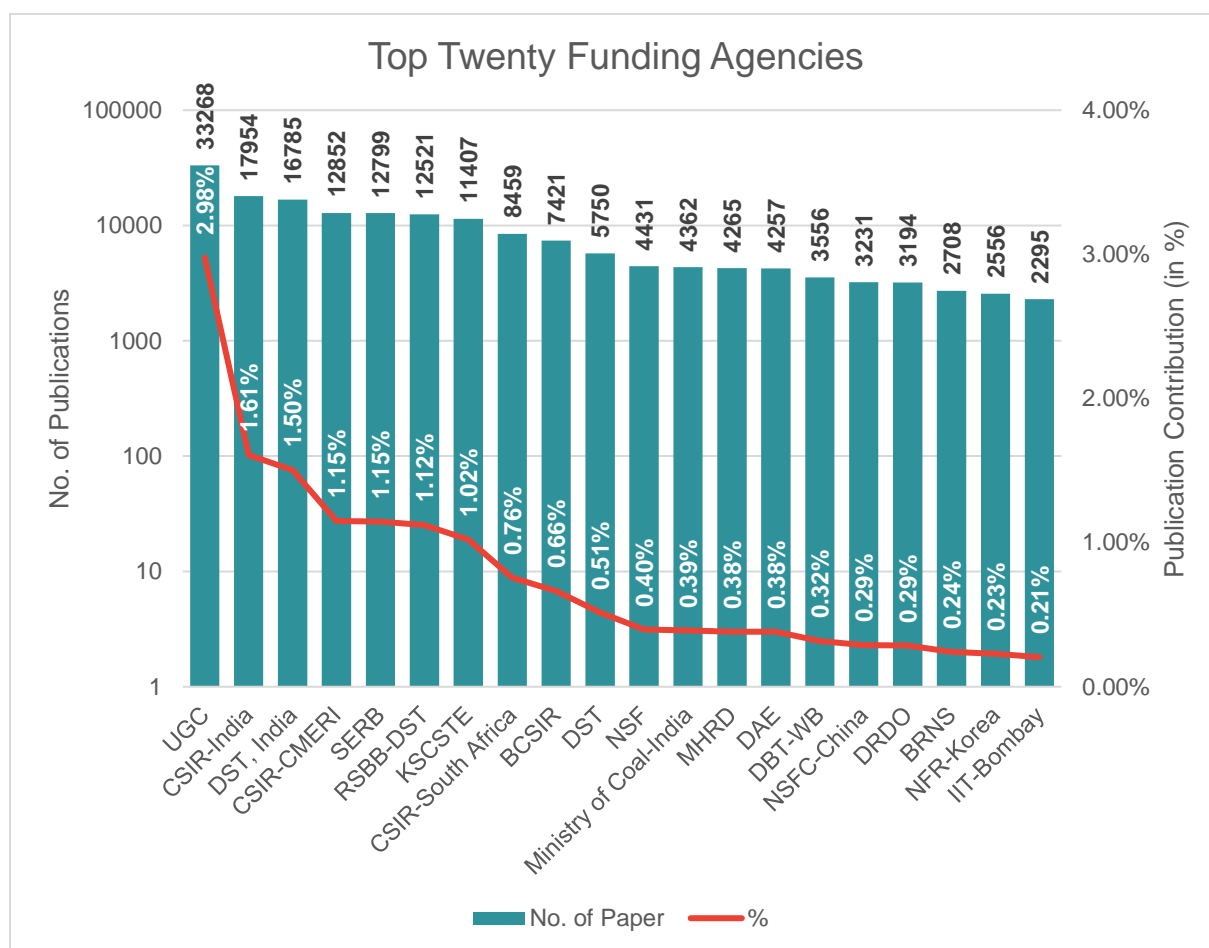


Figure 8: Top Twenty funding sponsor in Physical Science

Research impact can be measured based on the citations received by the publications. The impact of individual researchers can be measured by h-index. The more citations received by the author or publications is considered as impactful research. It may be observed from the figure 9 below that the author How, W.S. has published highest publications 1483 and received

28763 citations with h-index of 116 in Physical Sciences. Hou, W.S. and Tully, C. are the most prolific authors among other authors as they have published more research papers and received highest citation & h-index.

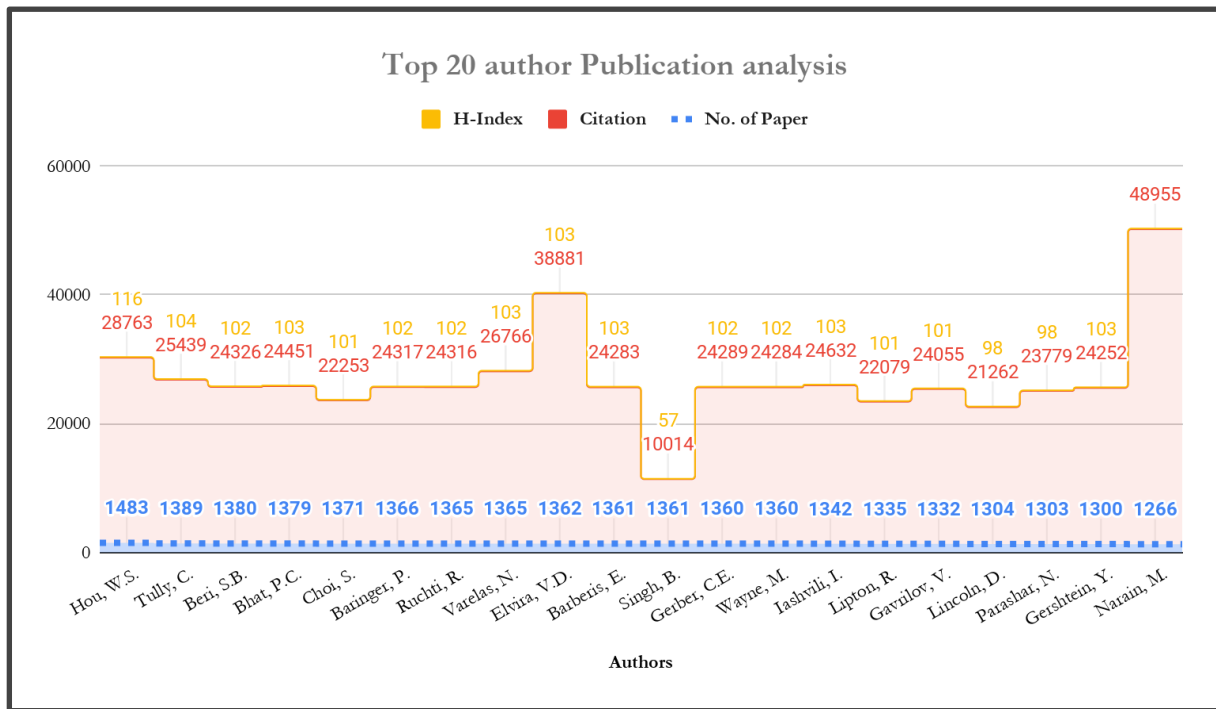


Figure 9: Top Twenty Most Productive Authors

7. Conclusion

India's research output in Physical Sciences is notable with a total of 1116847 publications during the period of 2000-2019. The study revealed that there are encouraging trends in Physical Science research across the country. It is observed that collaborative research with foreign counterparts is also encouraging. UGC, CSIR and DST are the major Government agencies funding Physical Science research in the country. It may be noted that the Indian Institute of Science, Bangalore has published the highest publications compared to other institutions in the country. Engineering subject has been emerged as one of the subjects having highest research work among the other subjects in physical sciences.

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